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Neil Archibald
Gilbert Ramirez
Noam Rathaus
Josh Burke Technical Editor
Brian Caswell Technical Editor
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Foreword

The first three books in my Open Source Security series covered Nessus, Snort, and Ethereal. The authors and I worked hard to make these books useful to complete beginners, enterprise-scaled users, and even programmers who were looking to enhance these tools. Giving programmers the capability to add components to each tool was one focus of several. For example, I dissected a preprocessor in the Snort 2.0 and 2.1 books and explained how you might build another. To do that, I had to learn Snort's inner workings by reading much of the code. My material helped you learn how to work on a preprocessor, but you still needed to do much of the same kind of code reading before you could make something truly complex. We could focus only so much of that book on development because there were so many other important topics to cover.

This book closes the gap between the level of understanding of each of these open source tools you gained in these first books and that of a full-fledged developer. It teaches you everything you need to understand about the internal program architecture of each tool and then takes you through meaningful examples in building new components for that tool. The components can be as simple as basic Snort rules and as complex as an entirely new protocol dissector for Ethereal.

This kind of access to development information is unique. Normally, adding components to one of these tools involves tons of code reading in an attempt to understand how the program works. It's usually the case in open source that the code serves as the only developer documentation. This book shortcuts all that code reading, giving you the developer documentation that we all wish existed for open source tools.

The best feature of the book in my mind is that it teaches through realistic examples. Whether they are explaining how to write a rule or a new detection plugin for Snort, a complex NASL test with custom functions for Nessus, or a new protocol dissector for Ethereal, the authors have worked to teach you the thought process. They start you off with a need, say, a new exploit, and teach you how to figure out what to code and how to finish that code. And there's a great team working to teach you: many of the authors have created large amounts of the code, test scripts, and rules that you're learning to customize.

I think this book is invaluable to developers who want to work on these tools, as well as power users who just want to create the best Ethereal function scripts, Snort rules, and Nessus tests for their organization. I hope you'll agree.

—Jay Beale
Series Editor

Companion Web Site

Much of the code presented throughout this book is available for download from **www.syngress.com/solutions**. Look for the Syngress icon in the margins indicating which examples are available from the companion Web site.

Part I
Nessus Tools

Chapter 1

The Inner Workings of NASL (Nessus Attack Scripting Language)

Scripts and samples in this chapter:

- **What Is NASL?**
- **Commonly Used Functions**
- **Nessus Daemon Requirements to Load a NASL**

Introduction

One of the most attractive attributes of Nessus is the simplicity of creating custom extensions (or plugins) to be run with the Nessus engine. This benefit is gained via the specialized language NASL (Nessus Attack Scripting Language). NASL supplies the infrastructure to write network-based scripts without the need to implement the underlying protocols. As NASL does not need to compile, plugins can be run at once, and development is fast. After understanding these benefits, it should be an easy decision to write your next network-based script using NASL. In this introduction we will overview how this is done, with an emphasis on usability and tips for writing your own scripts. If you are already familiar with the NASL language, we hope you will still find useful insights in this chapter.

What Is NASL?

NASL, as the name implies, is a scripting language specifically designed to run using the Nessus engine. The language is designed to provide the developer with all the tools he/she needs to write a network-based script, supporting as many network protocols as required.

Every NASL is intended to be run as a test. Thus, its first part will always describe what the test is and what a positive result means. In most cases, the test is being done for a specific vulnerability, and a successful test means that the target (host/service) is vulnerable. The second part of the script runs NASL commands to provide a success/fail result. The script can also use the Nessus registry (the knowledge base) to provide more information on the target.

Structure of a NASL Script

NASL scripts consist of a description section and a test section. Even though the test section is the one that does the actual testing, the description is equally important. The description part is crucial to the Nessus environment; without it, the environment would be unable to determine the order in which tests should be executed, unable to determine which tests require information from which other test or tests, unable to determine which test might need to be avoided as it may cause harm to the host being tested, and finally unable to determine which tests affect which service on the remote host, thus avoiding running them on irrelevant services or even hosts. Let's briefly discuss these sections.

The Description Section

The first part of a NASL file, the NASL description, is used by the Nessus engine to identify the plugin and provide the user with a description of the plugin. Finally, if the plugin run was successful, the engine will use this section to provide the user with the results. The description section should look something like the following (code taken from wu_ftpd_overflow):

```
if(description)
{
 script_id(10318);
 script_bugtraq_id(113, 2242, 599, 747);
 script_version ("$Revision: 1.36 $");
```

```
 script_cve_id("CVE-1999-0368");

 name["english"] = "wu-ftpd buffer overflow";
 script_name(english:name["english"]);

 desc["english"] = "
It was possible to make the remote FTP server crash
by creating a huge directory structure.
This is usually called the 'wu-ftpd buffer overflow'
even though it affects other FTP servers.
It is very likely that an attacker can use this
flaw to execute arbitrary code on the remote
server. This will give him a shell on your system,
which is not a good thing.
Solution : upgrade your FTP server.
Consider removing directories writable by 'anonymous'.

Risk factor : High";
 script_description(english:desc["english"]);

 script_summary(english:"Checks if the remote ftp can be buffer overflown");
 script_category(ACT_MIXED_ATTACK); # mixed
 script_family(english:"FTP");

 script_copyright(english:"This script is Copyright (C) 1999 Renaud Deraison");

 script_dependencies("find_service.nes", "ftp_write_dirs.nes");
 script_require_keys("ftp/login", "ftp/writeable_dir");
 script_require_ports("Services/ftp", 21);
 exit(0);
}
```

The section contained in the preceding *if* command is the description section of the NASL. When the NASL script is run with the *description* parameter set, it will run the code in this clause and exit, instead of running the actual script.

The description sets the following attributes:

- **script_id** This globally unique ID helps Nessus identify the script in the knowledge base, as well as in any other script dependencies.
- **script_bugtraq_id and script_cve_id** These functions set CVE and Bugtraq information, searchable in the Nessus user interface. This helps to index vulnerabilities and provide external resources for every vulnerability.
- **script_name** A short descriptive name to help the user understand the purpose of the script.
- **script_description** This sets the information displayed to the user if the script result was successful. The description should describe the test that was done, the consequences, and any possible solution available. It is also a good idea to set a *risk factor* for the script. This can help the user prioritize work when encountering the results of the script.
- **script_category** The script category is used by the Nessus engine to determine when the plugins should be launched.

- **script_family** A plugin might belong to one or more families. This helps the user to narrow down the amount of tests to run according to a specific family.
- **script_dependencies** If your NASL requires other scripts to be run, their *script_id*s should be written here. This is very useful, for example, to cause a specific service to run on the target machine. After all, there is little sense in running a test that overflows a command in an FTP (File Transfer Protocol) server if there is no FTP server actually running on the target host.
- **script_require_keys** The usage of the knowledge base as a registry will be explained later on, but this command can set certain requirements for knowledge base keys to exist before running the script.
- **script_require_ports** One of Nessus' capabilities is running a service mapping on the remote host in several ways; we can use this to detect servers running on non-standard ports. If in our example the target runs an FTP server on port 2100 instead of the default port 21, and Nessus was able to detect this, we are able to run the test more accurately, independent of the actual port where the service is running.

The Test Section

A lot of information is presented in the following sections on how to write plugins effectively and how to benefit from various capabilities of the NASL language, but first of all, what does a NASL test look like?

The first step will usually be to detect if the target runs the service or network protocol we want to test. This can be done either via Nessus' knowledge base or by probing ourselves. If we discovered the host runs the service we want to test, we will probably want to connect to this service and send some sort of test request. The request can be for the host to provide a specially crafted packet, read the service banner, or use the service to get information on the target. After getting a reply from the server, we will probably search for something in the reply to decide if the test was successful or not. Based on this decision, we will notify Nessus of our findings and exit.

For example, the test part of a script reading the banner of a target Web server can be written like the following:

```
include("http_func.inc"); #include the NASL http library functions
#Use the knowledge base to check if the target runs a web server
port = get_http_port(default:80);
if (! get_port_state(port)) exit(0);
#Create a new HTTP request
req = http_get(item:"/", port:port);
#Connect to the target port, and send the request
soc = http_open_socket(port);
if(!soc) exit(0);
send(socket:soc, data:req);
r = http_recv(socket:soc);
http_close_socket(soc);
```

```
#If the server replied, notify of our success
if(r)
    security_note(port:port, data:r);
```

Writing Your First Script

When writing NASL scripts, it is common practice to test them with the *nasl* command-line interpreter before launching them as part of a Nessus scan. The *nasl* utility is part of the Nessus installation and takes the following arguments:

```
nasl [-t <target>] [-T tracefile] script1.nasl [script2.nasl …]
```

where:

- **-t <target>** is the IP (Internet Protocol) address or hostname against which you would like to test your script. The NASL networking functions do not allow you to specify the destination address when establishing connections or sending raw packets. This limitation is as much for safety as for convenience and has worked very well so far. If this option is not specified, all connections will be made to the loopback address, 127.0.0.1 (localhost).
- **-T <tracefile>** forces the interpreter to write debugging information to the specified file. This option is invaluable when diagnosing problems in complex scripts. An argument of **-** will result in the output being written to the console.

This utility has a few other options covered later in this chapter. For a complete listing of available options, execute this program with the *-h* argument.

For our first NASL script, we will write a simple tool that connects to an FTP server on TCP (Transmission Control Protocol) port 21, reads the banner, and then displays it on screen. The following NASL code demonstrates how easy it is to accomplish this task:

```
soc = open_sock_tcp(21);
if ( ! soc ) exit(0);
banner = recv_line(socket:soc, length:4096);
display(banner);
```

Let's walk through this small example:

```
soc = open_sock_tcp(21);
```

This function opens a TCP socket on port 21 of the current target (as specified with *nasl –t*). This function returns NULL on failure (the remote port is closed or not responding) and a nonzero file descriptor on success.

```
banner = recv_line(socket:soc, length:4096);
```

This function reads data from the socket until the number of bytes specified by the *length* parameter has been received, or until the character *\n* is received, whichever comes first.

As you can see, the function *open_sock_tcp()* takes a single, non-named argument, while the function *recv_line()* takes two arguments that are prefixed by their names. These are referred to as *anonymous* and *named* functions. Named functions allow the plugin writer to specify only the

parameters that he needs, instead of having to supply values for each parameter supported by the function. Additionally, the writer does not need to remember the exact order of the parameters, preventing simple errors when calling a function that supports many options. For example, the following two lines produce identical results:

```
banner = recv_line(socket:soc, length:4096);
banner = recv_line(length:4096, socket:soc);
```

Save this script as test.nasl and execute it on the command line:

```
$ /usr/local/bin/nasl -t ftp.nessus.org test.nasl
** WARNING : packet forgery will not work
** as NASL is not running as root
220 ftp.nessus.org Ready
```

If you run *nasl* as a nonroot user, you will notice that it displays a warning message about packet forgery. NASL scripts are capable of creating, sending, and receiving raw IP packets, but they require root privileges to do so. In this example, we are not using raw sockets and can safely ignore this message.

Now, let's modify our script to display the FTP banner in a Nessus report. To do so, we need to use one of the three special-purpose reporting functions: *security_hole()*, *security_warning()*, and *security_note()*. These functions tell the Nessus engine that a plugin is successful (a vulnerability was found), and each denotes a different severity level. A call to the *security_note()* function will result in a low-risk vulnerability being added to the report, a call to *security_warn()* will result in a medium-risk vulnerability, and *security_hole()* is used to report a high-risk vulnerability. These functions can be invoked in two ways:

```
security_note(<port>)
```

or

```
security_note(port:<port>, data:<report>, proto:<protocol>)
```

In the first case, the plugin simply tells the Nessus engine that it was successful. The Nessus engine will copy the plugin description (as registered with *script_description()*) and will place it into the report. This is sufficient for most plugins; either a vulnerability is there and we provide a generic description, or it is not and we do not report anything. In some cases, you might want to include dynamic text in the report. This dynamic text could be the version number of the remote web server, the FTP banner, the list of exported shares, or even the contents of a captured password file.

In this particular example, we want to report the FTP banner that we received from the target system, and we will use the long form of the *security_note()* function to do this:

```
soc = open_sock_tcp(21);
if ( ! soc ) exit(0);
banner = recv_line(socket:soc, length:4096);
security_note(port:21, data:"The remote FTP banner is : " + banner, proto:"tcp");
```

If you execute this script from the command line, you will notice that the *data* parameter is written to the console. If no data parameter was specified, it will default to the string

"Successful." When this plugin is launched by the Nessus engine, this data will be used as the vulnerability description in the final report.

Now that our plugin code has been modified to report the FTP banner, we need to create the description section. This section will allow the plugin to be loaded by the Nessus engine:

```
if ( description )
{
        script_id( 90001);
        script_name(english:"Simple FTP banner grabber");
        script_description(english:"
This script establishes a connection to the remote host on port 21 and
extracts the FTP banner of the remote host");

        script_summary(english:"retrieves the remote FTP banner");
        script_category(ACT_GATHER_INFO);
        script_family(english:"Nessus Book");
        script_copyright(english:"(C) 2004 Renaud Deraison");
        exit(0);
}

soc = open_sock_tcp(21);
if ( ! soc ) exit(0);
banner = recv_line(socket:soc, length:4096);
security_note(port:21, data:"The remote FTP banner is : " + banner, proto:"tcp");
```

Commonly Used Functions

The Nessus NASL language is very versatile and has many different basic functions used for manipulating strings, opening sockets, sending traffic, generating raw packets, and more. In addition, many more advanced functions utilize the underlying basic functions to provide more advanced functionality, such as SSH (Secure Shell) connectivity, SMB (Server Message Block) protocol support, and advanced HTTP (Hypertext Transmission Protocol) traffic generation.

When writing a NASL you don't have to know all the functions available via the NASL interface; rather, you can use the most basic functions when low-level work is necessary or use more advanced functions that wrap these basic functions when more abstract work is needed, such as in the case where SQL injection or cross-site scripting vulnerabilities are being tested.

One example of this is using the open_sock_tcp() function to open a socket to a remote host or using the more common get_http_port() function when connectivity to a Web server is necessary. get_http_port() does everything for you—from opening the socket to marking it in the knowledge base as a functioning HTTP host that will be used later to speed up any future connectivity to this port.

At the time of this writing, more than 1,500 tests utilize the advanced functions provided for communication with Web servers. These functions reside inside the http_func.inc and http_keepalive.inc include files. They provide easy access to functionality that allows querying a remote host for the existence of a certain file, querying a remote host using a special URI (Universal Resource Identifier) that in turn might or might not trigger the vulnerability.

The functions included in the http_func.inc and http_keepalive.inc files make the NASL writer's life a lot easier, as they take away the hassle of opening the ports, generating HTTP traffic, sending this traffic to the remote host, receiving the response, breaking the response into its two parts (header and body), and finally closing the connection.

Writing a test for a Web-based vulnerability requires writing roughly 22 lines of code starting with a request to open a Web port if it hasn't been opened already:

```
port = get_http_port(default:80);
if ( ! port ) exit(0);
```

The get_http_port is called with a default port number for this specific vulnerability. In most cases the default value for the *default* parameter is 80, as the vulnerability is not expected to sit on any other port than the default Web server's port. However, in some cases the product might be listening by default on another port, for example in the case where a page resides on a Web server's administrative port.

Once we have confirmed that the host is in fact listening to HTTP traffic, we can continue by providing a list of directories under which we want to look for the vulnerability. This is done using the *foreach* function, which will call the lines that follow for each of the values provided by it:

```
foreach dir (cgi_dirs())
```

Next we issue a call to the http_get function that in turn will construct an HTTP GET request for us, we need to provide the function with the URI we want it to retrieve for us. The URI doesn't have to be a static one, rather we can use the string function or the plus sign to generate dynamic URIs:

```
buf = http_get(item:dir + "/store/BrowseCategories.asp?Cat0='1", port:port);
```

Next we need to send the generated HTTP traffic to the remote server. By utilizing the wrapper function http_keepalive_send_recv, we can avoid the need to actually call the send/recv function. Furthermore, we can utilize the remote host's, HTTP keepalive mechanism so that we will not be required to close our connection and reopen it whenever we want to send HTTP traffic to it:

```
r1 = http_keepalive_send_recv(port:port, data:buf, bodyonly:1);
```

In some cases we want to analyze only the HTTP response's body, discarding the header. This is for two reasons; first, the header might confuse our subsequent analysis of the response, and second, the content we are looking for will not appear in the header and analyzing its data would be a waste of time. In such cases where we only want to analyze the body, we can instruct the http_keepalive_send_recv function to return only the body by providing the *bodyonly* variable with the value of 1.

Once the data has returned to us, we can do either a static match:

```
if ( "Microsoft OLE DB Provider for ODBC Drivers error '80040e14'" >< r1 )
```

Or a more dynamic match:

```
if(egrep(pattern:"Microsoft.*ODBC.*80040e14", string:r1 ) )
```

The value of doing a dynamic match is that error messages are usually localized and statically testing for a match might cause the test to return a false negative (in which the test determines that the remote host is immune when in fact it is vulnerable). Therefore, whenever possible, try to use dynamic rather than static matching.

All that is left is to notify the Nessus environment that a vulnerability has been detected. This is done by calling up the security_hole, security_warning, or security_note function:

```
security_note(port: port);
```

Regular Expressions in NASL

Other commonly used functions are a set of functions that implement an interface to regular expression processing and handling. A full description of regular expressions is outside the scope of this book, but a good starting point is the article found at http://en.wikipedia.org/wiki/Regular_expressions.

To give you an idea of how common the regular expressions are in Nessus, there are over 2000 different tests that utilize the *egrep* function and over 400 different tests that utilize the *eregmatch* function. These two numbers do not take into account that many of the tests use the functionality provided by http_func.inc and http_keepalive.inc, which in turn utilize regular expressions' abilities parse data to great extent.

NASL supports egrep(1)-style operations through the *ereg()*, *egrep()*, and *ereg_replace()* functions. These functions use POSIX extended regular expression syntax. If you are familiar with Perl's regular expression support, please keep in mind that there are significant differences between how NASL and Perl will handle the same regular expression.

The *ereg()* function returns TRUE if a string matches a given pattern. The string must be a one-line string (in other words, it should not contain any carriage return character). In the following example, the string "Matched!" will be printed to the console:

```
if (ereg(string:"My dog is brown", pattern:"dog"))
{
      display("Matched\n");
}
```

The egrep() function works like ereg(), except that it accepts multiline strings. This function will return the actual string that matched the pattern or FALSE if no match was found. In the following example, the variable *text* contains the content of a UNIX passwd file. We will use egrep() to only return the lines that correspond to users whose ID value (the third field) is lower than 50.

```
text = "
root:*:0:0:System Administrator:/var/root:/bin/tcsh
daemon:*:1:1:System Services:/var/root:/dev/null
unknown:*:99:99:Unknown User:/dev/null:/dev/null
smmsp:*:25:25:Sendmail User:/private/etc/mail:/dev/null
www:*:70:70:World Wide Web Server:/Library/WebServer:/dev/null
mysql:*:74:74:MySQL Server:/dev/null:/dev/null
sshd:*:75:75:sshd Privilege separation:/var/empty:/dev/null
renaud:*:501:20:Renaud Deraison,,,:/Users/renaud:/bin/bash";
```

```
lower_than_50 = egrep(pattern:"[^:]*:[^:]:([0-9]|[0-5][0-9]):.*", string:text);
display(lower_than_50);
```

Running this script in command-line mode results in the following output:

```
$ nasl egrep.nasl
root:*:0:0:System Administrator:/var/root:/bin/tcsh
daemon:*:1:1:System Services:/var/root:/dev/null
smmsp:*:25:25:Sendmail User:/private/etc/mail:/dev/null
$
```

```
ereg_replace(pattern:<pattern>, replace:<replace>, string:<string>);
```

The ereg_replace() function can be used to replace a pattern in a string with another string. This function supports regular expression back references, which can replace the original string with parts of the matched pattern. The following example uses this function to extract the Server: banner from an HTTP server response:

```
include("http_func.inc");
include("http_keepalive.inc");
reply = http_keepalive_send_recv(data:http_get(item:"/", port:80), port:80);
if ( ! reply ) exit(0);

# Isolate the Server: string from the HTTP reply
server = egrep(pattern:"^Server:", string:reply);
if ( ! server ) exit(0);
server = ereg_replace(pattern:"^Server: (.*)$",
        replace:"The remote server is \1",
        string:server);
display(server, "\n");
```

Running this script in command-line mode results in the following output:

```
$ nasl -t 127.0.0.1 ereg_replace.nasl
The remote server is Apache/1.3.29 (Darwin)
$
```

String Manipulation

NASL is quite flexible when it comes to working with strings. String operations include addition, subtraction, search, replace, and support for regular expressions. NASL also allows you to use escape characters (such as *\n*) using the *string()* function.

How Strings Are Defined in NASL

Strings can be defined using single quotes or double quotes. When using double quotes, a string is taken as is—no interpretation is made on its content—while strings defined with single quotes interpret escape characters. For example:

```
A = "foo\n";
B = 'foo\n';
```

In this example, the variable *A* is five characters long and is equal to *foo\n*, while variable *B* is four characters long and equal to *foo*, followed by a carriage return. This is the opposite of how strings are handled in languages such as C and Perl, and can be confusing to new plugin developers.

We call an interpreted string (defined with single quotes) a *pure* string. It is possible to convert a regular string to a pure string using the string() function. In the following example, the variable *B* is now four characters long and is equal to *foo*, followed by a carriage return.

```
A = "foo\n";
B = string(A);
```

If you are familiar with C, you might be used to the fact that the zero byte (or NULL byte) marks the end of a string. There's no such concept in NASL—the interpreter keep tracks of the length of each string internally and does not care about the content. Therefore, the string *\0\0\0* is equivalent to three NULL byte characters, and is considered to be three bytes long by the strlen() function.

You may build strings containing binary data using the raw_string() function. This function will accept an unlimited number of arguments, where each argument is the ASCII code of the character you want to use. In the following example, the variable *A* is equal to the string *XXX* (ASCII code 88 and 0x58 in hexadecimal).

```
A = raw_string(88, 0x58, 88);
```

String Addition and Subtraction

NASL supports string manipulation through the addition (+) and subtraction (–) operators. This is an interesting feature of the NASL language that can save quite a bit of time during plugin development.

The addition operator will concatenate any two strings. The following example sets the variable *A* to the value *foobar*, and then variable *B* to the value *foobarfoobarfoobar*.

```
A = "foo" + "bar";
B = A + A + A;
```

The subtraction operator allows you to remove one string from another. In many cases, this is preferable to a search-and-replace or search-and-extract operation. The following example will set the variable *A* to the value *1, 2, 3*.

```
A = "test1, test2, test3";
A = A - "test";  # A is now equal to "1, test2, test3"
A = A - "test";  # A is now equal to "1, 2, test3"
A = A - "test";  # A is now equal to "1, 2, 3"
```

String Search and Replace

NASL allows you to easily search for one string and replace it with another, without having to resort to regular expressions. The following example will set the variable *A* to the value *foo1, foo2, foo2*.

```
A = "test1, test2, test3";
```

Nessus Daemon Requirements to Load a NASL

The Nessus daemon requires several things that a NASL implements before it will load a NASL placed in the plugin directory. These items are required as the Nessus daemon needs to know several things on the test such as its unique ID, name, description, summary, category, family, and copyright notice. While the name, description, summary, family, and copyright can be left as blank, the ID and category have to be properly defined or the test will not be listed by the Nessus daemon as being part of its test list.

The script_id function defines a test's unique ID. Test IDs are assigned by the Nessus community members, who make sure that no two tests are given the same ID number. The categories of the tests can be any of the following: ACT_INIT, ACT_SCANNER, ACT_SETTINGS, ACT_GATHER_INFO, ACT_ATTACK, ACT_MIXED_ATTACK, ACT_DESTRUCTIVE_ATTACK, ACT_DENIAL, ACT_KILL_HOST, ACT_FLOOD, or ACT_END. Depending on the type of category assigned to the test, Nessus will run it at a specific part of the scan. For example, defining a test as ACT_INIT or ACT_END will restrict the launch of the test to the beginning or end of the scan, respectively.

Once a test has the aforementioned settings, the Nessus daemon will load the test into its test list. The Nessus daemon will launch the test whenever the test's ID is included in a scan's plugin list.

Final Touches

Nessus' NASL language provides an easy-to-use interface for writing tests. The language is also easy to extend by building wrapper functions that utilize one or more basic functions provided by the NASL interpreter. Once such a wrapper is constructed, many tests can utilize it and gain access to otherwise hard-to-use protocols such as SMB, RPC, and so on. In most cases, NASL plugin writers do not need to hassle with the inner workings of the NASL language or the inner workings of the wrapper functions because they can call very few functions that handle HTTP traffic without having to know how to open a socket, send out data, or parse HTTP traffic.

Chapter 2

Debugging NASLs

Scripts and samples in this chapter:

- **How to Debug NASLs Using the Runtime Environment**
- **How to Debug NASLs Using the Nessus Daemon Environment**

In This Toolbox

There are two methods of debugging newly created or existing Nessus Attack Scripting Languages (NASLs): one is to use the command-line interpreter, and the other is to run it using the Nessus daemon. Each has its shortcomings; for example, running it using the command-line interpreter doesn't allow to debug any interaction between two tests that might be required, while debugging it using the Nessus daemon requires a longer startup process than simply providing the command-line interpreter with a hostname or IP (Internet Protocol) address and the name of the script to execute.

How to Debug NASLs Using the Runtime Environment

We will begin with debugging via the NASL command-line interpreter, as this method is the easiest to implement and the easiest to utilize. Debugging a NASL script can be composed of two main components; the easier part is testing the validity of the code and the harder part is testing the validity of the vulnerability test itself.

Validity of the Code

Testing the validity of the code (that is, ensuring that the code can be understood by the NASL interpreter) can be done by either running the NASL script with the command-line interpreter accompanied by the option **-p**, which in essence instructs the NASL interpreter to just parse and not execute the code found inside it.

Swiss Army Knife

NASL Reference Guide

NASL is a language of its own, having functions unique to it and sharing similarities with other scripting languages such as Perl and Python. You can learn more about how the NASL language is constructed, the different functions supported by it, and how the language syntax is constructed by reading through the NASL reference guide by Michel Arboi at http://michel.arboi.free.fr/nasl2ref/.

A skilled NASL code writer can utilize the NASL language to do diverse things and even write code sections that he will store inside include files that can be later reused to save on time or even to improve the performance of the Nessus scan process.

The option **-p** only checks to see whether the command syntax is written properly, not whether all the functions are available for execution. For example, suppose you are running the following script:

```
port = get_http_port(default:80);
```

With the NASL interpreter and the **-p** option set, no errors will be returned. An error should have returned, as the get_http_port() function is not part of the NASL; rather, it is an extension provided by the http_func.inc file. To overcome this problem the NASL interpreter comes with another option called **-L**, or *lint*, which does more extended testing.

Running the same script as before with the **-L** option set will result in the following error being shown:

```
[5148](beyondsecurity_sample1.nasl) Undefined function 'get_http_port'
```

The error returned is composed of three components: the number enclosed between the two square brackets is the process number that caused the error; the entry enclosed between the two regular brackets is the name of the script being executed; the third part defines the kind of error that has occurred.

The preceding error can be easily solved by adding the following line:

```
include("http_func.inc");
```

Just prior to the get_http_port() function call, the **-L** option is not able to spot problems that have occurred within functions; rather, it is only able to detect errors that occur within the main program. For example, the following code will come out error free by using both the **-L** option and the **-p** option:

```
function beyondsecurity(num)
{
 port = get_http_port(default:num);
}

beyondsecurity(num:80);
```

This is due to the fact that no calls to the function itself are being preformed by the error discover algorithm. Therefore, to determine whether your script is written properly or not, the best method is to actually run it against the target. We ran the following code against a test candidate that supports port 80 and Web server under that port number:

```
$ nasl -t 127.0.0.1 beyondsecurity_sample2.nasl
[5199](beyondsecurity_sample2.nasl) Undefined function 'get_http_port'
```

As you can see, the NASL interpreter has detected the error we expected it to detect. Some errors are nested and are caused by external files we included. Unfortunately, in those cases the error displayed will be the same as what would be displayed if the code used in the include file was inside the NASL file we wrote.

To demonstrate this we will create two files. The first file is an include file called beyondsecurity_sample3.inc that will contain the following code:

```
function beyondsecurity(num)
{
 port = get_http_port(default:num);
}
```

The second file, a NASL file that will be called beyondsecurity_sample3.nasl, will contain the following code:

```
include("beyondsecurity_sample3.inc");

beyondsecurity(num:80);
```

Running the script via the command-line interpreter with a valid hostname will result in the following error being returned:

```
[5274](beyondsecurity_sample3.nasl) Undefined function 'get_http_port'
```

As you can see, even though the error code should have been displayed in reference to the include file, the NASL language makes no differentiation between the include files and the actual NASL code. This is due to the fact that when an include() directive is present in the NASL code, the entire code present inside the include file is made part of the NASL code and regarded as an integrated part of it.

This can be better seen in action by utilizing the **-T** option. This option tells the NASL interpreter to trace its actions and print them back to either a file or to the standard output. Running the code in the previous example with the trace option set to true will result in the following content being returned by the interpreter:

```
[5286]() NASL> [080812b0] <- 1
[5286]() NASL> [080812e0] <- 0
[5286]() NASL> [08081310] <- 5
[5286]() NASL> [08081348] <- 6
[5286]() NASL> [08081380] <- 17
[5286]() NASL> [080813b8] <- 1
[5286]() NASL> [080813f0] <- 0
[5286]() NASL> [08081420] <- 2
[5286]() NASL> [08081458] <- 1
[5286]() NASL> [08081488] <- 2
[5286]() NASL> [080814c0] <- 3
[5286]() NASL> [080814f8] <- 4
[5286]() NASL> [08081530] <- 5
[5286]() NASL> [08081568] <- 2201
[5286]() NASL> [08081598] <- 1
[5286]() NASL> [080815c8] <- 2
[5286]() NASL> [080815f8] <- 4
[5286]() NASL> [08081628] <- 8
[5286]() NASL> [08081658] <- 16
[5286]() NASL> [08081688] <- 32
[5286]() NASL> [080816b8] <- 32768
[5286]() NASL> [080816e8] <- 16384
[5286]() NASL> [08081718] <- 8192
[5286]() NASL> [08081748] <- 8191
[5286]() NASL> [08081778] <- 0
[5286]() NASL> [080817a8] <- 3
[5286]() NASL> [080817e0] <- 4
[5286]() NASL> [08081810] <- 5
[5286]() NASL> [08081848] <- 6
[5286]() NASL> [08081888] <- 7
```

```
[5286]() NASL> [080818b8] <- 1
[5286]() NASL> [080818f0] <- 2
[5286]() NASL> [08081928] <- 8
[5286]() NASL> [08081960] <- 9
[5286]() NASL> [08081990] <- 10
[5286]() NASL> [080819c0] <- 1
[5286]() NASL> [08081a20] <- 1
[5286]() NASL> [08081a58] <- 0
[5286]() NASL> [08081a90] <- "beyondsecurity_sample3.nasl"
NASL:0003> beyondsecurity(...)
[5286]() NASL> [08081e68] <- 80
[5286](beyondsecurity_sample3.nasl) NASL> Call beyondsecurity(num: 80)
NASL:0003> port=get_http_port(...);
NASL:0003> get_http_port(...)
[5286](beyondsecurity_sample3.nasl) Undefined function 'get_http_port'
[5286]() NASL> [08081d60] <- undef
[5286](beyondsecurity_sample3.nasl) NASL> Return beyondsecurity: FAKE
```

The first parts are not relevant at the moment. What is more interesting is the part where we can actually see the script requesting the function beyondsecurity to be called with the value of 80 for its num parameter. Further, we can see the NASL interpreter looking the function get_http_port and not being able to locate it and consequently returning an error.

By adding to the preceding code the include (http_func.inc) directive and running the NASL trace command again, the following output will be returned (the end of the trace was dropped for simplicity):

```
[5316]() NASL> [08091d88] <- 1
[5316]() NASL> [08091db8] <- 0
[5316]() NASL> [08091de8] <- 5
[5316]() NASL> [08091e20] <- 6
[5316]() NASL> [08091e58] <- 17
[5316]() NASL> [08091e90] <- 1
[5316]() NASL> [08091ec8] <- 0
[5316]() NASL> [08091ef8] <- 2
[5316]() NASL> [08091f30] <- 1
[5316]() NASL> [08091f60] <- 2
[5316]() NASL> [08091f98] <- 3
[5316]() NASL> [08091fd0] <- 4
[5316]() NASL> [08092008] <- 5
[5316]() NASL> [08092040] <- 2201
[5316]() NASL> [08092070] <- 1
[5316]() NASL> [080920a0] <- 2
[5316]() NASL> [080920d0] <- 4
[5316]() NASL> [08092100] <- 8
[5316]() NASL> [08092130] <- 16
[5316]() NASL> [08092160] <- 32
[5316]() NASL> [08092190] <- 32768
[5316]() NASL> [080921c0] <- 16384
[5316]() NASL> [080921f0] <- 8192
[5316]() NASL> [08092220] <- 8191
[5316]() NASL> [08092250] <- 0
[5316]() NASL> [08092280] <- 3
```

```
[5316]() NASL> [080922b8] <- 4
[5316]() NASL> [080922e8] <- 5
[5316]() NASL> [08092320] <- 6
[5316]() NASL> [08092360] <- 7
[5316]() NASL> [08092390] <- 1
[5316]() NASL> [080923c8] <- 2
[5316]() NASL> [08092400] <- 8
[5316]() NASL> [08092438] <- 9
[5316]() NASL> [08092468] <- 10
[5316]() NASL> [08092498] <- 1
[5316]() NASL> [080924f8] <- 1
[5316]() NASL> [08092530] <- 0
[5316]() NASL> [08092568] <- "beyondsecurity_sample3.nasl"
NASL:0003> beyondsecurity(...)
[5316]() NASL> [08092ff0] <- 80
[5316](beyondsecurity_sample3.nasl) NASL> Call beyondsecurity(num: 80)
NASL:0005> port=get_http_port(...);
NASL:0005> get_http_port(...)
[5316](beyondsecurity_sample3.nasl) NASL> [08092ff0] -> 80
[5316]() NASL> [080932f0] <- 80
[5316](beyondsecurity_sample3.nasl) NASL> Call get_http_port(default: 80)
```

Again, the get_http_port function was called, but this time it was located and successfully launched. As pointed out before, there is no reference to get_http_port being part of the http_func.inc file, nor whether the beyondsecurity function is even part of the beyondsecurity_sample3.inc file.

As there is no information about which include file is causing the error, we have to resort to a more basic method of debugging—printing each step we take and determining which one has caused the problem by enclosing it between two printed steps. This kind of debugging method is very basic and very tiresome, as it requires you to either have some clue to where the problem might be stemmed from or to add a lot of redundant code until the culprit is found. To generalize the method you would need to add display() function calls every few lines and before every possible call to an external function. In the end, you would achieve something similar to the following:

```
step 1
step 2
step 3
step 3.1
step 3.2
step 3.3
step 3.1
step 3.2
step 3.3
[3517](beyondsecurity_sample4.nasl) Undefined function 'get_http_port'
step 4
step 5
done
```

All steps are a few lines apart, and a few steps are repeated, as they are inside some form of loop. The output in the preceding example tells us that somewhere between our step 3.3 and step 4 a call to the get_http_port, directly or indirectly via an include file, has been made.

Validity of the Vulnerability Test

Once we have our NASL script up and running and error-free, we can move to a more important part of the debugging stage—determining whether the script you have just written does actually determine the existence or nonexistence of the vulnerability.

There are a few methods you can use to debug your NASL script once the code has been confirmed to be free of coding mistakes: you can print out any variable you desire via the display function or, as an alternative, you can dump the contents of binary data via the dump function provided by the dump.inc file.

In both cases the shortcoming of the two functions is that unless you were the one generating the packet, both functions cannot display what was sent to the host being tested. Such is in the case of SMB, RPC, and others where the infrastructure of Nessus' include files provides the support for the aforementioned protocols.

In the previous two cases, SMB and RPC, your only alternative to Nessus' debugging routines is to do either of the following:

1. Add extensive debugging code to the include files being utilized.
2. Use a sniffer and capture the outgoing and incoming traffic.

As it is no easy feat to add debugging routines to the infrastructure used by the Nessus daemon, the more viable option would be to use a packet sniffer. To demonstrate how a sniffer would provide better debugging results, we will run a simple NASL script that tests the existence of a file inclusion vulnerability:


```
include("http_func.inc");
include("http_keepalive.inc");

debug = 1;

if (debug)
{
 display("First part stats here\n");
}

port = get_http_port(default:80);
if (debug)
{
 display("port: ", port, "\n");
}

if(!get_port_state(port))exit(0);

if (debug)
{
 display("First part ends here\n");
}

function check(loc)
{
```

```
 if (debug)
 {
  display("Second part starts here\n");
 }
 req = http_get (item: string(loc, "/inserter.cgi?/etc/passwd"), port: port);
 if (debug)
 {
  display("Second part ends here\n");
 }

 if (debug)
 {
  display("req: ", req, "\n");
 }

 if (debug)
 {
  display("Third part starts here\n");
 }
 r = http_keepalive_send_recv(port:port, data:req);
 if (debug)
 {
  display("Third part ends here\n");
 }

 if (debug)
 {
  display("r: ", r, "\n");
 }

 if( r == NULL )exit(0);
 if(egrep(pattern:".*root:.*:0:[01]:.*", string:r))
 {
  security_warning(port);
  exit(0);
 }
}

foreach dir (make_list(cgi_dirs()))
{
 if (debug)
 {
  display("dir: ", dir, "\n");
 }
 check(loc:dir);
}
```

Once launched against a vulnerable site, the code in the previous example would return the following results (we are launching it by using the NASL command-line interpreter):

```
$ nasl -t www.example.com inserter_file_inclusion.nasl
** WARNING : packet forgery will not work
** as NASL is not running as root
First part begins here
```

```
[17697] plug_set_key:internal_send(0)['3 Services/www/80/working=1;
']: Socket operation on non-socket
First part ends here
port: 80
dir: /cgi-bin
Second part starts here
Second part ends here
req: GET /cgi-bin/inserter.cgi?/etc/passwd HTTP/1.1
Connection: Close
Host: www.example.com
Pragma: no-cache
User-Agent: Mozilla/4.75 [en] (X11, U; Nessus)
Accept: image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, image/png, */*
Accept-Language: en
Accept-Charset: iso-8859-1,*,utf-8


Third part starts here
[17697] plug_set_key:internal_send(0)['1 www/80/keepalive=yes;
']: Socket operation on non-socket
Third part ends here
res: HTTP/1.1 200 OK
Date: Thu, 28 Apr 2005 09:26:22 GMT
Server: Apache/1.3.35 (Unix) PHP/4.3.3 mod_ssl/2.8.15 OpenSSL/0.9.7b FrontPage/4.0.4.3
Keep-Alive: timeout=15, max=100
Connection: Keep-Alive
Transfer-Encoding: chunked
Content-Type: text/html

<meta></meta>document.writeln('root:x:0:0:root:/root:/bin/bash');
document.writeln('bin:x:1:1:bin:/bin:');
document.writeln('daemon:x:2:2:daemon:/sbin:');
document.writeln('adm:x:3:4:adm:/var/adm:');
document.writeln('lp:x:4:7:lp:/var/spool/lpd:');
document.writeln('sync:x:5:0:sync:/sbin:/bin/sync');
document.writeln('shutdown:x:6:0:shutdown:/sbin:/sbin/shutdown');
document.writeln('halt:x:7:0:halt:/sbin:/sbin/halt');
document.writeln('mail:x:8:12:mail:/var/spool/mail:');
document.writeln('news:x:9:13:news:/var/spool/news:');
document.writeln('uucp:x:10:14:uucp:/var/spool/uucp:');
document.writeln('operator:x:11:0:operator:/root:');
document.writeln('games:x:12:100:games:/usr/games:');
document.writeln('gopher:x:13:30:gopher:/usr/lib/gopher-data:');
document.writeln('ftp:x:14:50:FTP User:/var/ftp:');
document.writeln('nobody:x:99:99:Nobody:/:');



Success
```

Master Craftsman…

Ethereal's Follow TCP Stream

In most cases incoming and outgoing HTTP (Hypertext Transfer Protocol) traffic gets divided into several packets, in which case debugging the data being transferred inside such packets cannot be easily read. To workaround such cases Ethereal has the ability to reconstruct the TCP (Transmission Control Protocol) session and display it in a single window. To enable Ethereal's Follow TCP stream option, all that is required is to capture the relevant packets and right-click on any of the TCP packets in question and select the **Follow TCP stream** option.

By running Ethereal in the background and capturing packets, we would notice the following traffic being generated, some of which will be generated because this is the first time this host is being contacted:

```
GET / HTTP/1.1
Host: www.example.com
(Traffic Capture 1)
```

This is followed by the following traffic:

```
GET / HTTP/1.1
Connection: Keep-Alive
Host: www.example.com
Pragma: no-cache
User-Agent: Mozilla/4.75 [en] (X11, U; Nessus)
(Traffic Capture 2)
```

Finally, the following traffic will be generated:

```
GET /cgi-bin/inserter.cgi?/etc/passwd HTTP/1.1
Connection: Keep-Alive
Host: www.example.com
Pragma: no-cache
User-Agent: Mozilla/4.75 [en] (X11, U; Nessus)
Accept: image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, image/png, */*
Accept-Language: en
Accept-Charset: iso-8859-1,*,utf-8
(Traffic Capture 3)
```

As you might have noticed, there is a lot of traffic being generated behind the scenes. Furthermore, if we compare the traffic capture 3 with the data returned by NASL interpreter for the parameter *req*, we see that one specifies the HTTP connection header setting as *Close*, while the latter specifies it as *Keep-Alive*; therefore, something had to not only do this but also determine whether the remote server even supports a keep-alive state.

To understand a bit more about how a single traffic transfer became three distinguishable data transfers, we need to drill deeper into the Nessus inner workings. We will start with what

appears to be a very simple function call, calling of the get_http_port(default:80) function. This function is responsible for initiating any HTTP traffic being done through the http_func.inc and http_keepalive.inc and not directly to the HTTP socket.

Once the function starts it will try determine whether the port being tested has been previously marked as Services/www, meaning that it supports WWW services. If so, it will return the appropriate port number:

```
port = get_kb_item("Services/www");
if ( port ) return port;
```

If this fails, it will try to determine whether the port provided is marked as broken; that is, not responding, not returning HTTP headers, and so on. If the port is broken the function and the script will exit:

```
p = get_kb_item("Services/www/" + default + "/broken");
if ( p ) exit(0);
```

If this fails and the function continues, the function will try to determine whether the port provided is marked as *working*. Working ports are those ports that can be connected to and that respond to the most basic HTTP traffic. If the port has been flagged as working, the function will return with the provided port number as its result:

```
p = get_kb_item("Services/www/" + default + "/working");
if ( p ) return default;
```

If the previous test has not failed, the function will continue to open a socket against the provided port number; if it fails to do so, it will report the specified port number as broken:

```
soc = http_open_socket(default);
if ( ! soc )
{
 set_kb_item(name:"Services/www/" + default + "/broken", value:1);
 exit(0);
}
```

Once the socket has been opened successfully, we notice that the function constructs an HTTP request, sends it to the socket, and waits for a response:

```
send(socket:soc, data:'GET / HTTP/1.1\r\nHost: ' + get_host_name() + '\r\n\r\n');
r = recv_line(socket:soc, length:4096);
close(soc);
```

As you might recall, we have seen this packet in our Ethereal capture; this sort of traffic is generated for any HTTP port being accessed for the first time, and subsequent requests to this port by the get_http_port function will not go through this, as the port will be marked either being broken or working. The following code will try to determine whether the provided port number is in fact broken by testing whether a response has not been received, that it doesn't look like HTTP traffic, or that it returns an "HTTP Forbidden" response:

```
if ( ! r || "HTTP" >!< r || ( ereg(pattern:"^HTTP.* 403 ", string:r) && (now - then >= 5)
) )
{
```

```
 set_kb_item(name:"Services/www/" + default + "/broken", value:1);
 exit(0);
}
```

If the function hasn't exited, the port has to be a valid one. It is marked as working, and the function returns the port number provided to it as the response:

```
set_kb_item(name:"Services/www/" + default + "/working", value:1);
return default;
```

From the code in the previous example, we have determined one of the traffic patterns captured using the Ethereal sniffer. We are still missing one traffic pattern. We know that the last piece of traffic was requested by us; the second traffic pattern we have captured.

The debugging code has captured the attempt by the NASL interpreter to write the value of keepalive=yes to the knowledge base. Consequently, our best hunch would be that the function http_keepalive_send_recv is the one responsible for generating our mystery traffic.

The function http_keepalive_send_recv is defined inside the http_keepalive.inc file. We will go into greater detail on this function in Chapter 5, but briefly, support for the keep-alive infrastructure has been called up for the first time. The value of __ka_enabled has not yet been set to any value but –1, which tells the keep-alive infrastructure it has no knowledge of whether the keep-alive mechanism is supported by the remote host.

Therefore, once the http_keepalive_send_recv is called, the http_keepalive_enabled function is called:

```
if(__ka_enabled == -1) __ka_enabled = http_keepalive_enabled(port:port);
```

As mentioned before, the role of the http_keepalive_enabled function is to determine whether the remote Web server supports keep-alive traffic by sending a Keep-Alive request to the server:

```
req = string("GET / HTTP/1.1\r\n",
"Connection: Keep-Alive\r\n",
"Host: ", get_host_name(), "\r\n",
"Pragma: no-cache\r\n",
"User-Agent: Mozilla/4.75 [en] (X11, U; Nessus)\r\n\r\n");

soc = http_open_socket(port);
if(!soc)return -2;
send(socket:soc, data:req);
r = http_recv(socket:soc);
```

By processing the response returned by the server, the function can determine whether the remote host supports keep-alive communication. There are two main types of keep-alive implementations. In the case of Apache-like servers the response will contain a keep-alive header line. In the case of IIS-like servers the response does not contain the keep-alive header. We can therefore determine that the remote server supports the keep-alive function by sending the previous request without reopening the previously opened socket and determining whether a response has been returned. Only IIS implementations would respond to the second request.

Swiss Army Knife…

HTTP Keep-Alive

Keep-alive support has been added to the HTTP protocol in version 1.1. The keep-alive mechanism's main objective is to reduce the number of open sockets between a browser and a server. You can learn more about the HTTP keep-alive mechanism by reading through RFC 2068 at www.faqs.org/rfcs/rfc2068.html.

Utilizing the HTTP keep-alive interface implemented by the http_keepalive.inc file will allow any Web-based test to work faster and to greatly reduce the amount of bandwidth utilized, as fewer sockets are opened and fewer packets are sent between the testing host and tested host.

The following code implements this concept:

```
# Apache-Like implementation
if(egrep(pattern:"^Keep-Alive:.*", string:r))
{
 http_close_socket(soc);
 set_kb_item(name:string("www/", port, "/keepalive"), value:"yes");
 enable_keepalive(port:port);
 return(1);
}
else
{
 # IIS-Like Implementation
 send(socket:soc, data:req);
 r = http_recv(socket:soc);
 http_close_socket(soc);
 if(strlen(r))
 {
  set_kb_item(name:string("www/", port, "/keepalive"), value:"yes");
  enable_keepalive(port:port);
  return(1);
 }
}
```

Master Craftsman…

Improving the HTTP Keep-Alive Detection Mechanism

The keep-alive detection mechanism is unable to detect IIS Web servers that support the keep-alive mechanism, but close the socket connected that connected to it unless the authentication mechanism has been satisfied, such as in the case where NTLM (NT LAN Manager) authentication has been enabled on the remote IIS server.

You probably noticed that the packet generated in the previous example is exactly the packet we have captured using Ethereal. As you have just seen, adding debugging code to NASL for debugging purposes is a good idea. However, it doesn't always reveal everything about what NASL is doing, as some code used by the NASL interpreter utilizes sockets and generates traffic of its own.

How to Debug NASLs Using the Nessus Daemon Environment

In some cases it is impossible to use the NASL interpreter to debug the scripts. This is especially true in those cases where a complex system of test dependencies is in place. In these cases the only option to debug the NASL is to generate debugging code that will be later gathered from Nessus daemon's debug log.

The log file to which the Nessus daemon writes is configured in the nessusd.conf file. By pointing the value of logfile to a file you desire, you can instruct the Nessus daemon where to create the log file. In most cases when Nessus is stored under the /usr/local/ directory the log file is stored under the /usr/local/var/nessus/logs/ directory.

The content of the Nessus daemon log file is called nessusd.dump. It contains all the output returned by the different tests, including errors and display function calls. Unlike when you use the NASL interpreter and immediately see the debug commands you have used, the log files do not list which NASL script produced the content you are seeing. The only exception to this is that when errors are listed, they are accompanied by the process id number, the filename, and the error that has occurred.

Final Touches

You have learned two ways of debugging your newly written or existing NASLs. Further, you have seen that there is more than one approach where external tools such as packet sniffers are utilized to determine the type of traffic traversing the medium between the Nessus daemon and the tested host. You have also seen a glimpse of the way Nessus communicates with a remote Web server and how it detects Web servers that support keep-alive.

Chapter 3

Extensions and Custom Tests

Scripts and samples in this chapter:

- **Extending NASL Using Include Files**
- **Extending the Capabilities of Tests Using the Nessus Knowledge Base**
- **Extending the Capabilities of Tests Using Process Launching and Results Analysis**

In This Toolbox

Most of the security vulnerabilities being discovered utilize the same attack vectors. These attack vectors can be rewritten in each NASL (Nessus Attack Scripting Language) or can be written once using an *include* file that is referenced in different NASLs. The include files provided with the Nessus environment give an interface to protocols such as Server Message Block (SMB) and Remote Procedure Call (RPC) that are too complex to be written in a single NASL, or should not be written in more than one NASL file.

Extending NASL Using Include Files

The Nessus NASL language provides only the most basic needs for the tests written with it. This includes socket connectivity, string manipulation function, Nessus knowledge base accessibility, and so on.

Much of the functionality used by tests such as SMB, SSH (Secure Shell), and extended HTTP (Hypertext Transfer Protocol) connectivity were written externally using include files. This is due to two main reasons. First, building them within Nesuss's NASL language implementation would require the user wanting to change the functionality of any of the extended function to recompile the Nessus NASL interpreter. On the other hand, providing them through external include files minimizes the memory footprint of tests that do not require the extended functionality provided by these files.

Include Files

As of April 2005, there were 38 include files. These include files provide functionality for:

- AIX, Debian, FreeBSD, HPUX, Mandrake, Red Hat, and Solaris local security patch conformance
- Account verification methods
- NASL debugging routines
- FTP, IMAP, Kerberos, NetOP, NFS, NNTP, POP3, SMB, SMTP, SSH, SSL, Telnet, and TFTP connectivity
- Extended HTTP (keep-alive, banners, etcetera)
- Cisco security compliance checks
- Nessus global settings
- Base64 encoding functions
- Miscellaneous related functions
- Test backporting-related functions
- Cryptographic-related functions
- NetOP connectivity
- Extended network functions

- Ping Pong denial-of-service testing functions
- Windows compliance testing functions

The aforementioned include files are very extensive and in most cases can provide any functionality your test would require. However, in some cases, new include files are needed, but before you start writing a new include file, you should understand the difference between an include file and a test. Once you understand this point, you can more easily decide whether a new include file is necessary or not.

Include files are portions of NASL code shared by one ore more tests, making it possible to not write the same code more than once. In addition, include files can be used to provide a single interface to a defined set of function calls. Unlike NASLs, include files do not include either a script_id or a description. Furthermore, they are not loaded until they are called through the include() directive, unlike NASLs, which are launched whenever the Nessus daemon is restarted.

In every occasion where a NASL calls upon the same include file, a copy of the include file is read from the disk and loaded into the memory. Once that NASL has exited and no other NASL is using the same include file, the include file is removed from the memory.

Before providing an example we will give some background on the include file we are going to build. One of the many tests Nessus does is to try to determine whether a certain server contains a server-side script, also known as CGI (Common Gateway Interface) and whether this script is vulnerable to cross-site scripting. More than two hundred tests do practically all the following steps with minor differences:

- Determine which ports support HTTP, such as Web traffic.
- Determine whether the port in question is still open.
- Depending on the type of server-side script, test whether it is supported. For example, for PHP (Hypertext Preprocessor)-based server-side scripts, determine whether the remote host supports PHP scripts.
- Determine whether the remote host is generically vulnerable to cross-site scripting; that is, any cross-site scripting attack would succeed regardless of whether the script exists or not on the remote host.
- Try a list of possible directories where the script might be found.
- Try a list of possible filenames for the script.
- Construct the attack vector using some injection script code, in most cases %3cscript%3ealert('foobar')%3c/script%3e.
- Try to use the attack vector on each of the directories and filename combination.
- Return success if <script>alert('foobar')</script> has been found.

The aforementioned steps are part of a classic include file; further parts of the aforementioned code are already provided inside include files (for example, the functionality of connecting to the remote host using keep-alive, determining whether the remote host supports PHP, and so on).

We can break the aforementioned steps into a single function and include it in an include file, and then modify any existing tests to use it instead of using their current code. We will start off with the original code:


```
#
# Script by Noam Rathaus of Beyond Security Ltd. <noamr@beyondsecurity.com>
include("http_func.inc");
include("http_keepalive.inc");

port = get_http_port(default:80);

if(!get_port_state(port))exit(0);
if(!can_host_php(port:port))exit(0);
if (get_kb_item(string("www/", port, "/generic_xss"))) exit(0);

function check(loc)
{
 req = http_get(item: string(loc,
"/calendar_scheduler.php?start=%22%3E%3Cscript%3Ealert(document.cookie)%3C/script%3E"),
port:port);

 r = http_keepalive_send_recv(port:port, data:req);

 if( r == NULL )exit(0);
 if('<script>alert(document.cookie)</script>"' >< r)
 {
  security_warning(port);
  exit(0);
 }
}

foreach dir (make_list("/phpbb", cgi_dirs()))
{
 check(loc:dir);
}
```

The script in the previous example can be easily converted to the following more generic code. The following parameters will hold the attack vector that we will use to detect the presence of the vulnerability:

```
attack_vector_encoded = "%3Cscript%3Ealert('foobar')%3C/script%3E";
attack_vector = "<script>alert('foobar')</script>";
```

The function we will construct will receive the values as parameters:

```
function test_xss(port, directory_list, filename, other_parameters, inject_parameter)
{
```

As before, we will first determine whether the port is open:

```
 if(!get_port_state(port))exit(0);
```

Next, we will determine whether the server is prone to cross-site scripting, regardless of which CGI is attacked:

```
if(get_kb_item(string("www/", port, "/generic_xss"))) exit(0);
```

We will also determine whether it supports PHP if the filename provided ends with a PHP-related extension:

```
if (egrep(pattern:"(.php(3?))|(.phtml)$", string:filename, icase:1))
{
 if(!can_host_php(port:port))exit(0);
}
```

Next we will determine whether it supports ASP (Active Server Pages), if the filename provided ends with an ASP-related extension:

```
if (egrep(pattern:".asp(x?)$", string:filename, icase:1))
{
 if(!can_host_asp(port:port))exit(0);
}
```

Then for each of the directories provided in the directory_list parameter, we generate a request with the directory, filename, other_parameters, inject_parameter, and attack_vector_encoded:

```
foreach directory (directory_list)
{
req = http_get(item:string(directory, filename, "?", other_parameters, "&",
inject_parameter, "=", attack_vector_encoded), port:port);
```

We then send it off to the server and analyze the response. If the response includes the attack_vector, we return a warning; otherwise, we continue to the next directory:

```
res = http_keepalive_send_recv(port:port, data:req, bodyonly:1);
if( res == NULL ) exit(0);
if( egrep(pattern:attack_vector, string:res) ){
       security_warning(port);
       exit(0);
}
```

If we have called the aforementioned function test_xss and the file in which it is stored xss.inc, the original code will now look like:

```
#
# Script by Noam Rathaus of Beyond Security Ltd. <noamr@beyondsecurity.com>
include("xss.inc");

port = get_kb_item("Services/www");
if(!port)port = 80;
```

The filename parameter will list the filename of the vulnerable script:

```
filename = "vulnerablescript.php";
```

This directory_list parameter will house a list of paths we will use as the location where the filename might be housed under:

```
directory_list = make_list( "/phpbb", cgi_dirs());
```

Under the other_parameters value we will store all the required name and value combinations that are not relevant to the attack:

```
other_parameters = "id=1&username=a";
```

Under the inject_parameter value, we will store the name of the vulnerable parameter:

```
inject_parameter = "password";
```

Finally, we will call up the new test_xss function:

```
test_xss(port, port, directory_list, filename, other_parameters, inject_parameter);
```

Swiss Army Knife…

Testing for Other Vulnerabilities

The code in the previous example verifies whether the remote host is vulnerable to cross-site scripting. The same code can be extended to test for other types of Web-based security vulnerabilities. For example, we can test for SQL injection vulnerabilities by modifying the tested attack_vector with an SQL injecting attack vector and modifying the tested response for SQL injected responses.

Repeating this procedure for more than 200 existing tests will reduce the tests' complexity to very few lines for each of them, not to mention that this will make the testing more standardized and easier to implement.

For an additional example see Chapter 5, where we discuss how one of the commonly used functions, GetFileVersion(), can be improved to provide faster response time and save on network resources. The GetFileVersion() function can either be placed in every NASL we want the improved version to be present at, or we can replace the original GetFileVersion() found in the smb_nt.inc include file. In the first case, one or more NASLs will use the new GetFileVersion() function, while in the second case, roughly 20 tests will use the new version, as they all include the same smb_nt.inc include file.

Extending the Capabilities of Tests Using the Nessus Knowledge Base

The Nessus daemon utilizes a database to store information that may be useful for one or more tests. This database is called the *knowledge base*. The knowledge base is a connected list-style database, where a *father* element has one or more *child* elements, which in turn may have additional child elements.

For example, some of the most commonly used knowledge base items are the SMB-related items, more specifically the registry-related SMB items. These are stored under the following hierarchy: SMB/Registry/HKLM/. Each item in this hierarchy will correspond to some part of

the registry. For example, the registry location of HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\W3SVC and the value of ImagePath are stored in the knowledge base under the SMB/Registry/HKLM/SYSTEM/CurrentControlSet/Services/W3SVC/ImagePath key.

Swiss Army Knife…

Storing More of the Registry in the Knowledge Base

Some parts of the Windows registry are stored inside the Nessus knowledge base. While other parts of the registry are accessed by different NASLs tests, these repeated registry accesses are both bandwidth and time consuming.

Registry reading and storing should be done in one centralized NASL and latter accessed only through the knowledge base. As most of Nessus' current registry reading is done in smb_hotfixes.nasl, any additional registry reading and storing should be added in it.

The entire registry tree is not mapped to the knowledge base; rather, essential parts of it are mapped smb_hotfixes.nasl, which uses RPC-based functionality to access the registry and requires administrative privileges or equivalent on the remote machine.

Once the values are there, the majority of NASLs that require information from the registry no longer access the registry to determine whether the test is relevant or not; rather, they access the knowledge base.

A good example of a set of NASLs is the smb_nt_msXX-XXX.nasl tests. Each of these tests utilizes the functions provided by smb_hotfixes.inc to determine whether a hotfix and service pack were installed on the remote machine, and if not, report a vulnerability. The functionally provided by smb_hotfixes.inc enumerates beforehand all the installed hotfixes and service packs, and can perform a simple regular expression search on the knowledge base to determine whether the patch has been installed or not.

The same method of collaborating information between two NASLs, as in the case of smb_hotfixes.nasl and the different smb_nt_msXX-XXX.nasl, can be done by your own tests. One very relevant case is when a certain type of product is found to be present on the remote machine, and this information can be stored in the knowledge base with any other information such as the product's banner. Therefore, if in the future any additional tests require the same information, network traffic can be spared and the knowledge base can be queried instead.

Extending the Capabilities of Tests Using Process Launching and Results Analysis

Nessus 2.1.0 introduced a mechanism that allows certain scripts to run more sensitive functions that would allow such things as the retrieval of locally stored files, execution of arbitrary commands, and so on.

Because these functions can be used maliciously by a normal user through the Nessus daemon to gain elevated privileges on the host running Nessus, they have been restricted to those scripts that are trusted/authenticated. Each test that has a line that starts with #TRUSTED, which will be checked to determine whether it is actually tested by taking the string that follows the #TRUSTED mark and verifying the signature found there with the public key provided with each installation of Nessus. The public key is stored in a file called nessus_org.pem. The nessus_org.pem file holds just the RSA public key, which can be used to verify the authenticity of the scripts, but not the RSA private key, which can be used to sign additional scripts and make them authenticated.

As authenticated scripts can be used for numerous tasks that cannot be carried out unless they are authenticated, the only method to allow creation of additional authenticated scripts is by adding to the nessusd.conf file the directive nasl_no_signature_check with the value of **yes**.

The change to nessusd.conf allows the creation of authenticated scripts. However, an alternative such as replacing the public key can also be considered. In both cases either of the following two problems may arise: First, Nessus.org signed tests may be no longer usable until you re-sign them with your own public/private key combinations. Second, arbitrary scripts may have been planted in www.nessus.org's host by a malicious attacker who compromised the host. Such a malicious script would be blindly executed by the Nessus daemon and in turn could be used to cause harm to the host running Nessus or to the network upon which this test is being launched.

Even though the latter option is more dangerous, we believe it is easier to do and maintain because it requires a single change in the Nessus configuration file to enable, whereas the first option requires constant maintenance every time an authenticated script changes.

What Can We Do with TRUSTED Functions?

The script_get_preference_file_content function allows authenticated scripts to read files stored in the Nessus daemon's file system. This function is executed under root privileges and the user running the Nessus client doesn't have to be a root user, so this function has the potential to read files that might allow the user to compromise the machine. Thus, the function cannot be accessed by unauthenticated scripts.

The script_get_preference_file_location function allows authenticated scripts to retrieve a file's preference location from the user. This function by itself poses no security problem because it does nothing other than get the string of the filename. This function is used in conjunction with the script_get_preference_file_content function, which requires authentication, and thus, the script_get_preference_file_location function is deemed allowed by authenticated functions only.

Nessus uses the shared_socket_register, shared_socket_acquire, and shared_socket_release functions to allow different types of scripts to use the same existing socket for its ongoing communication. Unlike Nessus's keep-alive support, which isn't essential, the support for shared sockets is essential for such connections as SSH because repeatedly disconnecting from, reconnecting to, and authenticating with the SSH server would cause some stress to the SSH server and could potentially hinder the tests that rely on the results returned by the SSH connection.

The same_host function allows a script to compare two provided strings containing either a qualified hostname or a dotted IP (Internet Protocol) address. The same_host function determines whether they are the same by translating both strings to their dotted IP form and comparing them.

The function has no use for normal tests, so you can't control the hostname or IP you test; rather, the test can test only a single IP address that it was launched against. This function has been made to require authentication, as it could be used to send packets to a third-party host using the DNS server.

pem_to and rsa_sign are two cryptographic functions that require authentication. The functions utilize the SSL library's PEM_read_bio_RSAPrivateKey/PEM_read_bio_DSAPrivateKey and RSA_sign functions, respectively. The first two functions allow for reading a PEM (Privacy Enhanced Mail) and extracting from inside of it the RSA private key or the DSA private key. The second function allows RSA to sign a provided block of data. These functions are required in the case where a public/private authentication mechanism is requested for the SSH traffic generated between the SSH client and SSH server.

The dsa_do_sign function utilizes the SSL's library DSA_do_verify function. The DSA_do_verify function confirms the validity of cryptographically signed content. The dsa_do_sign function is used by the ssh_func.inc include file to determine whether the traffic being received from the remote host is trustworthy. The same function is used in the dropbear_ssh.nasl test to determine the existence of a Dropbear SSH based Trojan as it has a special cryptographic signature.

The pread function allows NASL scripts to execute a command-line program and retrieve the standard output returned by the program. The aforementioned list of NASLs utilizes the function to execute the different programs and take the content returned by the pread function and analyze it for interesting results.

The find_in_path function allows Nessus to determine whether the program being requested for execution is in fact available; that is, in the path provided to the Nessus daemon for execution.

The get_tmp_dir function allows the NASL interpreter to determine which path on the remote host is used as a temporary storage location.

The fwrite, fread, unlink, file_stat, file_open, file_close, file_read, file_write, and file_seek functions allow the NASL scripts to perform local file manipulation, including writing, reading, deleting, checking the status of files, and jumping to a specific location inside a file.

Creating a TRUSTED Test

As a demonstration of how trusted tests can be used to build custom tests that can do more than just probe external ports for vulnerabilities, we have decided to build a ps scanner. For those who are not familiar with ps, it is a program that reports back to the user the status of the processes currently running on the machine.

If we take it a step further, by analyzing from a remote location the list retrieved using this command, an administrator can easily determine which hosts are currently running a certain process, such as tcpdump, ethereal, or even nessus, which in turn might be disallowed by the company policy.

To maintain simplicity we will explain how such a test is created that is only compatible with UNIX or more specifically with Linux's ps command-line program. The test can be easily extended to allow enumeration of running processes via a ps-like tool, such as PsList, which is available from www.sysinternals.com/ntw2k/freeware/pslist.shtml.

```
#
# This script was written by Noam Rathaus of Beyond Security Ltd.
<noamr@beyondsecurity.com>
#
# GPL
#
```

First we need to confirm that our NASL environment supports the function *pread*. If it does not, we need to exit, or any subsequent function calls will be useless, and might also cause false positives:

```
if ( ! defined_func("pread") ) exit(0);
```

We then define how our test is called, as well as its version and description. You might have noticed that the following code does not define a script_id(); this is intentional because only the maintainers of Nessus can provide you with a unique script_id number. However, if you do not provide this number, the Nessus daemon will refuse to load the script; instead the Nessus maintainers provide the code with a script_id that wouldn't be used by any future scripts, thus preventing collisions. For example, script_id 90001:


```
if(description)
{
 script_id();
 script_version ("1.0");
 name["english"] = "Ps 'scanner'";
 script_name(english:name["english"]);

 desc["english"] = "
This plug-in runs ps on the remote machine to retrieve a list of active processes. You can
also run a regular expression match on the results retrieved to try and detect malicious
or illegal programs.
See the section 'plugins options' to configure it.

Risk factor : None";

 script_description(english:desc["english"]);

 summary["english"] = "Find running processes with ps";
 script_summary(english:summary["english"]);

 script_category(ACT_SCANNER);

 script_copyright(english:"This script is Copyright (C) 2005 Noam Rathaus");
 family["english"] = "Misc.";
 script_family(english:family["english"]);
```

To provide an interface between the Nessus GUI (graphical user interface) and the test, we will tell the Nessus daemon that we are interested in users being able to configure one of my parameters, Alert if the following process names are found (regular expression), which in turn will make the Nessus GUI show an edit box configuration setting under the **Plugin Settings** tab. The following code and additional scripts discussed in this section are available on the Syngress Web site:

```
 script_add_preference(name: "Alert if the following process names are found (Regular
expression)", type: "entry", value: ".*");
```

Our test requires two things to run—a live host and SSH connectivity, so we need to highlight that we are dependent on them by using the following dependency directive:

```
 script_dependencies("ping_host.nasl", "ssh_settings.nasl");
 exit(0);
}
```

The functions required to execute SSH-based commands can be found inside the ssh_func.inc file; therefore, we need to include them.

```
include("ssh_func.inc");

buf = "";
```

If we are running this test on the local machine, we can just run the command without having to establish an SSH connection. This has two advantages, the first making it very easy to debug the test we are about to write, and the second is that no SSH environment is required, thus we can save on computer and network resources.

```
if (islocalhost())
```

In those cases where we are running the test locally, we can call the *pread* function, which receives two parameters—the command being called and the list of arguments. UNIX's style of executing programs requires that the command being executed be provided as the first argument of the argument list:

```
  buf = pread(cmd: "ps", argv: make_list("ps", "axje"));
```

Master Craftsman…

Rogue Process Detection

Rogue processes such as backdoors or Trojan horses, have become the number one threat of today's corporate environment. However, executing the ps process might not be a good idea if the remote host has been compromised, as the values returned by the ps process might be incorrect or misleading.

A better approach would be to read the content of the /proc directory, which contains the raw data that is later processed and returned in nicer form by the ps program.

We need to remember that if we use the pread function to call a program that does not return, the function pread will not return either. Therefore, it is important to call the program with those parameters that will ensure the fastest possible execution time on the program.

A very good example of this is the time it takes to run the *netstat* command in comparison with running the command **netstat -n**. The directive -n instructs netstat not to resolve any of the IPs it has, thus cutting back on the time it takes the command to return.

If we are not running locally, we need to initiate the SSH environment. This is done by calling the function ssh_login_or_reuse_connection, which will use an existing SSH connection to carry on any command execution we desire. If that isn't possible, it will open a new connection and then carry on any command we desire.

```
else
{
 sock = ssh_login_or_reuse_connection();
 if (! sock)  exit(0);
```

Once the connection has been established, we can call the same command we just wrote for the local test, but we provide it via a different function, in this case the function ssh_cmd. This function receives three parameters—SSH socket, command to execute, and the time-out for the command. The last parameter is very important because tests that take too long to complete are stopped by the Nessus daemon. We want to prevent such cases by providing a timeout setting:

```
 buf = ssh_cmd(socket:sock, cmd:"ps axje", timeout:60);
```

Once the command has been sent and a response has been received or a timeout has occurred, we can close the SSH connection:

```
 ssh_close_connection();
```

If the ssh_cmd function returned nothing, we terminate the test:

```
 if (! buf) { display("could not send command\n"); exit(0); }
}
```

In most cases, buffers returned by command-line programs can be processed line by line; in the case of the ps command the same rule applies. This means that we can split our incoming buffer into lines by using the split function, which takes a buffer and breaks it down into an array of lines by making each entry in the array a single line received from the buffer:

```
lines = split(buf);
```

Using the max_index function, we can determine how many lines have been retrieved from the buffer we received:

```
n = max_index(lines);
```

If the number of lines is equal to zero, it means that there is a single line in the buffer, and we need to modify the value of n to compensate:

```
if (n == 0) n = 1;
```

We will use the **i** variable to count the number of lines we have processed so far:

```
i = 0;
```

Because some interaction with the Nessus daemon that will also trickle down to the Nessus GUI is always a good idea, we inform the GUI that we are going to start scanning the response we received to the ps command by issuing the scanner_status function. The scanner_status function receives two parameters: first, a number smaller than or equal to the total number stating what is the current status and second, another number stating the total that we will reach.

Because we just started, we will tell the Nessus daemon that we are at position 0 and we have n entries to go:

```
scanner_status(current: 0, total: n);
```

The matched parameter will store all the ps lines that have matched the user provided regular expression string:

```
matched = "";
```

The script_get_preference will return the regular expression requested by the user that will be matched against the buffer returned by the ps command. The default value provided for this entry, .*, will match all lines in the buffer:

```
check = script_get_preference("Alert if the following process names are found (Regular
expression)");

foreach line (lines)
{
 #          1         2         3         4         5         6         7
 #01234567890123456789012345678901234567890123456789012345678901234567890
 # 12345 12345 12345 12345 12345678 12345 123456 123 123456 ...
 #  PPID   PID  PGID   SID TTY      TPGID STAT   UID   TIME COMMAND
 #     0     1     0     0 ?           -1 S        0   0:05 init [2]
 # 22935 22936 11983 24059 pts/132  24564 S        0   0:00 /bin/bash /etc/init.d/xprint
restart
 #     3 14751     0     0 ?           -1 S        0   0:00 [pdflush]

 if (debug) display("line: ", line, "\n");
```

As the ps command returns values in predefined locations, we will utilize the substr function to retrieve the content found in each of the positions:

```
 PPID = substr(line, 0, 4);
 PID = substr(line, 5, 10);
 PGID = substr(line, 11, 16);
 SID = substr(line, 17, 22);
 TTY = substr(line, 24, 31);
 TPGID = substr(line, 33, 37);
 STAT = substr(line, 39, 44);
 UID = substr(line, 46, 48);
 TIME = substr(line, 50, 55);

 left = strlen(line)-2;
 COMMAND = substr(line, 57, left);

 if (debug) display("PPID: [", PPID, "], PID: [", PID, "] PGID: [", PGID, "] SID: [", SID,
"] TTY: [", TTY, "]\n");
 if (debug) display("COMMAND: [", COMMAND, "]\n");
```

Once we have all the data, we can execute the regular expression:

```
 v = eregmatch(pattern:check, string:COMMAND);
```

Next we test whether it has matched anything:

```
 if (!isnull(v))
 {
```

If it has matched, append the content of the COMMAND variable to our matched variable:

```
  matched = string(matched, "cmd: ", COMMAND, "\n");
  if (debug) display("Yurika on:\n", COMMAND, "\n");
 }
```

Master Craftsman…

Advance Rogue Process Detection

The sample code can be easily extended to include the execution of such programs as md5sum, a program that returns the MD5 value of the remote file, to better determine whether a certain program is allowed to be executed. This is especially true for those cases where a user knows you are looking for a certain program's name and might try to hide it by changing the file's name. Conversely, the user might be unintentionally using a suspicious program name that is falsely detected.

As before, to make the test nicer looking, we will increment the i counter by one, and update location using the scanner_status function:

```
 scanner_status(current: i++, total: n);
}
```

If we have matched at least one line, we will return it using the security_note function:

```
if (matched)
{
 security_note(port:0, data:matched);
}
```

Once we have completed running the test, we can inform the GUI that we are done by moving the location to the end using the following line:

```
scanner_status(current: n, total: n);
exit(0);
```

Final Touches

You have learned how to extend the NASL language and the Nessus environment to support more advance functionality. You have also learned how to use the knowledge base to improve both the accuracy of tests and the time they take to return whether a remote host is vulnerable or not. You also now know how to create advanced tests that utilize advanced Nessus functions, such as those that allow the execution of processes on a remote host, and how to gather the results returned by those processes.

Chapter 4

Understanding the Extended Capabilities of the Nessus Environment

Solutions in this chapter:

- **Windows Testing Functionality Provided by the smb_nt.inc Include File**
- **Windows Testing Functionality Provided by the smb_hotfixes.inc Include File**
- **UNIX Testing Functionality Provided by the Local Testing Include Files**

In This Toolbox

Some of the more advanced functions that Nessus' include files provide allow a user to write more than just banner comparison or service detection tests; they also allow users to very easily utilize Windows' internal functions to determine whether a certain Windows service pack or hotfix has been installed on a remote machine, or even whether a certain UNIX patch has been installed.

This chapter covers Nessus' include files implementation of the SMB (Server Message Block) protocol, followed by Nessus' include files implementation of Windows-related hotfix and service pack verification. This chapter also addresses how a similar kind of hotfix and service pack verification can be done for different UNIX flavors by utilizing the relevant include files.

Windows Testing Functionality Provided by the smb_nt.inc Include File

Nessus can connect to a remote Windows machine by utilizing Microsoft's SMB protocol. Once SMB connectivity has been established, many types of functionality can be implemented, including the ability to query the remote host's service list, connect to file shares and open files that reside under it, access the remote host's registry, and determine user and group lists.

Swiss Army Knife

SMB Protocol Description

SMB (Server Message Block), aka CIFS (Common Internet File System), is an intricate protocol used for sharing files, printers, and general-purpose communications via pipes. Contrary to popular belief, Microsoft did not create SMB; rather, in 1985 IBM published the earliest paper describing the SMB protocol. Back then, the SMB protocol was referred to as the IBM PC Network SMB Protocol. Microsoft adopted the protocol later and extended it to what it looks like today. You can learn more on the SMB protocol and its history at http://samba.anu.edu.au/cifs/docs/what-is-smb.html.

In the following list of all the different functions provided by the smb_nt.inc file, some of the functions replace or provide a wrapper to the functions found in smb_nt.inc:

- **kb_smb_name** Returns the SMB hostname stored in the knowledge base; if none is defined, the IP (Internet Protocol) address of the machine is returned.
- **kb_smb_domain** Returns the SMB domain name stored in the knowledge base.
- **kb_smb_login** Returns the SMB username stored in the knowledge base.
- **kb_smb_password** Returns the SMB password stored in the knowledge base.

- **kb_smb_transport** Returns the port on the remote host that supports SMB traffic (either 139 or 445).
- **unicode** Converts a provided string to its unicode representation by appending for each of the provided characters in the original string a NULL character.

The following functions do not require any kind of initialization before being called. They take care of opening a socket to port 139 or 445 and logging in to the remote server. The registry functions automatically connect to \winreg and open HKLM, whereas smb_file_read() connects to the appropriate share to read the files.

- **registry_key_exists** Returns if the provided key is found under the HKEY_LOCAL_MACHINE registry hive. For example: if (registry_key_exists(key:"SOFTWARE\Microsoft")).
- **registry_get_sz** Returns the value of the item found under the HKEY_LOCAL_MACHINE registry hive. For example, the following will return the CSDVersion item's value found under the HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows NT\CurrentVersion registyr location:

```
 service_pack = registry_get_sz(key:"SOFTWARE\Microsoft\Windows
NT\CurrentVersion", item:"CSDVersion");
```

- **smb_file_read** Returns the *n* number of bytes found at the specified offset of the provided filename. For example, the following will return the first 4096 bytes of the boot.ini file:

```
data = smb_file_read(file:"C:\boot.ini", offset:0, count:4096);
```

To use the following lower-level functions, you need to set up a socket to the appropriate host and log in to the remote host:

- **smb_session_request** Returns a session object when it is provided with a socket and a NetBIOS name. The smb_session_request function sends a NetBIOS SESSION REQUEST message to the remote host. The NetBIOS name is stored in the Nessus knowledge base and can be retrieved by issuing a call to the kb_smb_name() function. The function also receives an optional argument called *transport*, which defines the port that the socket is connected to. If the socket is connected to port 445, then this function does nothing. If it's connected to port 139, a NetBIOS message is sent, and this function returns an unparsed message from the remote host.
- **smb_neg_prot** Returns the negotiated response when it is provided with a socket. This function negotiates an authentication protocol with the remote host and returns a blob to be used with smb_session_setup() or NULL upon failure.
- **smb_session_setup** Returns a session object when it is provided with a socket, login name, login password, and the object returned by the smb_neg_prot. This function logs in to the remote host and returns NULL upon failure (could not log in) or a blob to be used with session_extract_uid().

- **session_extract_uid** Returns the UID (user identifier) from the session object response. This function extracts the UID sent by the remote server after a successful login. The UID is needed in all the subsequent SMB functions.
- **smb_tconx** Returns a session context when it is provided with a socket, NetBIOS name, unique identifier, and a share name. This function can be used to connect to IPC$ (Inter Process Connection) or to any physical share on the remote host. It returns a blob to use with smb_tconx_extract_tid() upon success or NULL if it's not possible to connect to the remote share. For example, the following line will try to connect to the remote host's IPC$:

```
if ( smb_tconx(soc:socket, name:kb_smb_name(), uid:my_uid, share:"IPC$") == NULL
) exit(0);
```

- **smb_tconx_extract_tid** Returns the TID (tree id) from the session context reply.
- **smbntcreatex** Returns the session context when it is provided with a socket, user id, tree id, and name. This function connects to a named pipe (such as \winreg). It returns NULL on failure or a blob suitable to be used by smbntcreatex_extract_pipe().
- **smbntcreatex_extract_pipe** Returns the pipe id from the session context returned by smbntcreatex().
- **pipe_accessible_registry** Returns either NULL if it has failed or non-NULL if it has succeeded in connecting to the pipe when it is provided with a socket, user id, tree id, and pipe name. This function binds to the winreg MSRPC service and returns NULL if binding failed, or non-null if you could connect to the service successfully.
- **registry_open_hklm, registry_open_hkcu, registry_open_hkcr** Returns the equivalent to the MSDN's RegConnectRegistry() when its provided with a socket, user id, tree id, and a pipe name. The return value is suitable to be used by registry_get_key().
- **registry_get_key** Returns the MSDN's RegOpenKey() when it is provided with a socket, user id, tree id, pipe name, key name, and the response returned by one of the registry_open_hk* functions. The return value is suitable to be used by registry_get_key_item*() functions.
- **registry_get_item_sz** Returns the string object found under the provided registry key when it is provided with a socket, user id, tree id, pipe name, item name, and the response returned by the registry_get_key function. The return value needs to be processed by the registry_decode_sz() function.
- **registry_decode_sz** Returns the string content when it is provided with the reply returned by the registry_get_item_sz function.

The following functions are not used in any script, but could be useful to clean up a computer filled with spyware:

- **registry_delete_key** Deletes the specified registry key when it is provided with a socket, user id, pipe name, key name, and the response returned by the registry_open_hk* functions.
- **registry_delete_value** Deletes the specified registry key value when it is provided with a socket, user id, pipe name, key name, the response returned by the registry_open_hk* functions, and the name of the value to delete.
- **registry_shutdown** This function will cause the remote computer to shutdown or restart after the specified timeout. Before the actual shutdown process starts, a message will be displayed, when it is provided with a socket, user id, tree id, pipe name, message to display, and timeout in seconds. This message will also need to be provided with instructions on whether to reboot or shutdown and whether to close all the applications properly.

The following example shows how to determine whether the remote host's Norton Antivirus service is installed and whether it is running. If Norton Antivirus is not running, the example shows how to start it by utilizing the Microsoft Windows service control manager.

To determine whether the remote host has Norton AntiVirus or Symantec AntiVirus installed, first run the smb_enum_services.nasl test, which will return a list of all the services available on the remote host. Next, accommodate the required dependencies for smb_enum_services.nasl (netbios_name_get.nasl, smb_login.nasl, cifs445.nasl, find_service.nes, and logins.nasl). Next, get the value stored in the knowledge base item called SMB/svcs; this knowledge base item holds a list of all the services that are present on the remote host. You do this by using the following code:

```
service_present = 0;
services = get_kb_item("SMB/svcs");
if(services)
{
 if("[Norton AntiVirus Server]" >!< services || "[Symantec AntiVirus Server]" >!<
services)
 {
  service_present = 1;
 }
}
```

Windows Testing Functionality Provided by the smb_hotfixes.inc Include File

If the remote host's registry has been allowed access from a remote location, Nessus can gather information from it and store it in the knowledge base. Once the information is in the knowledge base, different types of tests can be created. The most common tests are service pack and hotfix presence verification.

All of the following functions work only if the remote host's registry has been enumerated. If the registry hasn't been enumerated, version-returning functions will return NULL, while product installation-checking functions will return *minus one* (-1) as the result. Furthermore, because

registry enumeration relies on the ability to successfully launch the smb_hotfixes.nasl test, it has to be provided as a dependency to tests you write using any of the following functions:

- **hotfix_check_exchange_installed** This function returns the version of the Exchange Server if one has been installed on the remote host.
- **hotfix_data_access_version** This function returns the version of the Access program if one has been installed on the remote host.
- **hotfix_check_office_version** This function returns the version of the remote host's Office installation. To determine the version, one of the following programs must be installed on the remote host: Outlook, Word, Excel, or PowerPoint.
- **hotfix_check_word_version, hotfix_check_excel_version, hotfix_check_powerpoint_version, hotfix_check_outlook_version** These functions return the version of the Word, Excel, PowerPoint, or Outlook program if one has been installed on the remote host.
- **hotfix_check_works_installed** This function returns the version of the MS Works program if one has been installed on the remote host.
- **hotfix_check_iis_installed** This function returns either the value of *one* or *zero* depending on whether the remote host has IIS (Internet Information Server) installed or not.
- **hotfix_check_wins_installed, hotfix_check_dhcpserver_installed** These functions return either the value of *one* or *minus one* depending on whether the remote host has the WINS (Windows Internet Naming Service) server or DCHP (Dynamic Host Control Protocol) server present or not.
- **hotfix_check_nt_server** This function returns either *zero* or *one* depending on whether the remote host is a Windows NT server or not.
- **hotfix_check_domain_controler** This function returns either *zero* or *one* depending on whether the remote host is a Windows Domain Controller or not.
- **hotfix_get_programfilesdir** This function returns the location of the Program Files directory on the remote host.
- **hotfix_get_commonfilesdir** This function returns the location of the Common Files directory on the remote host.
- **hotfix_get_systemroot** This function returns the location of the System Root directory on the remote host.
- **hotfix_check_sp** This function verifies whether a certain service pack has been installed on the remote host. The function uses the provided services pack levels to verify whether the remote host is running the specified product type and whether the remote host has the appropriate service pack installed. The function returns *minus one* if the registry hasn't been enumerated, *zero* if the requested service pack level has been properly installed, and *one* if the requested service pack level hasn't been installed.

- **hotfix_missing** This function verifies whether a certain hotfix has been installed on the remote host. The function returns *minus one* if the registry hasn't been enumerated, *zero* if the requested hotfix has been properly installed, and *one* if the requested hotfix hasn't been installed.

Master Craftsman

Registry Keys Stored in the Knowledge Base

The functions provided by the smb_hotfixes.inc include file all return values stored in the registry. By extending the amount of information Nessus holds in its knowledge base, you can speed up the scanning process. One example of doing this would be to include information about whether the ISA (Internet Security and Acceleration) server is installed on the remote server, what version is installed, and if any service packs/feature packs are installed for it. As of the writing of this book, seven tests can verify if the ISA server is installed on a remote server. Because all these tests call cached registry items, the time it takes to verify whether the remote host is vulnerable is negligible to reconnecting to the remote host's registry and pulling the required registry keys seven times.

For example, Microsoft has recently released an advisory called *Vulnerability in Web View Could Allow Remote Code Execution*. The vulnerability described in this advisory affects Windows 2000, Windows 98, Windows 98SE, and Windows ME. As you will see later in this chapter, it is fairly easy to add a registry-based test for the aforementioned security advisory's hotfix presence and to inform the user if it is in fact not present on the remote host.

Currently, Nessus supports security testing for only Windows NT, 2000, 2003, and XP. Moreover, as stated in the advisory, once Service Pack 5 is installed on the remote host, the Windows 2000 installation will be immune.

To create a test that verifies whether the remote host is immune to the vulnerability, you first need to verify that such a service pack has not been installed and that in fact the remote host is running Windows 2000. To do this, utilize the following lines:

```
nt_sp_version = NULL;
win2k_sp_version = 5;
xp_sp_version = NULL;
win2003_sp_version = NULL;

if ( hotfix_check_sp(   nt:nt_sp_version,
                                    win2k:win2k_sp_version,
                                    xp:xp_sp_version,
                                    win2003:win2003_sp_version) <= 0 ) exit(0);
```

Before calling the aforementioned lines, you must first satisfy a dependency on smb_hotfixes.nasl and verify that the remote registry has been enumerated. That is done by ensuring that

the knowledge base item *SMB/Registry/Enumerated* is present. This is done by adding the following lines to the script:

```
script_dependencies("smb_hotfixes.nasl");
script_require_keys("SMB/Registry/Enumerated");
```

Next, verify that hotfix Q894320 has been installed on the remote host. Do this by executing the following lines:

```
if ( hotfix_missing(name: "Q894320") > 0  )
        security_hole(get_kb_item("SMB/transport"));
```

The two functions you used in the code in the previous example are defined in the smb_hotfixes.inc file, which must be included before the functions can be called by adding the following line to your code:

```
include("smb_hotfixes.inc");
```

Swiss Army Knife

Microsoft's MSSecure.xml

Microsoft's Windows Update, Microsoft Baseline Security Analyzer, and Shavilk's HFNetCheck all use an XML file that contains the most current information on the latest software versions, service packs, and security updates available for various Microsoft operating systems, BackOffice components, services, and so on. Microsoft provides this file to the public for free. The MSSecure.xml file is both machine readable and human readable; thus, administrators can use the file to easily spot relevant patches or make an automated script that performs this task for them.

All the information required for the above Hotfix testing sample can be found in the MSSecure.xml's MS05-024 advisory section.

UNIX Testing Functionality Provided by the Local Testing Include Files

Nessus can connect to a remote UNIX host that supports SSH (Secure Shell). Currently, the following operating systems have tests that verify whether a remote host contains an appropriate path for a vulnerability: AIX, Debian, Fedora, FreeBSD, Geneto, HP-UNIX, Mandrake, Red Hat, Solaris, and SuSE.

Verifying whether a remote host has installed the appropriate patch is done via several query mechanisms, depending on the type of operating system and the type of package querying mechanism used by that operating system.

In most cases, pkg_list or dpkg, programs whose purpose is to list all available installed software on the remote host and each software's version, are used to retrieve a list of all the products

on the remote host. This information is then quantified and stored in the knowledge base under the item *Host/OS Type*. For example, in the case of Red Hat, the program *rpm* is launched, and the content returned by it is stored in *Host/RedHat/rpm-list*.

You do not have to directly access the content found in a knowledge base item; rather, several helper functions analyze the data found in the software list and return whether the appropriate patch has been installed or not.

A list of the software components of an operating system is not the only information that is indexed by the helper functions; the operating system's level, or more specifically its patch level, is also stored in the knowledge base and is used to verify whether a certain patch has been installed on the remote host.

Currently, several automated scripts take official advisories published by the operating system vendors and convert them into simple NASL (Nessus Attack Scripting Language) scripts that verify whether the advisory is relevant to the remote host being scanned. Let's discuss these scripts now.

The rpm_check function determines whether the remote host contains a specific RPM (RPM Package Manager, originally called Red Hat Package Manager) package and whether the remote host is of a certain release type. Possible release types are MDK, SUSE, FC1, FC2, FC3, RHEL4, RHEL3, and RHEL2.1. These correspond to Mandrake, SuSE, Fedora Core 1, Fedora Core 2, Fedora Core 3, Red Hat Enterprise Linux 4, Red Hat Enterprise Linux 3, and Red Hat Enterprise Linux 2.1, respectively.

The value of *one* is returned if the package installed on the remote host is newer or exactly as the version provided, whereas the value of *zero* is returned if the package installed on the remote host is newer or exactly the same as the version provided.

For example, the following code will verify whether the remote host is a Red Hat Enterprise Level 2.1 and whether the remote host has a Gaim package that is the same or later than version 0.59.9-4:

```
if ( rpm_check( reference:"gaim-0.59.9-4.el2", release:"RHEL2.1") )
```

The same test can be done for Red Hat Enterprise Level 3 and Red Hat Enterprise Level 4:

```
if ( rpm_check( reference:"gaim-1.2.1-6.el3", release:"RHEL3") || rpm_check(
reference:"gaim-1.2.1-6.el4", release:"RHEL4") )
```

However, in the preceding case, the Gaim version available for Red Hat Enterprise Level 3 and 4 is newer than the version available for Red Hat Enterprise Level 2.1.

The rpm_exists function is very similar to rpm_check. However, in this case, rpm_exists tests not for which version of the package is running, but for only whether the RPM package exists on the remote host. The value of *one* is returned if the package exists, whereas the value of *zero* is returned if the package does not exist.

The return values of rpm_check function are *zero* if the remote host's distribution is irrelevant and *one* if the package exists on the remote host.

For example, you can determine whether the remote Fedora Core 2 host has the mldonkey package installed; if it does, your cooperation policy is broken, and you will want to be informed of it:

```
if ( rpm_exists(rpm:"mldonkey", release:"FC2") )
```

The aix_check_patch function is very similar to rpm_check; however, AIX software patches are bundled together in a manner similar to the Microsoft's service packs; therefore, you verify whether a certain bundle has been installed, not whether a certain software version is present on a remote host.

The return values of this function are *zero* if the release checked is irrelevant, *one* if the remote host does not contain the appropriate patch, and *minus one* if the remote host has a newer version than the provided reference.

– The deb_check function is equivalent to the rpm_check function, but unlike the rpm_check, the different Debian versions are provided as input instead of providing a release type (such as Red Hat/Fedora/Mandrake/SuSE). In addition, unlike the rpm_check function, the version and the package name are broken into two parts: prefix, which holds the package name, and reference, which holds the version you want to be present on the remote host.

The return values of this function are *one* if the version found on the remote host is older than the provided reference and *zero* if the architecture is not relevant or the version found on the remote host is newer or equal to the provided reference.

For example, in Debian's DSA-727, available from www.debian.org/security/2005/dsa-727, you can see that for stable distribution (woody) this problem has been fixed in version 0.201-2woody1; therefore, you conduct the following test:

```
if (deb_check(prefix: 'libconvert-uulib-perl', release: '3.0', reference: '0.201-2woody1'))
```

For the testing (sarge) and unstable (sid) distributions, this problem has been fixed in version 1.0.5.1-1; therefore, you conduct the following test:

```
if (deb_check(prefix: 'libconvert-uulib-perl', release: '3.2', reference: '1.0.5.1-1'))
if (deb_check(prefix: 'libconvert-uulib-perl', release: '3.1', reference: '1.0.5.1-1'))
```

The pkg_cmp function is equivalent to the rpm_check, but is used for the FreeBSD operating system. The function pkg_cmp doesn't verify which version of FreeBSD is being queried; this has to be done beforehand by grabbing the information found under the *Host/FreeBSD/release* knowledge base key and comparing it with the FreeBSD release version. The return values of this function are *one* or larger if the remote host's version of the package is older than the provided reference, *zero* if both versions match, and *minus one* or smaller if the package is irrelevant to the remote host or the version running on the remote host is newer than the provided reference.

The hpux_check_ctx function determines whether the remote host is of a certain HP UNIX hardware version and HP UNIX operating system version. This is done by providing values separated by a space for each relevant hardware and operating system pair. Each such pair is separated by a colon. The return values of this function are *one* for architecture matched against the remote host and *zero* for architecture that does not match against the remote host.

For example, the string *800:10.20 700:10.20* indicates that you have two relevant sets for testing. The first hardware version is *800*, and its operating system version is *10.20*. The second hardware version is *700*, and its operating system version is also *10.20*. If one of the pairs is an exact match, a value of *one* is returned; if none of them match, the value of *zero* is returned. The value of the remote host's hardware version is stored under the *Host/HP-UX/version* knowledge

base item key, and the remote host's operating system version is stored under the *Host/HP-UX/hardware* knowledge base item key.

The hpux_patch_installed function determines whether a remote HP-UNIX host has an appropriate patch installed, such as AIX. HP-UNIX releases patches in bundles named in the following convention: PHCO_XXXXX. The return values of this function are *one* if the patch has been installed and *zero* if the patch has not been installed.

Once you have used the hpux_check_ctx function to determine that the remote host's hardware and operating system versions are relevant, you can call the hpux_patch_installed function and determine whether the patch has been installed. Multiple patches can be provided by separating each patch with a space character.

For example, to create a test for the vulnerability patched by PCHO_22107, available at ftp://ftp.itrc.hp.com/superseded_patches/hp-ux_patches/s700_800/11.X/PHCO_22107.txt, you'll start by verifying that the remote host's hardware and system operating system versions are correct:

```
if ( ! hpux_check_ctx ( ctx:"800:11.04 700:11.04 " ) )
{
 exit(0);
}
```

Follow up by testing whether the remote host has the appropriate PHCO installed and all the ones this PHCO_22107 depends on:

```
if ( !hpux_patch_installed (patches:"PCHO_22107 PHCO_21187 PHCO_19047 PHCO_17792
PHCO_17631 PHCO_17058 PHCO_16576 PHCO_16345 PHCO_15784 PHCO_14887 PHCO_14051 PHCO_13606
PHCO_13249"))
{
 security_hole(0);
}
```

However, the code in the previous example doesn't verify whether the remote host's patch files have been installed; instead, it verifies only whether the remote host has launched the appropriate patches. To verify whether the remote host has been properly patched, you need to call the hpux_check_patch function.

The hpux_check_patch function verifies whether a remote HP-UNIX system has installed a patch and if the user has let the patch modify the operating system's files. The return values of this function are *one* if the package is not installed on a remote host and *zero* if the patch has been installed or is irrelevant for a remote host.

For example, for the aforementioned PHCO_22107 advisory, you must confirm that *OS-Core.UX-CORE*'s version is B.11.04. The following code will verify that *OS-Core.UX-CORE* is in fact of the right version; if it is not, it will notify that the remote host is vulnerable:

```
if ( hpux_check_patch( app:"OS-Core.UX-CORE", version:"B.11.04") )
{
 security_hole(0);
 exit(0);
}
```

The qpkg_check function is equivalent to the rpm_check, but it is used for testing the existence of packages on Gentoo distributions. The function verifies that the package has been installed on the remote host and then verifies whether a certain version is *equal to*, *lower than,* or *greater than* the provided version of vulnerable and immune versions.

The return values of this function are *zero* for irrelevant architecture or when a package is not installed on a remote host, and *one* if the patch has been installed.

In the following example, you will verify whether a remote host contains the patches provided for the gdb package, as described in www.gentoo.org/security/en/glsa/glsa-200505-15.xml:

For the GLSA-200505-15 you need to check first the package named *sys-devel/gdb* and then the unaffected version >= 6.3-r3, meaning you need to write **ge 6.3-r3** followed by the vulnerable version < 6.3-r3. So you need to write **l 6.3-r3**. The complete line of this code reads as follows:

```
if (qpkg_check(package: "sys-devel/gdb", unaffected: make_list("ge 6.3-r3"), vulnerable:
make_list("lt 6.3-r3") ))
{
 security_hole(0);
 exit(0);
}
```

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Adding Additional Operating Systems

The aforementioned functions do not cover all available UNIX-based operating systems. Extending these functions to support other operating systems is easy. Operating systems that are extensions of other operating systems would require little, if any, changes; for example, Ubuntu, which is an extension of Debian. Other operating systems would require more changes; however, if you can provide two functions to the Nessus environment, you can easily add support to your operating system:

- SSH connectivity
- A way to list all the packages/products installed on the operating systems and their corresponding versions

If the preceding two functions are available, you can index the list of packages and their versions through the SSH channel. You then can create a test that determines whether the package is installed and if its version is lower than the one that is immune to attack.

The solaris_check_patch function verifies whether a certain patch exists on a remote Solaris machine. As in the case of HP-UNIX, the function verifies the release type, architecture—hardware type, patch (which can be made obsolete by some other patch), followed by the name of the vulnerable package. The vulnerable packages can be more than one, in which case they are separated by the character space.

The return values of this function are *minus one* if the patch is not installed, *zero* for irrelevant architecture or if the package is not installed on the remote host, and *one* if the patch has been installed.

Final Touches

You have learned different functions provided by the smb_nt.inc include file and the smb_hotfixes.inc file that can be used to test Windows-based devices. Furthermore, you have seen what functions are provided by the aix.inc, debian_package.inc, freebsd_package.inc, hpux.inc, qpkg.inc, rpm.inc, and solaris.inc include files to test UNIX-based devices. After viewing examples in this chapter, you should understand how to use these various functions.

Chapter 5

Analyzing GetFileVersion and MySQL Passwordless Test

Scripts and samples in this chapter:

- **Integrating NTLM Authentication into Nessus' HTTP Authentication Mechanism**
- **Improving the MySQL Test by Utilizing Packet Dumps**
- **Improving Nesuss' GetFileVersion Function by Creating a PE Header Parser**

In This Toolbox

NTLM (NT LAN Manager) authentication is a widely used type of authentication mechanism, and until now, Nessus has lacked the support necessary to test Web sites that use NTLM authentication for their protection. In this chapter we will underline the steps that must be taken so that Nessus can incorporate support for NTLM. We will also look into how the MySQL test can be improved to work better with the different versions of MySQL servers. We will conclude with an in-depth analysis of Windows's PE header file structure and how the GetFileVersion function can be improved to better utilize this structure to produce less network overhead when trying to determine a remote file's version.

Integrating NTLM Authentication into Nessus' HTTP Authentication Mechanism

We will begin this chapter by explaining how NTLM-based authentication works, describing how to write an NTLM testing NASL, discussing where changes to Nessus are needed to support Nessus-wide NTLM authentication, and finally, illustrating how everything is glued together.

NTLM

NTLM is an authentication protocol originally constructed by Microsoft to allow its products to talk securely to each other. The authentication protocol was originally conceived for the file-sharing service given by Microsoft (implemented by the Server Message Block [SMB] protocol). However, the proliferation of sites on the Web has created a need for a stronger authentication mechanism, and Microsoft decided that it would incorporate its NTLM authentication protocol to its Internet Explorer browser.

The original Hypertext Transfer Protocol (HTTP) did not incorporate any support for NTLM; Microsoft added NTLM support to HTTP later. Unlike the basic authentication mechanism that all browsers support, NTLM is not supported by default. Some browsers such as Mozilla Firefox have chosen to support it, whereas others like Konqueror have chosen to not support it for the time being.

Further, the basic authentication mechanism authenticates requests, whereas the NTLM authentication mechanism authenticates connections. Therefore, we are forced to keep the connection alive as long as possible or else we will be required to reauthenticate the newly created connection.

However, Nessus uses the HTTP keep-alive mechanism to minimize traffic and minimize the requirement to open and close connections. Therefore, all that is necessary is to extend the functionality of the existing keep-alive mechanism to support NTLM. This, however, is no easy feat, in addition to adding to the existing connection an extensive overhead whenever a keep-alive connection is closed and reopened.

Before diving into code writing, you will need to understand a bit more about how NTLM authentication is conducted. This section is by no means a complete guide to NTLM authentication; there are a lot of resources out there that explain in depth how NTLM authentication works.

Because NTLM authentication is a challenge-response protocol, it requires you to transmit three different types of messages between the browser and the Web server:

1. The browser has to first send a Type 1 message containing a set of flags of features supported or requested to the Web server.
2. The Web server then responds with a Type 2 message containing a similar set of flags supported or required by the Web server and a random challenge (8 bytes).
3. The handshake is completed by the browser client using the challenge obtained from the Type 2 message and the user's authentication credentials to calculate a response. The calculation methods differ based on the NTLM authentication parameters negotiated before, but in general, MD4/MD5 hashing algorithms and Data Encryption Standard (DES) encryption are applied to compute the response. The response is then sent to the Web server in a Type 3 message.

We can illustrate the three-way handshake that takes place between a browser marked as B and a server marked as S as follows:

```
1: B --> S   GET ...
2: B <--  S   401 Unauthorized
              WWW-Authenticate: NTLM
3: B  --> S   GET ...
              Authorization: NTLM <base64-encoded type-1-message>
4: B <--  S   401 Unauthorized
              WWW-Authenticate: NTLM <base64-encoded type-2-message>
5: B  --> S   GET ...
              Authorization: NTLM <base64-encoded type-3-message>
6: B <--  S   200 OK
```

The script in the preceding example is a variation of the example of the NTLM handshake shown at http://www.innovation.ch/java/ntlm.html. As can be seen, there is quite a bit of overhead until we get the content of the desired page. This overhead can get a lot bigger if we drop our connection at stage six instead of keeping the connection alive and conducting another request.

As mentioned before, NTLM authentication requires our browser and server to handle three types of messages. Let's look a little deeper at how they are constructed. Message Type 1 is described in Table 5.1.

Table 5.1 Construction of Message Type 1

Byte Offset	Description	Content
0	NTLMSSP Signature	Null-terminated ASCII "NTLMSSP" (0x4e544c4d53535000)
8	NTLM Message Type	Long (0x01000000)
12	Flags	Long

Continued

Table 5.1 continued Construction of Message Type 1

Byte Offset	Description	Content
(16)	Supplied Domain (*Optional*)	Security buffer
(24)	Supplied Workstation (*Optional*)	Security buffer
(32)	*Start of data block (if required)*	

As shown at http://www.innovation.ch/java/ntlm.html, the C structure for message Type 1 is as follows:

```
struct {
    byte    protocol[8];     // 'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0'
    long    type;            // 0x01
    long   flags;           // NTLM Flags
    short   dom_len;         // domain string length
    short   dom_len;         // domain string length
    short   dom_off;         // domain string offset
    byte    zero[2];
    short   host_len;        // host string length
    short   host_len;        // host string length
    short   host_off;        // host string offset (always 0x20)
    byte    zero[2];
    byte    host[*];         // host string (ASCII)
    byte    dom[*];          // domain string (ASCII)
} type-1-message
```

Message Type 2 is described in Table 5.2.

Table 5.2 Construction of Message Type 2

Byte Offset	Description	Content
0	NTLMSSP Signature	Null-terminated ASCII "NTLMSSP" (0x4e544c4d53535000)
8	NTLM Message Type	Long (0x02000000)
12	Target Name	Security buffer
20	Flags	Long
24	Challenge	8 bytes
(*32*)	Context (*optional*)	8 bytes (two consecutive longs)
(*40*)	Target Information (*optional*)	Security buffer
32 (*48*)	*Start of data block*	

The C structure (without the optional sections) for message Type 2 is shown in the following example:

```
struct {
        byte    protocol[8];     // 'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0'
        long    type;            // 0x02
        long    target_name;
        long    flags;           // NTLM Flags
        byte    challenge[8];        // nonce
    } type-2-message
```

Message Type 3 is described in Table 5.3.

Table 5.3 Construction of Message Type 3

Byte Offset	Description	Content
0	NTLMSSP Signature	Null-terminated ASCII "NTLMSSP" (0x4e544c4d53535000)
8	NTLM Message Type	Long (0x03000000)
12	LM/LMv2 Response	Security buffer
20	NTLM/NTLMv2 Response	Security buffer
28	Domain Name	Security buffer
36	User Name	Security buffer
44	Workstation Name	Security buffer
(*52*)	Session Key (*optional*)	Security buffer
(*60*)	Flags (*optional*)	Long
52 (*64*)	*Start of data block*	

The C structure for message Type 3 is as follows.

```
struct {
    byte    protocol[8];     // 'N', 'T', 'L', 'M', 'S', 'S', 'P', '\0'
    long    type;            // 0x03

    short   lm_resp_len;     // LanManager response length (always 0x18)
    short   lm_resp_len;     // LanManager response length (always 0x18)
    short   lm_resp_off;     // LanManager response offset
    byte    zero[2];

    short   nt_resp_len;     // NT response length (always 0x18)
    short   nt_resp_len;     // NT response length (always 0x18)
    short   nt_resp_off;     // NT response offset
    byte    zero[2];

    short   dom_len;         // domain string length
    short   dom_len;         // domain string length
    short   dom_off;         // domain string offset (always 0x40)
    byte    zero[2];

    short   user_len;        // username string length
    short   user_len;        // username string length
```

```
        short   user_off;        // username string offset
        byte    zero[2];

        short   host_len;        // host string length
        short   host_len;        // host string length
        short   host_off;        // host string offset
        byte    zero[6];

        short   msg_len;         // message length
        byte    zero[2];

        short   flags;           // 0x8201
        byte    zero[2];

        byte    dom[*];          // domain string (unicode UTF-16LE)
        byte    user[*];         // username string (unicode UTF-16LE)
        byte    host[*];         // host string (unicode UTF-16LE)
        byte    lm_resp[*];      // LanManager response
        byte    nt_resp[*];      // NT response
    } type-3-message
```

As you can see, the data transmitted cannot be trivially handled or generated, as different data types are required. In addition, some parts have to be used by hashing algorithms (for example, MD4), making it harder to incorporate support for HTTP-based NTLM authentication for Nessus.

You should not be discouraged, however, because the same authentication mechanism used by Nessus to connect to Windows machines can be used to enable HTTP-based NTLM authentication. More specifically, by using crypto_func.inc's internal functions, you can provide the necessary hashed response required for the Type 3 message without much effort.

To give you a better understanding of how we are going to extend the functionality of Nessus, let's start off by building an NASL script that connects to a remote host, generates the necessary message types, and retrieves an NTLM-protected Web page. Our code will start off by setting a few parameters that will we will user later on, and we don't want to redefine them each time. The following code and additional scripts discussed in this section are available on the Syngress Web site:


```
username = "administrator";
domain = "beyondsecurity.com";
hostname = "ntlm.securiteam.beyondsecurity.com";
host_off = raw_string(0x20); # host string offset (always 0x20)
domain_off = host_off + strlen(hostname);

type_1_message = raw_string("NTLMSSP", 0x00,
 0x01,0x00, 0x00, 0x00, # type 0x01 - NTLM_NEGOTIATE
 0x02, 0x32, # Flags
 0x00, 0x00, # Two more zeros
 0x00, 0x00, # We don't sent any of the optional fields
 0x00, 0x00, # We don't sent any of the optional fields
 0x00, 0x00, 0x00, 0x00, # We don't sent any of the optional fields
 0x00, 0x00, # We don't sent any of the optional fields
 0x00, 0x00, # We don't sent any of the optional fields
```

```
 0x00, 0x00, 0x00, 0x00);
```

We can easily dump the raw_string data by using the dump.inc function dump():

```
include("dump.inc");
dump(dtitle: "type_1_message", ddata: type_1_message);
```

Before we can send this Type 1 message, we need to base64 encode it. The required function can be found in the misc_func.inc file and can be used by writing the following lines into your NASL script:

```
include("misc_func.inc");
type_1_message_base64 = base64(str: type_1_message);
```

All we need to do now is generate an HTTP request. Remember that NTLM authentication works only on persistent connections, so for now, we will assume that the remote host supports it. A more intelligent test would first try to determine whether such persistent connections are even supported.

```
request = string("GET / HTTP/1.1\r\n",
 "Host: ntlm.securiteam.beyondsecurity.com\r\n",
 "User-Agent: Mozilla/5.0 (X11; U; Linux i686; en-US; rv:1.7.5)\r\n",
 "Accept: text/html\r\n",
 "Keep-Alive: 300\r\n",
 "Connection: keep-alive\r\n",
 "Authorization: NTLM ", type_1_message_base64, "\r\n",
 "\r\n");
```

The keep-alive headers are shown in two lines. One states that we want to keep the connection alive for the next *300* seconds; the other tells the server that we are requesting a *keep-alive* connection.

All we have to do now is write up all the functions that will open the required port, send the data, and receive the response from the server.

```
port = 80;
if(get_port_state(port))
{
 soc = open_sock_tcp(port);
 if(soc)
 {
  send(socket:soc, data:request);

  res = recv(socket:soc, length:2048);
  display("res: [", res, "]\n");
```

We have requested that Nessus read just the first 2,048 bytes, as we are looking for something that is found in the headers. However, prior to receiving the actual page we requested, as the connection is persistent, we will need to read the whole buffer waiting for us.

We can grab the response sent back by the server by using a regular expression such as this one:

```
  v = eregmatch(pattern: "WWW-Authenticate: NTLM (.+)$", string: res);
```

We can then verify whether it is found in the headers sent back by the server by checking whether the parameter *v* is not NULL:

```
if (!isnull(v))
{
```

Once we have determined that the parameter is not NULL, we need to strip any characters found after our buffer by issuing the following command:

```
v[1] = v[1] - strstr(v[1], string("\r\n"));
```

We can display the Type 2 message response that is base64 encoded:

```
display("NTLM: ", v[1], "\n");
```

We can then follow through and base64 decode the data using the following command:

```
type_2_response = base64_decode(str: v[1]);
```

As the response is in binary form, we can dump its content by reusing the dump() function:

```
dump(dtitle: "type_2_response", ddata: type_2_response);
```

Once we have our binary data, we can start to extract the response type to verify that the response received is in fact what we are expecting. The function hexstr() allows us to quickly compare a stream of bytes with a string by returning a hex string form from binary data.

```
type = hexstr(raw_string(type_2_response[8], type_2_response[9], type_2_response[10],
type_2_response[11]));
display("type: ", type, "\n");
```

As we sent an NTLMSSP_NEGOTIATE message, we are expecting the Web server to return an NTLMSSP_CHALLENGE whose type is 0x02000000. We verify that the type is as such:

```
if (type == "02000000") # NTLMSSP_CHALLENGE
{
 display("Type is NTLMSSP_CHALLENGE\n");
}
```

Once we have verified that the data is in fact of the right type, we can proceed to process the target type and target length being returned. Because we aren't creating extensive support for NTLM, we won't cover the different target types and their corresponding target lengths; rather, we will assume that the type returned is the right one.

```
target_type = hexstr(raw_string(type_2_response[12], type_2_response[13]));
display("target type: ", target_type, "\n");
target_len = ord(type_2_response[14]) + ord(type_2_response[15])*256;
display("target len: ", target_len, "\n");
```

As mentioned before, the response provides a list of different flags; each flag has a different meaning (Table 5.4). Note that the flags are bit-wise. If they are there, the flag is on; if they aren't there, the flag is off.

Table 5.4 Flags Provided by the Server Response

Flag	Name	Description
0x00000001	Negotiate Unicode	Indicates that Unicode strings are supported for use in security buffer data.
0x00000002	Negotiate OEM	Indicates that OEM strings are supported for use in security buffer data.
0x00000004	Request target	Requests that the server's authentication realm be included in the Type 2 message.
0x00000008	Unknown	This flag's usage has not been identified.
0x00000010	Negotiate sign	Specifies that authenticated communication between the client and server should carry a digital signature (message integrity).
0x00000020	Negotiate seal	Specifies that authenticated communication between the client and server should be encrypted (message confidentiality).
0x00000040	Negotiate datagram style	Indicates that datagram authentication is being used.
0x00000080	Negotiate LAN manager key	Indicates that the LAN manager session key should be used for signing and sealing authenticated communications.
0x00000100	Negotiate Netware	This flag's usage has not been identified.
0x00000200	Negotiate NTLM	Indicates that NTLM authentication is being used.
0x00000400	Unknown	This flag's usage has not been identified.
0x00000800	Unknown	This flag's usage has not been identified.
0x00001000	Negotiate domain supplied	Sent by the client in the Type 1 message to indicate that the name of the domain in which the client workstation has membership is included in the message. This is used by the server to determine whether the client is eligible for local authentication.
0x00002000	Negotiate workstation supplied	Sent by the client in the Type 1 message to indicate that the client workstation's name is included in the message. This is used by the server to determine whether the client is eligible for local authentication.
0x00004000	Negotiate local call	Sent by the server to indicate that the server and client are on the same machine. Implies that the client may use the established local credentials for authentication instead of calculating a response to the challenge.
0x00008000	Negotiate always sign	Indicates that authenticated communication between the client and server should be signed with a "dummy" signature.

Continued

Table 5.4 continued Flags Provided by the Server Response

Flag	Name	Description
0x00010000	Target type domain	Sent by the server in the Type 2 message to indicate that the target authentication realm is a domain.
0x00020000	Target type server	Sent by the server in the Type 2 message to indicate that the target authentication realm is a server.
0x00040000	Target type share	Sent by the server in the Type 2 message to indicate that the target authentication realm is a share. Presumably, this is for share-level authentication. Usage is unclear.
0x00080000	Negotiate NTLM2 key	Indicates that the NTLM2 signing and sealing scheme should be used for protecting authenticated communications. Note that this refers to a particular session security scheme, and is not related to the use of NTLMv2 authentication. This flag can, however, have an effect on the response calculations (as detailed in the "NTLM2 Session Response" section).
0x00100000	Request init response	This flag's usage has not been identified.
0x00200000	Request accept response	This flag's usage has not been identified.
0x00400000	Request Non-NT session key	This flag's usage has not been identified.
0x00800000	Negotiate target info	Sent by the server in the Type 2 message to indicate that it is including a Target Information Block in the message. The Target Information Block is used in the calculation of the NTLMv2 response.
0x01000000	Unknown	This flag's usage has not been identified.
0x02000000	Unknown	This flag's usage has not been identified.
0x04000000	Unknown	This flag's usage has not been identified.
0x08000000	Unknown	This flag's usage has not been identified.
0x10000000	Unknown	This flag's usage has not been identified.
0x20000000	Negotiate 128	Indicates that 128-bit encryption is supported.
0x40000000	Negotiate key exchange	Indicates that the client will provide an encrypted master session key in the "Session Key" field of the Type 3 message. This is used in signing and sealing, and is RC4-encrypted using the previous session key as the encryption key.
0x80000000	Negotiate 56	Indicates that 56-bit encryption is supported.

We don't plan to provide support for all the different flags, nor is it required if we are only trying to build the most basic support for HTTP-based NTLM authentication. However, we will provide a short example just to illustrate how the flags are used. Consider the following message that is specified:

```
Negotiate Unicode (0x00000001)
Request Target (0x00000004)
Negotiate NTLM (0x00000200)
Negotiate Always Sign (0x00008000)
```

The combined numerical code in the preceding example equals 0x00008205. This would be physically laid out as 0x05820000 (it is represented in little-endian byte order).

The following code will extract the flags returned in the response and provide it as a hex string:

```
   flags = hexstr(raw_string(type_2_response[16+4+target_len],
type_2_response[17+4+target_len], type_2_response[18+4+target_len],
type_2_response[19+4+target_len]));
   display("flags: ", flags, "\n");
```

We are expecting the following as the response for our NTLM authentication:

```
   if (flags == "b2020000")
   {
    display("flags as expected\n");
   }
```

The next bytes are the challenge provided by the remote Web server that will be combined with the password to create the MD4 response required to complete the authentication process:

```
   challenge = raw_string(type_2_response[20+4+target_len],
type_2_response[21+4+target_len], type_2_response[22+4+target_len],
type_2_response[23+4+target_len], type_2_response[24+4+target_len],
type_2_response[25+4+target_len], type_2_response[26+4+target_len],
type_2_response[27+4+target_len]);
   dump(dtitle: "Challenge", ddata: Challenge);
```

Once we have extracted them, we can include the required authentication functions already created for us in the crypto_func.inc file:

```
   include("crypto_func.inc");
```

We also can start building our response to the Web server by first converting the password to Unicode form. Note that this is a quick hack to generating a Unicode string from a plain ASCII string; this is by no means a real method of converting an ASCII string to Unicode. Mainly this form doesn't enable support for non-ASCII characters in the password; that is, there is no support for any language other than English.

```
   password = "beyondsecurity";
   pass = NULL;
   for (i=0;i < strlen(password);i++)
            pass += password[i] + raw_string(0x00);
```

Once we have converted our password to Unicode, we can feed it into the NTLM_Response function, which in turn will compute the required NTLM response to the challenge:

```
ntlm_response = NTLM_Response(password:pass, challenge:challenge);
if (!isnull(ntlm_response))
 ipass = ntlm_response[0];
dump(dtitle: "ipass", ddata: ipass);
```

The challenge response will then be stored in the variable *ipass*. You probably noticed that the ntlm_response returned from the NTLM_Response function contains an array of values; however, we are interested in only the data found at location zero. The rest of the data is of no use to us.

We are almost ready to create our response. We first need to compute a few values:

```
domain_off = 66;
username_off = domain_off + strlen( domain );
hostname_off = username_off + strlen ( username );
lm_off = hostname_off + strlen(hostname);
```

Now we put everything together: domain name, hostname, username, and challenge response.

```
  type_3_message = raw_string("NTLMSSP", 0x00,
0x03, 0x00, 0x00, 0x00, # Type 3 message
0x18, 0x00, # LanManager response length (always 0x18)
0x18, 0x00, # LanManager response length (always 0x18)
lm_off, 0x00, #  LanManager response offset (4 bytes)
0x00, 0x00, # Zeros
0x18, 0x00, # NT response length (always 0x18)
0x18, 0x00, # NT response length (always 0x18)
lm_off, 0x00, # NT response offset (4 bytes)
0x00, 0x00, # Zeros
strlen(domain), 0x00, # domain string length
strlen(domain), 0x00, # domain string length
domain_off, 0x00, # domain string offset (4 bytes)
0x00, 0x00, # Zeros
strlen(username), 0x00, # username string length
strlen(username), 0x00, # username string length
username_off, 0x00, # username string offset (4 bytes)
0x00, 0x00, # Zeros
strlen(hostname), 0x00, # host string length
strlen(hostname), 0x00, # host string length
hostname_off, 0x00, # host string offset (4 bytes)
0x00, 0x00, # Zeros
0x00,
0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, # Session key
0x82, 0x01, # Flags
0x00, 0x00, # Zeros
0x00,
domain,
username,
hostname,
```

```
 ipass,
 0x00);
 dump(dtitle: "type_3_message", ddata: type_3_message);
```

Once we have constructed our Type 3 message, we just need to encode it, put it inside an HTTP request, and send it off to the server. All these steps, of course, are done without disconnecting our existing socket, as the challenge response is valid for only this connection:

```
   type_3_message_base64 = base64(str:type_3_message);
   request = string("GET / HTTP/1.1\r\n",
"Host: 192.168.1.243\r\n",
"User-Agent: Mozilla/5.0 (X11; U; Linux i686; en-US; rv:1.7.5) Beyond Security\r\n",
"Accept: text/html\r\n",
"Keep-Alive: 300\r\n",
"Connection: keep-alive\r\n",
"Authorization: NTLM ", type_3_message_base64, "\r\n",
"\r\n");
    soc = open_sock_tcp(port);
    send(socket:soc, data:request);

The data returned from the next lines should be the requested page, if a HTTP error code
401 is returned our authentication process wasn't completed properly:
    while (response = recv(socket:soc, length: 2048))
    {
     display("response: ", response, "\n");
    }
    close(soc);
  }
 }
}
```

Swiss Army Knife…

Bringing It All Together

Now that we have a working NTLM implementation, we can place it into the http_keepalive.inc mechanism which in turn will allow any Web-based sessions being conducted against an NTLM-requiring server to be properly authenticated. The changes required in http_keepalive.inc include resending the type_1_message whenever a connection is dropped, retrieving the response, and generating the type_3_message to complete the NTLM session.

Improving the MySQL Test by Utilizing Packet Dumps

Many of the product tests incorporated into Nessus try to determine the existence of a vulnerability with the least effort possible. This is due to two main reasons: the sheer number of tests being created makes it impossible to spend too much time on each test, and most vulnerabilities can be determined without implementing the full range of the protocol required.

However, this approach poses a problem once the products have become more advanced and different versions of the product come out. Not talking to the product with its protocol is most likely to cause false positives or, even worse, false negatives.

One such example is the MySQL *Unpassworded* test. Version 1.22 of the test used a very simple algorithm to extract the database names returned by the *show databases* command. The algorithm simply went through the response, looked into predefined positions for mark points, and read anything afterward. This kind of algorithm is prone to problems because it lacks the proper implementation of the protocol, and as such, can cause false positives or in some cases, false negatives. One such false negative is the protocol difference that exists between MySQL version 3.xx and MySQL version 4.xx, which caused the tests to return garbage or empty values in some cases.

These kinds of false positives and false negatives can be easily remedied by implementing the MySQL protocol, or at least part of it. In our case all we are interested in is connecting to the MySQL server, authenticating with a NULL password, and extracting a list of all the databases available to us. This can be done with very little understanding of the whole MySQL protocol, using a very commonly used network sniffer called Ethereal.

For our development environment, we will be using MySQL version 3.23.58 and will foolproof our updates by running it against MySQL version 4.xx.xx. We will begin with capturing the traffic generated by the command-line utility *mysql* and then comparing it to our existing test, currently at version 1.22.

The command line *mysql* executed with the following commands will return the packets shown in the following example (this example displays an abbreviated form of the packets):

Master Craftsman…

Further Improving the MySQL Implementation

The code illustrated in the following example doesn't completely implement the MySQL protocol. For example, it lacks support for its cryptographic layer because supporting the cryptographic layer is currently outside the scope of this test.

Future versions of this script that will support the cryptographic layer will improve the ability of this script to detect whether a remote host is vulnerable or not.

```
heart.beyondsecurity.com:$ mysql -h 192.168.1.56 -u root
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 19300 to server version: 3.23.58

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.

mysql> show databases;
+-------------+
| Database    |
+-------------+
| SecuriTeam  |
| mysql       |
| test        |
+-------------+
2 rows in set (0.00 sec)

mysql> \q
Bye
```

Upon connecting to the MySQL server, we send the following packet to it:

```
MySQL Protocol
    Packet Length: 40
    Packet Number: 0
    Server Greeting
        Protocol: 10
        Version: 3.23.58
        Thread ID: 19300
        Salt: |".b%-Q2
        Caps: 0x002c
            .... .... .... ...0 = Long Password: Not set
            .... .... .... ..0. = Found Rows: Not set
            .... .... .... .1.. = Long Flag: Set
            .... .... .... 1... = Connect With Database: Set
            .... .... ...0 .... = Dont Allow database.table.column: Not set
            .... .... ..1. .... = Can use compression protocol: Set
            .... .... .0.. .... = ODBC Client: Not set
            .... .... 0... .... = Can Use LOAD DATA LOCAL: Not set
            .... ...0 .... .... = Ignore Spaces before (: Not set
            .... ..0. .... .... = Support the mysql_change_user(): Not set
            .... .0.. .... .... = an Interactive Client: Not set
            .... 0... .... .... = Switch to SSL after handshake: Not set
            ...0 .... .... .... = Ignore sigpipes: Not set
            ..0. .... .... .... = Client knows about transactions: Not set
        Charset: latin1 (8)
        Status: AUTOCOMMIT (2)
        Unused:
```

We don't need any of the aforementioned information to conclude an authentication process with the MySQL server; therefore, we can move ahead to the next packet:

```
MySQL Protocol
    Packet Length: 10
    Packet Number: 1
```

```
    Login Packet
        Caps: 0x2485
            .... .... .... ...1 = Long Password: Set
            .... .... .... ..0. = Found Rows: Not set
            .... .... .... .1.. = Long Flag: Set
            .... .... .... 0... = Connect With Database: Not set
            .... .... ...0 .... = Dont Allow database.table.column: Not set
            .... .... ..0. .... = Can use compression protocol: Not set
            .... .... .0.. .... = ODBC Client: Not set
            .... .... 1... .... = Can Use LOAD DATA LOCAL: Set
            .... ...0 .... .... = Ignore Spaces before (: Not set
            .... ..0. .... .... = Support the mysql_change_user(): Not set
            .... .1.. .... .... = an Interactive Client: Set
            .... 0... .... .... = Switch to SSL after handshake: Not set
            ...0 .... .... .... = Ignore sigpipes: Not set
            ..1. .... .... .... = Client knows about transactions: Set
        MAX Packet: 16777215
        Username: root
        Password:
```

As you can see, we are logging in with the username *root* with an empty password. We now need to start processing the response as it contains whether we were successful or not:

```
MySQL Protocol
    Packet Length: 3
    Packet Number: 2
    Response Code: 0
    Payload:
```

Response code *0* means that we were able to complete the previous transaction (that is, log on to the remote MySQL server). We can now continue and send our *show databases* request:

```
MySQL Protocol
    Packet Length: 15
    Packet Number: 0
    Command
        Command: Query (3)
        Parameter: show databases
```

What follows next is the response to our *show databases* request:

```
MySQL Protocol
    Packet Length: 1
    Packet Number: 1
    Response Code: 1
MySQL Protocol
    Packet Length: 20
    Packet Number: 2
    Response Code: 0
    Payload: \bDatabase\003@
MySQL Protocol
    Packet Length: 1
    Packet Number: 3
    Response Code: 254
```

```
MySQL Protocol
    Packet Length: 11
    Packet Number: 4
    Response Code: 11
    Payload: SecuriTeam
MySQL Protocol
    Packet Length: 6
    Packet Number: 5
    Response Code: 5
    Payload: mysql
MySQL Protocol
    Packet Length: 5
    Packet Number: 6
    Response Code: 4
    Payload: test
MySQL Protocol
    Packet Length: 1
    Packet Number: 7
    Response Code: 254
```

As you can see, the packet is fairly simple to parse because its structure is the same for all blocks found in the response. The following example is a pseudo-structure because we are not quoting it from the official protocol specification:

```
struct mysql_reponse
        {
         byte Packet_Len[3];
         byte Packet_Num;
         byte Response_Code;
         byte *Additional_Data;
        }
```

The Additional_Data section's structure and length depend on two factors: the Packet_Len value and the Response_Code value. We will concentrate on one Response_Code, response code number 254.

The first instance of response code number 254 means that from this point any additional structures that follow are part of the response to the command *show databases,* whereas the second instance of response code number 254 means that no additional responses to the command *show databases* will follow.

Once the response code number 254 has been specified, the value returned within the response code field is the length in bytes of the name of the database present on the remote MySQL server. For example:

```
MySQL Protocol
    Packet Length: 11
    Packet Number: 4
    Response Code: 11
    Payload: SecuriTeam
```

Thus, we need to build a fairly simple response interpreter that supports two states—grab database name after the first appearance of response code 254 and stop grabbing database names after the second appearance of the response code 254.

Let's begin with writing the improved NASL:

```
#
# MySQL Unpassworded improved by Noam Rathaus of Beyond Security Ltd.
#
#
# The following is a complete rewrite of the mysql_unpassworded.nasl file
# making it more compatible throughout the versions of MySQL Noam Rathaus
#
```

We will use the dump() function found in the dump.inc file to allow us to better debug our progress:

```
include("dump.inc");
debug = 0;
```

We will start off with determining which port MySQL is listening on. By default, it will listen on port 3306; however, this doesn't have to be so.

```
port = get_kb_item("Services/mysql");
if(!port)port = 3306;
if(!get_port_state(port))exit(0);
```

Once we know the port MySQL listens on, we can open a connection to it and start recreating what we have just seen using Ethereal and the *mysql* command-line client:

```
soc = open_sock_tcp(port);
if(!soc)exit(0);
r1 = recv(socket:soc, length:1024);
```

As the minimum length of the response received from a MySQL is 7 bytes, we first need to determine that we aren't processing a response that isn't from a MySQL server:

```
if(strlen(r1) < 7)exit(0);
```

Because some MySQL servers will automatically respond with an *Access Denied* response or something similar, we can quickly determine this by checking for predetermined strings. We can also alter the user if MySQL is blindly refusing connections because of high load, which means that it would be worthwhile to re-scan the MySQL service when it is less loaded with connections:

```
if (" is not allowed to connect to this MySQL" >< r1) exit(0);
if ("Access denied" >< r1)exit(0);
if ("is blocked because of many connection errors" >< r1) {
  security_note(port:port, data:'This MySQL server is temporarily refusing
connections.\n');
  exit(0);
}
```

Once we have established a connection, we can proceed to tell MySQL that we are interested in logging on to it:

```
str = raw_string(0x0A, 0x00, 0x00, # Packet Length
 0x01, # Packet Number
 0x85, 0x04, # Capabilities (Long Password, Long Flag, Can Use LOAD DATA LOCAL,
Interactive Client, Client Knows Transactions
 0x00, 0x00, 0x80, # Max Packet (arbitrary value is also OK)
 0x72, 0x6F, 0x6F, 0x74, 0x00 # NULL terminated root username
 );
```

Once we have constructed our packet, we can send it to the MySQL server and monitor its response:

```
send(socket:soc, data:str);
r1 = recv(socket:soc, length:4096);
```

If needed we can also dump the content of the response:

```
if (debug)
{
 dump(dtitle: "r1", ddata: r1);
}
```

If the response returned is of length zero, we shamefully exit the test, as something must have gone wrong:

```
if(!strlen(r1))exit(0);
```

We can now proceed to disassemble the packet received. We start with determining the packet length, packet number, and response code:

```
packetlen = ord(r1[0]) + ord(r1[1])*256 + ord(r1[2])*256*256 - 1; # Packet Length of 1 is
actually 0
packetnumber = ord(r1[3]);
responsecode = ord(r1[4]);
```

As we already have proceeded to disassemble some parts of the packet, we can capture just the payload part by using the handy substr function, which reads a stream from an initial position up to number of bytes we want (i.e. length):

```
payload = substr(r1, 5, 5+packetlen-1);
```

Because we find debugging a handy tool in determining that we have done everything correctly up to a certain point, we used the following line to display all of the processed variables:

```
if (debug)
{
 display("packetlen: ", packetlen, " packetnumber: ", packetnumber, "\n");
 display("responsecode: ", responsecode, "\n");
 dump(dtitle: "payload", ddata: payload);
}
```

As you recall, the response code of zero indicates that we in fact were able to log on to the remote MySQL server. The following code will determine if this is true by verifying the response code's value.

If the response code is as we expected, we can move forward and again create a much smaller payload for processing. If it's not, for example in this case, response code number 255 or Access Denied, we need to exit gracefully.

```
if (responsecode == 255)
{
 errorcode = ord(r1[5]) + ord(r1[6])*256;
 payload = substr(r1, 7, 7+packetlen-1);
```

By steadily decreasing the size of the payload, we can verify that we have in fact successfully analyzed all previous parts of the packet. Again, we can dump the newly acquired error code and payload with the following code:

```
if (debug)
{
  display("errorcode: ", errorcode, "\n");
  dump(dtitle: "payload", ddata: payload);
 }
```

Again, as error code 255 means Access Denied, we need to close the socket and exit:

```
 # ErrorCode 255 is access denied
 close(soc);
 exit(0);
}
```

Once we have completed the logon process, we can proceed to querying the remote MySQL server for a list of its databases. This step is done by generating such a packet as this one:

```
str = raw_string(
 0x0F, 0x00, 0x00, # Packet length
 0x00, # Packet number
 0x03 # Command: Query
 ) + "show databases"; # The command we want to execute
```

Swiss Army Knife…

MySQL Query Support

Once this implementation of the MySQL protocol is utilized, the *show databases* command can be replaced with other more informative commands, for example the *show tables* or a list of the users on the remote host via the *select * from mysql.user* command.

As before, once we have constructed the packet to send, we send it, await the MySQL's server response, and disconnect the connection, as we require no additional information from the remote MySQL server:

```
send(socket:soc, data:str);
r = recv(socket:soc, length:2048);
close(soc);

if (debug)
{
 dump(dtitle: "r", ddata: r);
 display("strlen(r): ", strlen(r), "\n");
}
```

We will use a few markers to help us analyze the response. The first one is *pos,* which will store the position inside the packet we are at. The *dbs* marker will be a comma separated by a list of databases we have discovered, whereas *ok* will store the state of the packet analysis (that is, whether additional data has to be processed or not).

```
pos = 0;
dbs = "";
ok = 1;
```

We will store the state of the database name-capturing process using two parameters:

```
Database_response = 0;
Database_capture = 0;
```

We will also verify whether we have handled this section of the packet using the following parameter:

```
skip = 0;
```

The following algorithm can be used to analyze the data returned by the remote MySQL server:

- Subtract a subsection packet from the original one depending on the *pos* parameter and pass it on
- Check the value of the response code. If it's the first appearance of error code 254, it will initiate the database name-capturing process. If it's the second appearance of the error code 254, it will terminate the database name-capturing process.
- The *pos* parameter will be moved to next subsection of the packet.
- Return to 1 unless no additional data is available for processing.

The following is the NASL interpretation of the preceding algorithm.

```
while(ok)
{
 skip = 0;

 if (debug)
 {
```

```
  display("pos: ", pos, "\n");
 }

 packetlen = ord(r[pos]) + ord(r[pos+1])*256 + ord(r[pos+2])*256*256 - 1; # Packet Length
is 1 is actually 0 bytes
 packetnumber = ord(r[pos+3]);
 responsecode = ord(r[pos+4]);
 payload = substr(r, pos+5, pos+5+packetlen-1);

 if (debug)
 {
  display("packetlen: ", packetlen, " packetnumber: ", packetnumber, " responsecode: ",
responsecode, "\n");
  dump(dtitle: "payload", ddata: payload);
 }

 if ((!skip) && (responsecode == 254) && (Database_capture == 1))
 {
  skip = 1;
  Database_capture = 0;
  if (debug)
  {
   display("Stopped capturing DBS\n");
  }
 }

 if ((!skip) && (responsecode == 254) && (Database_capture == 0))
 {
  skip = 1;
  Database_capture = 1;
  if (debug)
  {
   display("Capuring DBS\n");
  }
 }

 if ((!skip) && (payload >< "Database") && (responsecode == 0))
 {
  skip = 1;
  if (debug)
  {
   display("Found Database list\n");
  }
  Database_response = 1;
 }

 if ((!skip) && Database_capture)
 {
  if (debug)
  {
   display("payload (dbs): ", payload, "\n");
  }
  if (dbs)
```

```
  {
   dbs = string(dbs, ", ", payload);
  }
  else
  {
   dbs = payload;
  }
 }

 pos = pos + packetlen + 5;
 if (pos >= strlen(r))
 {
  ok = 0;
 }
}
```

Once the algorithm has completed its job, all that is left is to print the results and dynamically add our comma-separated database list to the response displayed by the Nessus client:

```
report = string("Your MySQL database is not password protected.\n\n",
"Anyone can connect to it and do whatever he wants to your data\n",
"(deleting a database, adding bogus entries, ...)\n",
"We could collect the list of databases installed on the remote host :\n\n",
dbs,
"\n",
"Solution : Log into this host, and set a password for the root user\n",
"through the command 'mysqladmin -u root password <newpassword>'\n",
"Read the MySQL manual (available on www.mysql.com) for details.\n",
"In addition to this, it is not recommended that you let your MySQL\n",
"daemon listen to request from anywhere in the world. You should filter\n",
"incoming connections to this port.\n\n",
"Risk factor : High");

security_hole(port:port, data:report);
```

If you compare the NASL code in the preceding example with the original version of NASL that didn't include the preceding interpretation of the MySQL protocol, you will probably notice that the version in the preceding example is more complex and that it requires a deeper understanding of the MySQL protocol.

It doesn't mean that the original version was not able to detect the presence of the vulnerability; rather, it wasn't able to handle any changes to what it expected to receive, whereas this version "understands" how the MySQL protocol works and would work as long as the MySQL protocol remains the same.

Improving Nessus' GetFileVersion Function by Creating a PE Header Parser

Some of Nessus' Windows-based security tests, mainly those related to MSXX-XXX advisories, require the ability to open executables or DLLs (Dynamic Link Libraries) and retrieve from them the product version. This product version is then used to determine whether the version

being used on the remote host is vulnerable to attack. This kind of testing is very accurate and in most cases imitates the way Microsoft's Windows Update determines whether you are running a vulnerable version.

Nessus includes a special function called GetFileVersion() provided by the smb_nt.inc include file that handles this version retrieval. The function receives four parameters, a socket through which all communication will be conducted, a *uid* and *tid* pair that are assigned to each SMB communication channel, and an *fid*, the file descriptor that will be used to read information in the remote file.

The current version of the GetFileVersion() function reads 16,384 bytes from the file descriptor using the *ReadAndX* function:

```
tmp = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, count:16384, off:off);
```

It removes all the *NULL* characters:

```
tmp = str_replace(find:raw_string(0), replace:"", string:tmp);
```

It also goes off to look for the string *ProductVersion:*

```
version = strstr(data, "ProductVersion");
```

Once it has found the product version, it will start off by reading the content of the bytes that follow it, and it will accumulate into its *v* buffer only those characters that are either the number zero through nine or are the character that represents the character dot:

```
 for(i=strlen("ProductVersion");i<len;i++)
 {
  if((ord(version[i]) < ord("0") || ord(version[i]) > ord("9")) && version[i] != ".")
return (v);
  else
    v += version[i];
 }
```

If the string is not found, the function will move to the next 16,384 bytes. If none are found there as well and there are no more bytes available for reading, the function will terminate and return *NULL* as the version.

As you probably understand, this is not a very good method of finding what we seek, mainly because reading 16,384 bytes and then looking for the string *ProductVersion* can be made redundant if we would beforehand read the file's headers and jump to the right offsets where the *ProductVersion* data is stored.

Before we begin writing the actual code, we need to first understand how the executable and DLL files are structured in Windows. Both executable and DLL files of Windows are defined by the PE (Portable Executable) file format.

PE files can be outlined in the following manner:

- MS-DOS header
- MS-DOS stub
- PE header
- Section header

- Section 1
- Section 2
- Section ...
- Section n

PE files must start with a simple DOS MZ header that allows the DOS operating system to recognize this file as its own and proceed to running the DOS stub that is located just after the DOS MZ header. The DOS stub holds inside it a very simple executable that in very plain words just writes to the user that: "This program requires Windows." Programmers may replace this section with any other executable they desire; however, in most cases they leave it to the assemblers or compilers to add. In any case both these sections are of no interest to us.

After the *DOS stub* you can find the *PE header.* This is the first section that we are interested in reading. This section contains essential things that the PE requires for its proper execution. The section is constructed in accordance with the IMAGE_NT_HEADERS data structure.

To save time and network traffic, we would want to skip the *DOS stub* section altogether; therefore, we could do what the operating system does: read the *DOS MZ header*, retrieve the offset where the *PE header* can be found, and read from that offset skipping the entire *DOS stub* section.

The PE header contains a *Signature* variable that actually consists of the following constant four bytes: PE\0\0, the letters P and E followed by two NULL characters, and two variables that contain information on the file. As before this section can be skipped, as it doesn't hold the value of *ProductVersion*.

Next, we stumble upon *Section Header,* or as it's called by Microsoft, *COFF File Header.* The section contains the information shown in Table 5.5.

Table 5.5 The GetFileVersion() Section Header

Size	Field	Description
2	Machine	Number identifying type of target machine.
2	NumberOfSections	Number of sections; indicates size of the Section Table, which immediately follows the headers.
4	TimeDateStamp	Time and date the file was created.
4	PointerToSymbolTable	File offset of the COFF symbol table or 0 if none is present.
4	NumberOfSymbols	Number of entries in the symbol table. This data can be used in locating the string table, which immediately follows the symbol table.
2	SizeOfOptionalHeader	Size of the optional header, which is required for executable files but not for object files. An object file should have a value of 0 here. The format is described in the section "Optional Header."
2	Characteristics	Flags indicating attributes of the file.

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The only information found here that is of interest to us is the *NumberOfSections* field, as it holds the size of the *Section table* that follows the *Section header*. Inside one of the *Sections* that follow is our *ProductVersion* value. Once we know the *NumberOfSections* value, we can proceed to reading through them. The structure of each section is shown in Table 5.6.

Table 5.6 The Structure of Each Section of GetFileVersion()

Size	Field	Description
8	Name	An 8-byte, null-padded ASCII string. There is no terminating null if the string is exactly eight characters long. For longer names, this field contains a slash (/) followed by an ASCII representation of a decimal number. This number is an offset into the string table. Executable images do not use a string table and do not support section names longer than eight characters. Long names in object files will be truncated if emitted to an executable file.
4	VirtualSize	Total size of the section when loaded into memory. If this value is greater than SizeofRawData, the section is zero-padded. This field is valid only for executable images and should be set to 0 for object files.
4	VirtualAddress	For executable images this is the address of the first byte of the section, when loaded into memory, relative to the image base. For object files, this field is the address of the first byte before relocation is applied; for simplicity, compilers should set this to zero. Otherwise, it is an arbitrary value that is subtracted from offsets during relocation.
4	SizeOfRawData	Size of the section (object file) or size of the initialized data on disk (image files). For executable image, this must be a multiple of FileAlignment from the optional header. If this is less than VirtualSize, the remainder of the section is zero filled. Because this field is rounded while the VirtualSize field is not, it is possible for this to be greater than VirtualSize as well. When a section contains only uninitialized data, this field should be 0.
4	PointerToRawData	File pointer to section's first page within the COFF file. For executable images, this must be a multiple of FileAlignment from the optional header. For object files, the value should be aligned on a four-byte boundary for best performance. When a section contains only uninitialized data, this field should be 0.
4	PointerToRelocations	File pointer to beginning of relocation entries for the section. Set to 0 for executable images or if there are no relocations.
4	PointerToLinenumbers	File pointer to beginning of line-number entries for the section. Set to 0 if there are no COFF line numbers.
2	NumberOfRelocations	Number of relocation entries for the section. Set to 0 for executable images.

Continued

Table 5.6 continued The Structure of Each Section of GetFileVersion()

Size	Field	Description
2	NumberOfLine-numbers	Number of line-number entries for the section.
4	Characteristics	Flags describing section's characteristics.

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Inside each section we are interested just in the *PointerToRawData* that we read from and the *SizeOfRawData*, which tells us how many bytes we need to read from *PointerToRawData*. Once we have found the Unicode representation of the string *ProductVersion*, any bytes that follow it will be our product version.

Master Craftsman…

Shortening the PE Header Analysis Algorithm

The algorithms in the following example represent an almost complete description of Windows' PE header file parsing algorithms, but it lacks a few sections such as those made to support internationalization. The algorithm, however, is not optimized to the task at hand, (returning the remote host's file version), so it can be further trimmed down by making assumptions regarding the different sizes the algorithm tries to determine from the file, such as in the case of section sizes, resource locations, etcetera.

We can summarize the algorithms as follows:

1. Read the first 64 bytes off the file (*DOS_HEADER_SIZE).*
2. Verify that it contains the string MZ.
3. Return the PE_HEADER_OFFSET value from DOS_HEADER.
4. Read the first 4 bytes off the file while taking into account the offset (PE_SIGNATURE_SIZE).
5. Verify that it contains the string PE\0\0 (the letters P and E followed by two NULL characters).
6. Read 64 bytes off the file while taking into account the offset of PE_HEADER. This would return the Optional Header section.
7. Extract the NumberOfSections field found inside the Optional Header section
8. Extract the size of the OPTIONAL_HEADER_SIZE if it's larger than zero; align any future file reading accordingly.

9. Read the OPTIONAL_HEADER_SIZE data section and verify that it is in fact an Optional Header by verifying that the first two bytes are 0x0B and 0x01.
10. Extract the SectionAligment field from the Optional Header—this is optional, as most PE files are properly aligned.
11. Extract the FileAligment field from the Optional Header—this is optional, as most PE files are properly aligned.
12. Skip to the Section Table by moving out offset past the Optional Header section.
13. Read the first 40 bytes off the file while taking into account the offset we just calculated.
14. Extract the SectionName field by analyzing the first 8 bytes of the buffer we just read.
15. Compare the value given inside with the constant string .rsrc, if it isn't equal, return to step 13.
16. Extract the ResourceSectionVA, the resource section virtual address, by reading the 4 bytes that follow the SectionName.
17. Extract the ResourceSectionOffset by reading the 4 bytes that follow the ResourceSectionVA field.
18. Return to step 13 until the number of sections defined by NumberOfSections haves been processed.
19. Move our offset position to the last ResourceSectionOffset and read the first 16 bytes.
20. Extract the value of NumberOfTypes and NumberOfNames found at the beginning of the buffer.
21. Move forward our offset position by 16 bytes (IMAGE_RESOURCE_DIRECTORY_SIZE).
22. Move forward our offset position by NumberOfNames multiplied by 2 (for the Unicode calculation) and by 2 again (for the unsigned short calculation).
23. Now we can go through all the resources found and find the entry that lists the ProductVersion value.
24. Read the first 8 bytes off the file while taking into account the offset we just calculated (IMAGE_RESOURCE_DIRECTORY_ENTRY_SIZE).
25. Extract the ResourceName by reading the first 4 bytes from the buffer.
26. Compare it with 0x10000000 if no match, move the offset by 8 more bytes (IMAGE_RESOURCE_DIRECTORY_ENTRY_SIZE) and return to step 24.
27. If it matches, extract the ResourceOffset by reading the next 4 bytes.
28. Move the offset by the value found in ResourceOffset and ResourceSectionOffset.
29. Read the first 4 bytes off the file while taking into account the offset we just calculated.
30. Extract the value of NumberOfVersionResources and NumberOfVersionNames.

31. In the case where there is more than one NumberOfVersionResources or NumberofVersionNames, move the offset accordingly.
32. Read the first 8 bytes off the file while taking into account the offset we just calculated.
33. The first 8 bytes are the ResourceVirtualAddress, whereas the next 8 bytes are the ResourceVirtualAddressSize.
34. Once we have both of these values, we can read the content of the Virtual Address, and compare whether it contains the Unicode representation of the string ProductVersion; if it does pull out the ProductVersion value.
35. We are done.

The algorithms look complicated; however, it is much more efficient than reading 16 kilobytes. In fact much less bandwidth is required by the aforementioned algorithms. They are also faster than reading 16 kilobytes, as they require fewer large files reading via ReadAndX().

The following is a representation of how the new GetFileVersion() function would look:


```
#####
# Improved version of GetFileVersion by Beyond Security Ltd.
# Authors:
#               Noam Rathaus
#               Ami Chayun
#               Eli Kara

function GetFileVersionEx(socket, uid, tid, fid)
{
 debug_fileversion = 0;

 if (debug_fileversion)
 {
  include("dump.inc");
 }

 DOS_HEADER_OFFSET = 0;
 DOS_HEADER_SIZE = 64;
 USHORT_SIZE = 2;
 ULONG_SIZE = 4;
 local_var PE_HEADER_OFFSET;
 PE_HEADER_SIZE = 20;
 PE_SIGNATURE_SIZE = 4;
 OPTIONAL_HEADER_OFFSET = 0;
 OPTIONAL_HEADER_SIZE = 0;
 SECTION_HEADER_SIZE = 40;
 SECTION_NAME_LENGTH = 8;
 SECTION_NAME_RESOURCE = ".rsrc";

 IMAGE_RESOURCE_DIRECTORY_SIZE = 2*ULONG_SIZE + 4*USHORT_SIZE;
 IMAGE_RESOURCE_DIRECTORY_ENTRY_SIZE = 2*ULONG_SIZE;
 IMAGE_RESOURCE_DATA_ENTRY_SIZE = 4*ULONG_SIZE;
```

```
 UNICODE_PRODUCT_VERSION = raw_string("P", 0x00, "r", 0x00, "o", 0x00, "d", 0x00, "u",
0x00, "c", 0x00, "t", 0x00, "V", 0x00, "e", 0x00, "r", 0x00, "s", 0x00, "i", 0x00, "o",
0x00, "n", 0x00);
 UNICODE_FILE_VERSION = raw_string("F", 0x00, "i", 0x00, "l", 0x00, "e", 0x00, "V", 0x00,
"e", 0x00, "r", 0x00, "s", 0x00, "i", 0x00, "o", 0x00, "n", 0x00);

 # open the PE file and read the DOS header (first 64 bytes)
 # validate DOS signature and get pointer to PE signature
 section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, count:DOS_HEADER_SIZE,
off:DOS_HEADER_OFFSET);
 if (debug_fileversion)
 {
  dump(dtitle: "section", ddata: section);
  display("strlen(section): ", strlen(section), "\n");
 }

 if (strlen(section) == 0)
 {
  if (debug_fileversion)
  {
   display("File empty?! maybe I was unable to open it..\n");
  }
  return NULL;
 }

 DOSSig = substr(section, 0, USHORT_SIZE);

 if (debug_fileversion)
 {
  dump(dtitle: "DOSSig", ddata: DOSSig);
 }

 if (!((strlen(DOSSig) == 2) && (hexstr(DOSSig) == "4d5a")))
 { # not a MZ file
  display("invalid DOS signature or missing DOS header in PE file\n");
  return NULL;
 }

 # get pointer to PE signature (e_lfanew)
 data = substr(section, DOS_HEADER_SIZE-ULONG_SIZE, DOS_HEADER_SIZE);
 if (debug_fileversion)
 {
  dump(dtitle: "data PE_HEADER_OFFSET", ddata: data);
 }
 PE_HEADER_OFFSET = ord(data[0])+ord(data[1])*256;

 if (debug_fileversion)
 {
  display("PE_HEADER_OFFSET: ", PE_HEADER_OFFSET, "\n");
 }

 # get PE signature (validate it) and header
 section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, count:PE_SIGNATURE_SIZE,
off:PE_HEADER_OFFSET);
```

```
 if (debug_fileversion)
 {
  dump(dtitle: "PE", ddata: section);
 }

 PESig = substr(section, 0, PE_SIGNATURE_SIZE);

 if (debug_fileversion)
 {
  dump(dtitle: "PESig", ddata: PESig);
 }

 if (!((strlen(PESig) == 4) && (hexstr(PESig) == "50450000")))
 {
  display("invalid PE signature before PE header\n");
  return NULL;
 }

 # real offset to header
 PE_HEADER_OFFSET += PE_SIGNATURE_SIZE;
 if (debug_fileversion)
 {
  display ("* PE header found at offset ", PE_HEADER_OFFSET, "\n");
 }

 OPTIONAL_HEADER_OFFSET = PE_HEADER_OFFSET + PE_HEADER_SIZE;

 section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off: PE_HEADER_OFFSET, count:
PE_HEADER_SIZE);
 data = substr(section, 2, 2+USHORT_SIZE);
 nSections = ord(data[0]) + ord(data[1])*256;

 if (debug_fileversion)
 {
  display("* Number of sections: ", nSections, "\n");
 }

 data = substr(section, PE_HEADER_SIZE-(2*USHORT_SIZE), PE_HEADER_SIZE-USHORT_SIZE);
 OPTIONAL_HEADER_SIZE = ord(data[0]) + ord(data[1])*256;

 if (debug_fileversion)
 {
  display("* Optional header size: ", OPTIONAL_HEADER_SIZE, "\n");
 }

 # read optional header if present and extract file and section alignments
 if (OPTIONAL_HEADER_SIZE > 0)
 {
  section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off: OPTIONAL_HEADER_OFFSET,
count: OPTIONAL_HEADER_SIZE);
  OptSig = substr(section, 0, USHORT_SIZE);
  if (!((strlen(OptSig) == 2) && (hexstr(OptSig) == "0b01")))
  {
   display ("invalid PE optional header signature or no optional header found where one
SHOULD be!\n");
```

```
   return NULL;
  }

  # get file and section alignment
  data = substr(section, 8*ULONG_SIZE, 9*ULONG_SIZE);
  SectionAlignment = ord(data[0]) + ord(data[1])*256 + ord(data[2])*256*256 +
ord(data[3])* 256 * 256 * 256;

  if (debug_fileversion)
  {
   display("* Section alignment: ", SectionAlignment, "\n");
  }

  data = substr(section, 9*ULONG_SIZE, 10*ULONG_SIZE);

  FileAlignment = ord(data[0]) + ord(data[1]) * 256 + ord(data[2]) * 256 * 256 +
ord(data[3])* 256 * 256 * 256;
  if (debug_fileversion)
  {
   display ("* File alignment: ", FileAlignment, "\n");
  }
 }

 # iterate the section headers by reading each until we find the resource section (if
present)
 # we're starting right after the optional header

 pos = OPTIONAL_HEADER_OFFSET + OPTIONAL_HEADER_SIZE;
 local_var i;
 found = 0;
 local_var ResourceSectionVA;
 local_var ResourceSectionOffset;

 for(i = 0 ; (i < nSections) && (!found) ; i++)
 {
  # read section and get the name string
  section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off: pos, count:
SECTION_HEADER_SIZE);
  SectionName = substr(section, 0, strlen(SECTION_NAME_RESOURCE));

  if (debug_fileversion)
  {
   dump(dtitle: "SectionName", ddata: SectionName);
  }

  if (SectionName >< raw_string(SECTION_NAME_RESOURCE))
  {
   # found resource section, extract virtual address of section (VA for later use) and
offset to raw data
   found = 1;

   data = substr(section, SECTION_NAME_LENGTH + ULONG_SIZE, SECTION_NAME_LENGTH + 2 *
ULONG_SIZE - 1);
   ResourceSectionVA = ord(data[0]) + ord(data[1]) * 256 + ord(data[2]) * 256 * 256 +
ord(data[3]) * 256 * 256 * 256;
```

```
   if (debug_fileversion)
   {
    display("* Resource section VA: ", ResourceSectionVA, "\n");
   }

   data = substr(section, SECTION_NAME_LENGTH + (3*ULONG_SIZE), SECTION_NAME_LENGTH +
(4*ULONG_SIZE));
   ResourceSectionOffset = ord(data[0]) + ord(data[1]) * 256 + ord(data[2]) * 256 * 256 +
ord(data[3]) * 256 * 256 * 256;
   if (debug_fileversion)
   {
    display("* Resource section found at raw offset: ", ResourceSectionOffset, "\n");
   }
  }
  # we haven't found the resource section, move on to next section
  pos += SECTION_HEADER_SIZE;
 }

 if (!found)
 {
  display ("\n* Couldn't locate resource section, aborting..\n");
  return NULL;
 }

 # moving to the rsrc section, reading the first RESOURCE_DIRECTORY which is the root of
the resource tree
 # read the number of resource types
 pos = ResourceSectionOffset;
 section = ReadAndX(socket:soc, uid: uid, tid: tid, fid: fid, off: pos, count:
IMAGE_RESOURCE_DIRECTORY_SIZE);

 if (debug_fileversion)
 {
  dump(dtitle: "section of rsc", ddata: section);
 }

 data = substr(section, IMAGE_RESOURCE_DIRECTORY_SIZE-USHORT_SIZE,
IMAGE_RESOURCE_DIRECTORY_SIZE);
 nTypes = ord(data[0]) + ord(data[1])*256;

 data = substr(section, IMAGE_RESOURCE_DIRECTORY_SIZE - (2 * USHORT_SIZE),
IMAGE_RESOURCE_DIRECTORY_SIZE - USHORT_SIZE - 1);
 nNames = ord(data[0]) + ord(data[1]) * 256;

 if (debug_fileversion)
 {
  display("* Number of resource names at root node: ", nNames, "\n");
 }

 # optional step if there are resource names would be to SKIP them :)
 # This is because resource names at the root node CANNOT be a Version resource type, at
the root they
 # are always user-defined types

 pos += IMAGE_RESOURCE_DIRECTORY_SIZE;   # offset to entries array
```

```
 if (nNames > 0)
 {
  pos += 2*nNames*ULONG_SIZE;
 }

 if (debug_fileversion)
 {
  display("* Number of resource types (RESOURCE_DIRECTORY_ENTRYs in root node): ", nTypes,
"\n");
 }

 # iterate the resource types and locate Version information resource
 # node offsets are from the BEGINNING of the raw section data
 # our 'pos' was already incremented to skip over to the entries

 local_var ResourceName;
 local_var ResourceOffset;

 found = 0;
 for(i = 0 ; (i < nTypes) && (!found) ; i++)
 {
  # get one RESOURCE_DIRECTORY_ENTRY struct and check name
  # in the root level, resource names are type IDs. Any ID not listed in the spec is user-
defined
  # any name (not ID) is always user-defined here
  section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off: pos, count:
IMAGE_RESOURCE_DIRECTORY_ENTRY_SIZE);
  ResourceName = substr(section, 0, ULONG_SIZE);
  if (((strlen(ResourceName) == 4) && (hexstr(ResourceName) == "10000000")))
  {
   # found it, get the offset and clear the MSB (but consider that the byte ordering is
reversed)
   found = 1;
   data = substr(section, ULONG_SIZE, 2 * ULONG_SIZE - 1);

   if (debug_fileversion)
   {
    dump(dtitle: "ResourceOffset", ddata: data);
   }

   ResourceOffset = ord(data[0]) + ord(data[1]) * 256 + ord(data[2]) * 256 * 256 +
(ord(data[3]) & 127) * 256 * 256 * 256;

   if (debug_fileversion)
   {
    display("* Version resources found at offset ", ResourceSectionOffset+ResourceOffset,
"\n");
   }
  }
  pos += IMAGE_RESOURCE_DIRECTORY_ENTRY_SIZE;   # next entry
 }

 if (!found)
 {
```

```
  display ("\n* Couldn't find any Version information resource in resource section,
aborting..\n");
  return NULL;
 }

 # found Version resource in tree, now we parse ID or name, there should only be one
Version resource here
 # offset from beginning of raw section data
 pos = ResourceSectionOffset + ResourceOffset;
 section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off: pos, count:
IMAGE_RESOURCE_DIRECTORY_SIZE);
 data = substr(section, IMAGE_RESOURCE_DIRECTORY_SIZE-USHORT_SIZE,
IMAGE_RESOURCE_DIRECTORY_SIZE);
 nVersionResources = ord(data[0]) + ord(data[1])*256;

 data = substr(section, IMAGE_RESOURCE_DIRECTORY_SIZE-(2*USHORT_SIZE),
IMAGE_RESOURCE_DIRECTORY_SIZE-USHORT_SIZE);
 nVersionNames = ord(data[0]) + ord(data[1])*256;

 if (debug_fileversion)
 {
  display("* Number of Version resource IDs: ", nVersionResources," \n");
  display("* Number of Version resource Names: ", nVersionNames, "\n");
 }

 # TODO: iterate the resource names and IDs in case there is more than 1 (highly unlikely)
 # for now just use the first ID
 pos += IMAGE_RESOURCE_DIRECTORY_SIZE;  # offset to entries array
 section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off:pos,
count:IMAGE_RESOURCE_DIRECTORY_ENTRY_SIZE);
 data = substr(section, ULONG_SIZE, 2*ULONG_SIZE);
 ResourceOffset = ord(data[0]) + ord(data[1])*256 + ord(data[2])*256*256 + (ord(data[3]) &
127)* 256 * 256 * 256;

 if (debug_fileversion)
 {
  display ("* Language ID node found at offset ", ResourceSectionOffset+ResourceOffset,
"\n");
 }

 # we're in the language ID node, just going one more level to get to the DATA_DIRECTORY
struct
 # TODO: check that there are no more than 1 language IDs and if so take the default
0x0409 (us-en)
 pos = ResourceSectionOffset + ResourceOffset;
 section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off:pos,
count:IMAGE_RESOURCE_DIRECTORY_SIZE);
 nLanguageIDs = substr(section, IMAGE_RESOURCE_DIRECTORY_SIZE-USHORT_SIZE,
IMAGE_RESOURCE_DIRECTORY_SIZE);
 pos += IMAGE_RESOURCE_DIRECTORY_SIZE; # go to the entries array

 section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off:pos,
count:IMAGE_RESOURCE_DIRECTORY_ENTRY_SIZE);
 data = substr(section, 0, ULONG_SIZE);
```

```
 ResourceName = ord(data[0]) + ord(data[1])*256 + ord(data[2])*256*256 + ord(data[3])* 256
* 256 * 256;

 data = substr(section, ULONG_SIZE, 2*ULONG_SIZE);
 ResourceOffset = ord(data[0]) + ord(data[1])*256 + ord(data[2])*256*256 + ord(data[3])*
256 * 256 * 256;

 if (debug_fileversion)
 {
  display("* Found ", nLanguageIDs, " language IDs in node: ");
  display("Language ID ", ResourceName, ", Offset ", ResourceSectionOffset+ResourceOffset,
"\n");
 }

 # we're in the RESOURCE_DATA_ENTRY which is the last leaf. It's the one pointing to the
 # raw resource binary block. However, only the VA is given so a bit calculation is needed
 pos = ResourceSectionOffset + ResourceOffset;

 if (debug_fileversion)
 {
  display("ResourceSectionOffset + ResourceOffset: ", pos, "\n");
 }

 section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off:pos,
count:IMAGE_RESOURCE_DATA_ENTRY_SIZE);
 data = substr(section, 0, ULONG_SIZE);
 ResourceVA = ord(data[0]) + ord(data[1])*256 + ord(data[2])*256*256 + ord(data[3])* 256 *
256 * 256;

 if (debug_fileversion)
 {
  display("ResourceVA calculated: ", ResourceVA, "\n");
 }

 data = substr(section, ULONG_SIZE, 2*ULONG_SIZE);
 ResourceSize = ord(data[0]) + ord(data[1])*256 + ord(data[2])*256*256 + ord(data[3])* 256
* 256 * 256;

 if (debug_fileversion)
 {
  display("ResourceSize calculated: ", ResourceSize, "\n");
 }

 ResourceOffset = ResourceVA - ResourceSectionVA;

 if (debug_fileversion)
 {
  display("* Raw version resource VA: ", ResourceVA, " (raw offset: ",
ResourceSectionOffset+ResourceOffset, "), Size: ", ResourceSize, "\n");
 }

 # read the raw block and look for the UNICODE string 'Product Version'
 pos = ResourceSectionOffset + ResourceOffset;

 section = ReadAndX(socket: soc, uid: uid, tid: tid, fid: fid, off:pos, count:ResourceSize);
```

```
if (debug_fileversion)
{
 dump(dtitle: "Product Version chunk", ddata: section);
}

# look for ProductVersion string
stroff = -1;
stroff = stridx(section, UNICODE_PRODUCT_VERSION);
if (stroff >= 0)
{
 data = substr(section, stroff-4, stroff-4+USHORT_SIZE);
 if (debug_fileversion)
 {
  dump(dtitle: "UNICODE_PRODUCT_VERSION", ddata: data);
 }

 len = ord(data[0]) + ord(data[1])*256;
 if (debug_fileversion)
 {
  display("len: ", len, "\n");
 }

 start = stroff+strlen(UNICODE_PRODUCT_VERSION)+2;
 end = stroff+strlen(UNICODE_PRODUCT_VERSION)+2+2*(len)-2;

 if (debug_fileversion)
 {
  display("start: ", start, " end: ", end, "\n");
 }

 ProductVersion = substr(section, start, end);

 if (debug_fileversion)
 {
  dump(dtitle: "RAW ProductVersion", ddata: ProductVersion);
 }

 ProductVersion = str_replace(find:raw_string(0), replace:"", string:ProductVersion);
 if (debug_fileversion)
 {
  display("\n* ProductVersion: ", ProductVersion, "\n");
 }

 return ProductVersion;
}

stroff = -1;
stroff = stridx(section, UNICODE_FILE_VERSION);
if (stroff >= 0)
{
 data = substr(section, stroff-4, stroff-4+USHORT_SIZE);
 if (debug_fileversion)
 {
  dump(dtitle: "UNICODE_FILE_VERSION", ddata: data);
 }
```

```
  len = ord(data[0]) + ord(data[1])*256;
  if (debug_fileversion)
  {
   display("len: ", len, "\n");
  }

  start = stroff+strlen(UNICODE_FILE_VERSION)+2;
  end = stroff+strlen(UNICODE_FILE_VERSION)+2+2+2*(len);
  if (debug_fileversion)
  {
   display("start: ", start, " end: ", end, "\n");
  }

  FileVersion = substr(section, start, end);

  if (debug_fileversion)
  {
   dump(dtitle: "RAW FileVersion", ddata: FileVersion);
  }

  FileVersion = str_replace(find:raw_string(0), replace:"", string:FileVersion);
  if (debug_fileversion)
  {
   display("* FileVersion: ", FileVersion, "\n");
  }

  return FileVersion;
 }

 return NULL;
}
```

You can learn more about PE by going to Microsoft Portable Executable and Common Object File Format Specification at www.microsoft.com/whdc/system/platform/firmware/PECOFF.mspx.

Final Touches

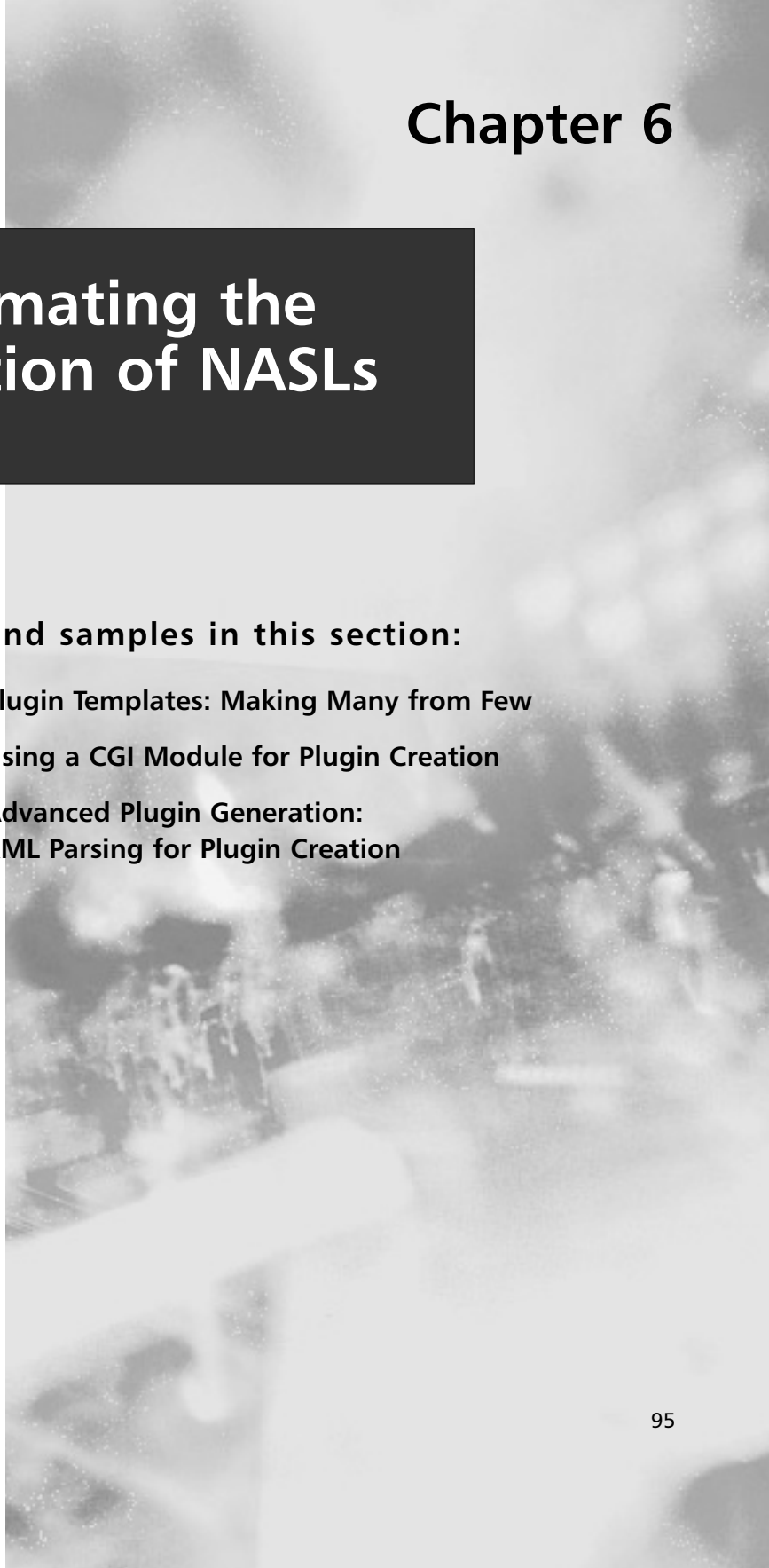
You have learned how to improve the three mechanisms provided by the Nessus environment. Once these mechanisms are improved they will each contribute to making the test being launched by the Nessus environment become more accurate and faster. Each of these mechanisms can be improved without harming or modifying large sections of the Nessus code base. Moreover, each of these mechanisms can be improved by better implementing the protocol that the Nessus functionality tried to implement.

Chapter 6

Automating the Creation of NASLs

Scripts and samples in this section:

- **Plugin Templates: Making Many from Few**
- **Using a CGI Module for Plugin Creation**
- **Advanced Plugin Generation: XML Parsing for Plugin Creation**



In This Toolbox

Nessus' most powerful feature is that it enables users to write custom plugins. At first glance, writing your own plugin seems to be an intimidating job, requiring deep knowledge in security and networking. This chapter's goal is to present several tools to automate and simplify plugin creation. First, we will examine the similarities among plugins from the same family with the goal of creating templates that can be used for more than one plugin. Second, we will discuss the more general approach to plugin creation using XML (Extensible Markup Language) data structures.

Plugin Templates: Making Many from Few

To get the most out of Nessus, you need powerful plugins. An effective plugin should have maximum detection abilities and minimum false positives. Instead of reinventing the wheel for every plugin, templates provide a solid and tested base for entire plugin families. In this section, we will discuss templates that you can create for Web applications.

Web applications have gained increasing popularity in the last couple of years. Additionally, Web standards allow Web applications (if written properly) to be almost platform-independent.

Web applications typically include several security issues, some of them quite different from the ones classic applications suffer. Because the user has much more control over the input the application receives, the application must enforce strict content filtering. Insufficient content filtering is the main cause of all Web application security problems.

Common Web Application Security Issues

The security issues that we will discuss here are divided into two distinct families; server-side execution and client-side execution. In the first type of vulnerability, the attacker has control over code being run on the application server itself, whether the application is running the script (PHP, or Hypertext Preprocessor, engine, for example) or a database that the application communicates with. The latter type allows an attacker to inject code that runs on clients of the application.

Server-Side Execution (SQL Injection, Code Inclusion)

Common server-side execution techniques include SQL injection and code inclusion. In this section we will cover the subject only superficially because there are many resources about this subject available on the Internet. The following paragraphs, will, however, describe the subject briefly. This background information was taken from frequently asked questions that appeared on a Web page titled "SQL Injection Walkthrough" on Beyond Security's Securiteam Web site, *http://www.securiteam.com/securityreviews/5DP0N1P76E.html*.

SQL (Structured Query Language) injection is a trick to inject SQL queries and commands as input via Web pages. Many Web pages take parameters from users, and make SQL queries to the database. For instance, when a user logs in, the login Web page queries the database to determine if that username and password are valid. Using SQL injection, someone can send a crafted username and/or password field that will change the SQL query and grant that person gained privileges (i.e., arbitrary access to the database).

When trying to determine SQL injection vulnerabilities, you should look for pages that allow you to submit data such as login page, search pages, and so on. Sometimes HTML pages use the POST command to send parameters to another active server page (ASP). Therefore, you may not see the parameters in the URL. However, you can check the source code of the HTML and look for the *FORM* tag in the HTML code. You may find something like this in some HTML codes:

```
<FORM action=Search/search.asp method=post>
<input type=hidden name=A value=C>
</FORM>
```

Everything between <*FORM*> and </*FORM*> has parameters that could potentially be exploited.

You should also look for vulnerabilities on ASP, Java Server Page (JSP), Common Gateway Interface (CGI), or PHP Web pages with URLs like **http://duck/index.asp?id=10**.

Any page containing URL encoded parameters, like *id* in the preceding example, is interesting and should be tested for SQL injection.

Once you have located a potentially vulnerable Web page, you can test it for vulnerabilities. Start with a single quote trick. Enter something like **hi'** or **1=1--**in the login, password, or URL (Uniform Resource Locator) field.

If you must do this with a hidden field, just download the source HTML from the site, save it in your hard disk, and modify the URL and hidden field accordingly. For example:

```
<FORM action=http://duck/Search/search.asp method=post>
<input type=hidden name=A value="hi' or 1=1--">
</FORM>
```

If there is a vulnerability, you will be able to log in without a valid username or password.

Let us look at why **'** or **1=1--** is important. Other than bypassing login pages, it is also possible to view extra information that is not normally available. Take an ASP that will link you to another page using the URL

http://duck/index.asp?category=food.

In the URL, *category* is the variable name, and *food* is the value assigned to the variable. In this case, an ASP might contain the following code:

```
v_cat = request("category")
sqlstr="SELECT * FROM product WHERE PCategory='" & v_cat & "'"
set rs=conn.execute(sqlstr)
```

As you can see, the variable will be wrapped into v_cat and thus the SQL statement should become:

```
SELECT * FROM product WHERE PCategory='food'
```

The query should return a result set containing one or more rows that match the WHERE condition, in this case, *food*.

Now, assume that we change the URL into something like this: http://duck/index.asp?category=food' or 1=1--

Now, our variable v_cat equals *food* or 1=1-- ‘. If we substitute this in the SQL query, we will have:

```
SELECT * FROM product WHERE PCategory='food' or 1=1--'
```

The query should now select everything from the product table regardless if PCategory is equal to food or not. A double dash (--) tells the SQL server to ignore the rest of the query, which will get rid of the last hanging single quote (‘). Sometimes, it may be possible to replace double dash with single hash (#).

However, if it is not an SQL server, or you simply cannot ignore the rest of the query, you also may try:

```
' or 'a'='a
```

The SQL query will now become:

```
SELECT * FROM product WHERE PCategory='food' or 'a'='a'
```

And it should return the same result.

Client-Side Execution (Code Injection, Cross-Site Scripting, HTTP Response Splitting)

On the other side of the Web application vulnerability rainbow are the client-side vulnerabilities. This type of vulnerability is caused by the same issue as SQL injections: unfiltered user parameters. When user parameters are passed to the Web application, they can contain HTML (Hypertext Markup Language) or HTTP (Hypertext Transfer Protocol) special characters. Even if the input is never used in SQL or exec commands, an attacker can use this weakness if the user input is printed back by the script as a result. For example, if the user is required to fill his or her name in an HTML field, the HTML source can look something like:

```
<INPUT NAME="username" VALUE="please provide a valid username">
```

The attacker can enter something like:

```
 "><SCRIPT SRC="http://hostilepage/evilscript.asp"></SCRIPT>
```

If the content is printed back unfiltered, the resultant HTML will include:

```
<INPUT NAME="username" VALUE=" "><SCRIPT SRC="http://hostilepage/evilscript.asp"></SCRIPT>
">
```

As you can see, the attacker injected arbitrary HTML code into the original HTML page, and the resultant HTML will run the attacker’s script.

This is, of course, being run on the client browser, not on the server. This does present a threat, though. For example, let us assume that a company holds a Web portal for its employees.

If the company’s site is vulnerable to cross-site scripting, an attacker can exploit the vulnerability combined with some social engineering. The attacker can send an e-mail to all the employees of the company, falsely stating that all the employees must renew their passwords owing to a problem in the database. The e-mail would also contain a link that points to the company’s site. To the untrained eye it will look valid, but actually it will point the person to the attacker’s page to harvest passwords.

Creating Web Application Plugin Templates

Let's begin with an example, a plugin that tests a simple SQL Injection vulnerability in phpBB's (http://phpbb.com) Calendar Pro Mod (www.securiteam.com/exploits/5XP021FFGU.html).

The first part is divided into two sections: The first part of the plugin is the description used if the vulnerability was detected. Usually the description supplies details on the vulnerable product, the vulnerability, and a proposed solution. The second part runs the test and detects the vulnerability.

```
#
# Copyright 2005 Ami Chayun
#
if (description) {
  script_version("$Revision: 1.0 $");

  name["english"] = "SQL Injection in phpBB 2.0.13 Calendar Pro Mod";
  script_name(english:name["english"]);

  desc["english"] = "
The remote host is running a version of phpBB that suffers from an SQL injection flaw in
the cal_view_month.php script.
An attacker can execute arbitrary SQL commands by injecting SQL code in the category
parameter.

Solution : Upgrade to a version after phpBB 2.0.13 when it becomes available and disable
the Calendar Pro mod until then.

Risk factor : Medium";
  script_description(english:desc["english"]);

  summary["english"] = "Checks for SQL injection in phpBB Calendar Pro Mod";
  script_summary(english:summary["english"]);

  script_category(ACT_GATHER_INFO);
  script_copyright(english:"This script is Copyright (C) 2005 Ami Chayun");

  family["english"] = "CGI abuses";
  script_family(english:family["english"]);

  script_require_ports("Services/www", 80);
  exit(0);
}

include("http_func.inc");
include("http_keepalive.inc");
# Test starts here
port = get_http_port(default:80);
if (!get_port_state(port)) exit(0);

req = http_get(item: "/cal_view_month.php?&month=04&year=2005&category='&action=print",
port:port);
buf = http_keepalive_send_recv(port:port, data:req, bodyonly:1);
```

```
if(buf == NULL)exit(0);

if("SQL Error : 1064" >< buf)
        security_warning(port);
```

Detecting Vulnerabilities

So how does the plugin detect the vulnerability? The vulnerability occurs in the *category* parameter of the script. We are able to inject arbitrary SQL content into the script by requesting a page like:

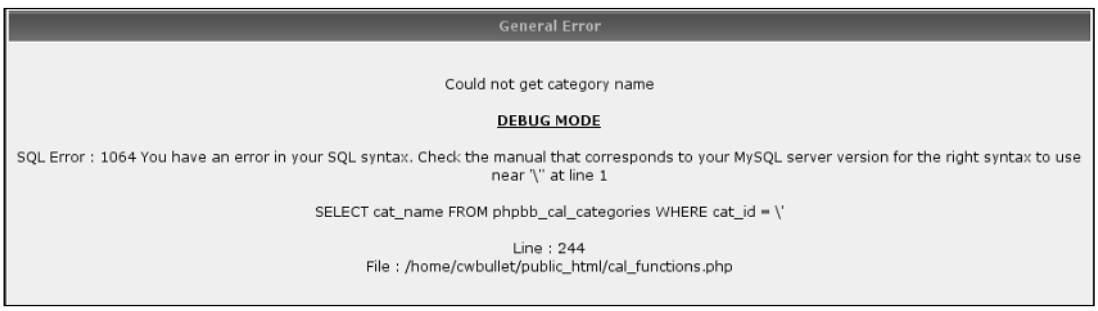
http://target/cal_view_month.php?month=04&year=2005&**category='**&action=print

As shown in Figure 6.1, a vulnerable server would usually contain the following text in the reply:

"SQL Error: 1064 You have an error in your SQL syntax near '\" at line 1."

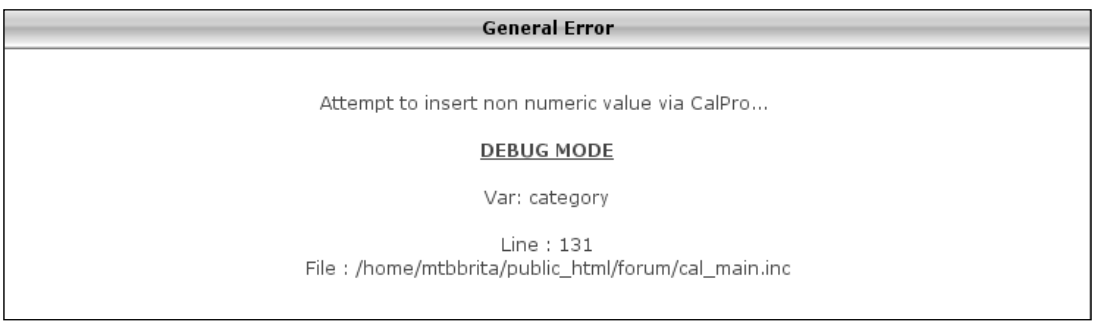
```
SELECT cat_name FROM phpbb_cal_categories WHERE cat_id = \'
```

Figure 6.1 Exploiting a Vulnerability on a Vulnerable Site



The vendor released a patch for the issue, and trying to exploit the vulnerability on an immune site should give a reply like the one shown in Figure 6.2.

Figure 6.2 Exploiting a Vulnerability on an Immune Site



The script requests the vulnerable page with an injected quote ('). This will trigger the SQL injection and will output the desired error. If the error is found in the reply, we can conclude that the target host is vulnerable.

Making the Plugin More General

Let's start generalizing the plugin. From here on we will change only the test itself; the description will be written again only if it is changed.

Parameterize the Detection and Trigger Strings

We are interested in a plugin suitable for general purposes, so we need to parameterize the URI that triggers the error and the error string:

```
...
vulnerable_string = "SQL Error : 1064";
page = "cal_view_month.php";
params = "month=04&year=2005&category='&action=print";
uri = "/"+page+params;
req = http_get(item:uri, port:port);
buf = http_keepalive_send_recv(port:port, data:req, bodyonly:1);
if(buf == NULL)exit(0);
if(vulnerable_string >< buf)
        security_warning(port);
```

After getting the strings out of the code, we can replace them with appropriate tags:

```
port = get_http_port(default:80);
if (!get_port_state(port)) exit(0);
vulnerable_string = "<VulnerableString/>";
page = "<Page/>";
params = "<CGIParams/>";
uri = string("/", page, params);
req = http_get(item:uri, port:port);
buf = http_keepalive_send_recv(port:port, data:req, bodyonly:1);
if(buf == NULL)exit(0);
if(vulnerable_string >< buf)
        security_warning(port);
```

Allow Different Installation dirs

Another thing to consider is the installation path. What if the script is installed under /cgi-bin and not in the Web server root? Nessus supplies us with a function just for this:

The *cgi_dirs()* function in the http_func include file will return the default installation path cgi-bin (in apache) and /scripts (in IIS). If the user configured custom Web dirs in the knowledge base, they will also be included.

An extended functionality is included in the *DDI_Directory_Scanner.nasl* plugin, which scans for more than 700 known paths. This capability, combined with *webmirror.nasl*, which will be discussed next, provides accurate mapping of the target's CGI paths. Both *DDI_Directory_Scanner.nasl* and *webmirror.nasl* update the *cgi_dirs* list, so the only requirement is to include either *DDI_Directory_Scanner.nasl* or *webmirror.nasl* (as it includes *DDI_Directory_Scanner.nasl*) in the script dependencies.

Webmirror.nasl is a directory crawler, which allows a method of mapping a Web server by the contents of its pages. For example, if the main index page contains a link to: */my-cgis/login.php*,

webmirror will add the *my-cgis* directory to the *cgi_dir()* list. This, of course, simplifies the work of our plugin because we can use the knowledge gathered from this plugin in our test.

So the general approach to test under several directories will be:

```
foreach d (cgi_dirs())
{
 req = http_get(item:string(d, uri), port:port);
 buf = http_keepalive_send_recv(port:port, data:req,  bodyonly:1);
 if(buf == NULL) exit(0);
 if(vulnerable_string >< buf)
 {
   security_warning(port);
   exit(0);
 }
}
```

NOTE

The downside of depending on *webmirror.nasl* or its counterpart, *DDI_Directory_Scanner.nasl,* is the fact that these tests take a substantial amount of time to run, especially on a Web server containing a lot of content or that responds slowly. When testing the plugin before releasing it, you can remove *webmirror.nasl from the dependency list.*

Also, if you plan to run your plugin as a stand-alone, or if you are sure that the target application is installed in one of the default paths, it is not absolutely necessary to depend on the webmirror.nasl or DDI_Directory_Scanner.nasl plugins. For general usage, however, we highly recommend using these plugins.

Another important task is to check whether the page actually exists. This can be done with *is_cgi_installed_ka* in *http_func.*

```
 if(is_cgi_installed_ka(item: string(d, page), port:port))
 {
  req = http_get(item:string(d, uri), port:port);
  buf = http_keepalive_send_recv(port:port, data:req,
...
}
```

Allow Different HTTP Methods

HTTP supports two major protocols to send form information: one is URI-encoded GET, and the other is POST. Parameters passed in the GET method are written after a question mark (?), for example, http://target/page.cgi?param=value.

The actual HTTP request will look like the following:

```
GET /page.cgi?param=value HTTP/1.1
Host: target
...
```

Passing parameters via GET is simple because it can be written as a URI (link to a browser) where a POST command requires a FORM part in the HTML. The main reason POST is

sometimes preferred over GET is that some Web servers enforce maximum size on URI length, limiting the amount of data that can be sent.

The same command in POST will look like the following:

```
<form action="/page" method="POST">
<input type="hidden" name="param" value="value">
<input type=submit value="Click Me" name="button">
</form>
```

According to the preceding command, the user will see a **Click Me** button. When this button is clicked, the browser will perform a POST request like the following:

```
POST  /page.cgi HTTP/1.1
Host: target
Content-Type: application/x-www-form-urlencoded
Content-Length: 27
param=value&button=Click+Me
...
```

The same parameters that were passed in the URI of the GET request are now encoded in the body of the POST request. Because there is no limit to the size of the body, we must pass the server the length of the content, in this case 27.

We want to be able to test SQL injection in POST as well as GET; therefore, we can change the template to allow the user to select the preferred method:

```
  if(method == "GET")
  {
   uri = string(d, page, "?", cgi_params);
   req = http_get(item: uri, port:port);
  }
  else if (method == "POST")
  {
   req = http_post(item: string(d, page), port:port);
   idx = stridx(req, '\r\n\r\n');
   req = insstr(req, '\r\nContent-Length: ' + strlen(data) + '\r\n' +
     'Content-Type: application/x-www-form-urlencoded\r\n\r\n' + cgi_params, idx);
  }
  buf = http_keepalive_send_recv(port:port, data:req, bodyonly:1);
  if(buf == NULL)exit(0);
...
```

Multiple Attack Vectors

The power of a good plugin is in its attack vector. A string that would set off a vulnerability in one product can be useless in another. Server reply strings are even more complicated and can be completely different from one product version to the next.

The plugin template presented in this section aims to help the user build an effective plugin with minimum effort. To provide this, we need to generalize the mechanism that searches for the vulnerability.

Until now, the user supplied a URI and an expected response. How about letting the plugin do the hard work for us?

We add this code to the beginning of the test, letting the users be as flexible as they need:

```
user_vulnerable_string = "";
user_trigger_string = "";
vulnerable_param = "category";

page = string("/","cal_view_month.php");
cgi_params = "month=04&year=2005&category=&action=print";

test_dir_traversal = 1;
test_sql_injection = 1;
test_xss = 1;
```

First, we provide a valid page and parameter set, so our requests are legal to the target application. Next, we provide a vulnerable CGI parameter name. We suspect that the *category* parameter is vulnerable to SQL injection, so we mark that we want to test for SQL injection. We know that the vendor fixed the SQL injection in this parameter, but was the cross-site scripting fixed, too? We would like to know, so we mark all three test options.

The next part of this addition is the attack vectors themselves. Here are some common attack vectors and reply strings to match them:

```
###
# Attack vectors
dir_traversal[0] = "/etc/passwd";
dir_traversal[1] = "../../../../../../../../../etc/passwd";
dir_traversal[2] = "../../../../../../../../../etc/passwd%00";

passwd_file[0]   = "root:";

sql_injection[0] = "'";
sql_injection[1] = "%27";
sql_injection[2] = " group by";

sql_error[0]     = "SQL Error : 1064";
sql_error[1]     = "ODBC Microsoft Access Driver";
sql_error[2]     = "SQLServer JDBC Driver";
sql_error[3]     = "Microsoft JET Database Engine error '80040e14'";

XSS[0]           = "<script>alert(document.cookie)</script>";
XSS[1]           = "%22%3E%3Cscript%3Ealert%28document.cookie%29%3C%2Fscript%3E";
XSS[2]           = "%22+onmouseover%3D%22javascript:alert%28%27foo%27%29%22+%22";

XSS_reply[0]     = "<script>alert(document.cookie)</script>";
XSS_reply[1]     = "javascript:alert('foo')";
```

From these attack vectors we can build the pool of options we will have for the attack. We build a list of trigger strings and vulnerable reply strings:

```
trigger_strings = make_list(user_trigger_string);
vulnerable_strings = make_list(user_vulnerable_string);
if(test_dir_traversal)
{
    trigger_strings = make_list(trigger_strings, dir_traversal);
    vulnerable_strings = make_list(vulnerable_strings, passwd_file);
```

```
}
if(test_sql_injection)
{
    trigger_strings = make_list(trigger_strings, sql_injection);
    vulnerable_strings = make_list(vulnerable_strings, sql_error);
}
if(test_xss)
{
    trigger_strings = make_list(trigger_strings, XSS);
    vulnerable_strings = make_list(vulnerable_strings, XSS_reply);
}
```

The *user_trigger_string* and *user_vulnerable_string* are custom strings the user can add for the test without modifying the generic strings.

Now for the test loop itself (this loop shows only the GET method. See the complete template later for the entire loop):

```
foreach d ( cgi_dirs() )

{
  if(is_cgi_installed_ka(item: string(d, page), port:port))
  {
  foreach trigger_string (trigger_strings)
  {
   attack_vector = ereg_replace(string:cgi_params,
                       pattern:vulnerable_param + "=[^&]*",
                       replace:vulnerable_param + "="+ trigger_string);

    uri = string(d, page, "?", attack_vector);
    req = http_get(item: uri, port:port);
   #Send the request, and put in buf the response (body only or entire result)
   buf = http_keepalive_send_recv(port:port, data:req, bodyonly:test_only_body);
   if(buf == NULL) exit(0);
   foreach vulnerable_string (vulnerable_strings)
   {
    if(strlen(vulnerable_string) > 0 && vulnerable_string >< buf)
    {
     display(req,"\n");
     security_warning(port);
     exit(0);
    }
   }
  } #foreach attack vector
 } #Is CGI installed
} #foreach web dir
```

The test is performed in two parts. First, we make sure the page we want exists in the current directory. Then we take the original parameter list and change it to contain the trigger string. The regular expression grabs the *vulnerable_param=value* part of the parameter list. We then replace it with *vulnerable_param=trigger_string* to try to trigger the vulnerability.

The second part of the test id is the detection string in the server response. For each of the strings in hand, we try to see if the information we want exists in the response.

This algorithm actually performs a comprehensive test for all the known attack vectors. This allows the user to perform vulnerability research on a specific Web application; all you need to pass to the NASL is the parameter you suspect to be vulnerable, and the test will work its magic.

We now have several vulnerabilities at our disposal, so it would be wise to alert the user about the exact situation that triggered the vulnerability. If we detect a vulnerability, we return the exact details in the security warning:

```
if(strlen(vulnerable_string) > 0 && vulnerable_string >< buf)
   {
    report = "By injecting: '" + trigger_string +
             "' to the '" + vulnerable_param +
             "' parameter of " + page + " via " + method +
             ", we were able to trigger the following response '" +
             vulnerable_string;

    security_warning(port:port, data:report);
    exit(0);
   }
```

Swiss Army Knife…

Creepy Crawlers: Learn More about Web Application Vulnerability Scanning

Writing a test for a specific Web application security flaw is one thing, but finding new flaws in custom in-house applications is a completely different art. The Whisker project provides a framework in Perl that supplies functionality for HTTP-based vulnerability testing. For more information visit the tool's Web page at www.wiretrip.net/rfp/lw.asp.

The most popular application based on this library is Nikto (www.cirt.net/code/nikto.shtml). It performs a thorough scan of a Web server for many known Web-based security flaws.

Nessus also has its own Web application scanner, a test known as *torturecgis.nasl*. This test runs a set of attack vectors on each of the CGIs discovered by *webmirror.nasl*.

Think you can do even better? The templates described here can easily be turned into your own personal Web application scanners. Once you are thoroughly acquainted with Nessus' built-in functionality, you can write a plugin that scans your in-house application for an abundance of security holes and flaws.

Increasing Plugin Accuracy

The weak spot of every security analysis is its credibility. If you fail to detect a real vulnerability, you're in trouble. If you falsely detect a vulnerability, you're in trouble again. What causes these troubles, and how can we overcome them?

The "Why Bother" Checks

If the target host doesn't run an HTTP server, there is no point in testing it for SQL injection, right?

A plugin can run a series of tests to avoid being run uselessly:

- **Test if the service is running on the target host**. This is done with the following commands:

```
script_require_ports("Services/www", 80);
and in the plugin body:
port = get_http_port(default:80);
if (!get_port_state(port)) exit(0);
```

  These lines determine if a Web server is running on the target host and will abort if it is not.

- **Test for server capabilities**. Let's assume we are testing for a vulnerability in an ASP-based Web application. Testing a target running Apache HTTP server is quite futile, as Apache cannot serve ASP pages. Nessus provides the functionality to test for server capabilities with the *can_host_php* and *can_host_asp* functions in *http_func*. Before we decide if we want to use these functions, first let's see how this check is being done.

  Every Web server should return a *Server* header when it replies to any HTTP request. For Apache HTTP server, this header usually looks like the following:

```
Server: Apache/1.3.27 (Linux/SuSE) PHP/4.3.1 mod_perl/1.27 mod_ssl/2.8.12
OpenSSL/0.9.6i
```

  The server declares it is an Apache server and lists its capabilities (mod_perl, mod_ssl, OpenSSL version and PHP). It makes sense to look in this reply to see whether we should run the test or not.

  An IIS server will usually answer with the simple header, "Server: Microsoft-IIS/6.0," stating only that it is in fact a Microsoft IIS server, and its version.

  Looks quite simple, right? Actually too simple. In the effort to enforce security on Web servers, a popular trend requires diligent system administrators to obscure the *Server* header as much as possible. Load balancers and other content-aware firewalls also sometimes decide that the *Server* header is too informative and cut it to a bare minimum. Even though the *can_host_** functions try to evade such tricks, it is still easily fooled, and the user should consider whether to test for capabilities beforehand.

  One trick up our sleeves comes again from the friendly *webmirror.nasl* plugin. When webmirror crawls the target's Web site, it will look for PHP and ASP pages; if it stumbles upon any, it will make sure to set the *can_host_php* and *can_host_asp* reliably, even if the Web server banner does not include any useful information.

Avoiding the Pitfalls

Here are some ways to avoid pitfalls:

- **Test for generic XSS.** Assume the following scenario. You have discovered a new vulnerability in a popular Web platform. The reckless designers forgot to test the *id* parameter for metacharacters, allowing any hacker to show his l33t skillz (http://en.wikipedia.org/wiki/Leet), take over the board and write his too-cool name everywhere. You are eager to write a test for Nessus and gain eternal glory. Your test looks something like the following:

```
if (description)
{
 script_name(english:"Popular Web Forum (R) XSS");
 desc["english"] = "A serious security flaw in Popular Web Forum 2.0.13 allows an
attacker to run arbitrary commands on your host.
Solution : Reinstall from scratch. No one is safe!
Risk factor : High";
script_description(english:desc["english"]);
}
include("http_func.inc");
include("http_keepalive.inc");
port = get_http_port(default:80);
if(!get_port_state(port))exit(0);
req = http_get(item:
"/index.asp?id=%3cscript%3ealert('I%20was%20here')%3c/script%3e", port:port);
buf = http_keepalive_send_recv(port:port, data:req, bodyonly:1);
if(buf == NULL)exit(0);
if("<script>alert('I was here')</script>" >< buf)
  security_warning(port);
```

  Besides the writer's overenthusiasm, this plugin suffers from a serious flaw; it does not check to see if we already detected generic SQL injection on the target.

  Let's say the target is an in-house Web application that is also written in ASP, and by blind luck, it does not filter user input. Requesting **http://target/index.asp?id=%3Cscript** would also affect the target host, even though the host doesn't run Popular Web Forum. If we had run a scan on this host and not tested for generic XSS, the user would be alerted with more than he or she bargained for. Upon receiving the results, you can be sure to expect a mail or phone call in the spirit of, "All this automated vulnerability assessment may be good for kids, but how do you expect us to trust your results when you alert us that we have a problem in a product we don't even have installed?" Now go try and explain to the customer that the flaw does actually exist, but under different name.

  For this type of scenario, it is the better-safe-than-sorry policy that will save your hide. So we should add the generic XSS test:

```
if (get_kb_item(string("www/", port, "/generic_xss"))) exit(0);
```

- **Test for product installation**. A popular approach in Web application testing states that to make sure a target host is vulnerable to a specific vulnerability, first check that

the vulnerable product is even installed. Nessus provides various NASLs that test for many Web applications. For example, the plugin *phpbb_detect.nasl* tests for an installation of phpbb. The plugin looks in the source of several pages (*index.php* and */docs/CHANGELOG.html*) for the regular expression *Powered by.*phpBB.*

To use the installation check, you should use *script_dependencies("phpbb_detect.nasl")* and perform the following test in the test phase:

```
install = get_kb_item(string("www/", port, "/phpBB"));
if (isnull(install)) exit(0);
```

If the target host has an installation of phpBB, the string will exist, and the test will run. The license of phpBB requires you to leave the *docs* directory intact, but if someone decides to remove all the "Powered by ..." strings, the test will fail to detect the installation. Again, the user has a choice of whether to use detection plugins.

- **Test for no404**. A known issue when testing for Web application insecurities is the infamous no 404 page. According to the HTTP 1.0 protocol (www.w3.org/Protocols/rfc1945/rfc1945), when a server fails to find a requested URI, it should return a reply with the code 404. When we build a request, we create something like the following:

```
http_get(item: uri, port:port);
buf = http_keepalive_send_recv(port:port, data:req);
```

If the page in the *uri* does not exist, *buf* should return with the server reply for nonexistent pages. Preferably the reply will contain the "404 Not Found" header.

Some Web developers prefer to redirect the user to a known page when an unknown page is requested. Although this usually does not affect the end user of the product, when testing for a security vulnerability, this can be disastrous. For example, if we request *index.php?id='* , the page does not exist, but instead of getting a 404 response, we get the main index page. In most cases this should present no problem, but in the unlikely situation where the index page contains the string "SQL Error : 1064," we will get a false positive.

Fortunately, there are a few countermeasures at our disposal:

- **Look for distinctive replies from the server**. Looking for the string "*Error*" in the reply is obviously more prone to false positives than looking for "You have an error in your SQL syntax near '\'." The key is to find the right balance between testing for too specific a string, and too generic a string.
- **Require *script_dependencies("no404.nasl")***. The no404 plugin connects to the Web server on the target host and requests several pages. Some of these should be existing pages (like /, for example, which should be the page index) and some that should never exist (random page names, for example). From the replies of the server, the script tries to dig a string that appears only when a nonexistent page is requested. If it finds such a string, it is saved in the knowledge base under the following line:

  no404 = get_kb_item(strcat("www/no404/", port));

  This string can be used later to detect whether the page we requested actually exists on the server, or the page we received is a canned response. This will make your life a *lot* easier when trying to debug false positive issues.

- **Use *is_cgi_installed_ka*.** The *is_cgi_installed_ka* function is aware of the no404 issue. If the script has included no404.nasl in the dependencies, it will check if the no404 string was set. If the no404 string is set, the function will return *FALSE*, preventing false positives.

  Following these guidelines when writing a Web-based test will improve your accuracy and help you evade the 404 situation.

- **Use *body* only when needed.** Nessus was designed to be a network-oriented auditing tool. This means that most of the built-in capabilities provide low-level access to network protocol. When we use buf = *http_keepalive_send_recv(*, the reply will contain the page we requested, but it will contain also all of the HTTP headers! When we search for a string in the reply of the server, we may stumble upon a header containing the string we sought, resulting in a false positive.

  On the other hand, sometimes the body of the response will not contain any useful information. For example, if the vulnerability triggers an internal server error (code 500 family), the body of the response will probably be empty, but if we look in the headers, we can see that the server replied with an error status.
  Once again, it is up to the user to decide where to look for the result string.

Master Craftsman…

Getting Accurate: Add Attack Vectors to Increase Your Detection Abilities

Web applications are odd creatures. User input is being parsed several times before it reaches the target application. A firewall, an IDS (intrusion detection system), and finally the Web server can all carry out different functions on your input.

Some Web application developers trust content filtering in the hands of dedicated software such as Urlscan for the IIS (Internet Information Services) Web server (www.microsoft.com/windows2000/downloads/recommended/urlscan/default.asp) and mod_security for Apache (www.modsecurity.org/).

We all know that the < character is dangerous if not filtered properly and that it can lead to cross-site scripting, but how many ways can one encode the < character? Here are just a few possibilities: %3C < &LT &#60 &#060 \x3C

To gain the real benefits of your Web application plugin, you need to increase the amount of attack vectors in hand. Testing only for < can be insufficient, as it can be filtered along the way, and the scan will come up empty. The more possibilities of encoding you supply the plugin, the more accurate the scan will be. One handy tool is Rsnake's XSS Cheatsheet (www.shocking.com/~rsnake/xss.html), which supplies some nifty tricks to enhance your ability to detect XSS and other Web application insecurities.

The Final Plugin Template

Here is the final plugin, following the guidelines to be as general as possible. The plugin now has tags instead of specific contents.


```
#
# Web application test template
# Copyright 2005 Ami Chayun
#

if (description) {
  script_version("$Revision: 1.0 $");

  name["english"] = "<Name/>";
  script_name(english:name["english"]);

  desc["english"] = "
<Description/>
Solution : <Solution/>
Risk factor : <RiskFactor/>";
  script_description(english:desc["english"]);

  summary["english"] = "<Summary/>";
  script_summary(english:summary["english"]);

  script_category(ACT_GATHER_INFO);
  script_copyright(english:"This script is Copyright (C) 2005 <Author/>");

  family["english"] = "CGI abuses";
  script_family(english:family["english"]);
  script_dependency("no404.nasl", "cross_site_scripting.nasl",
                    "webmirror.nasl");
  script_require_ports("Services/www", 80);
  exit(0);
}

include("http_func.inc");
include("http_keepalive.inc");

###
#User defined variables
user_trigger_string = '<UserTrigger/>';    #User custom trigger string
user_vulnerable_string = '<UserReply/>'; #User custom reply string
vulnerable_param = "<VulnerableParam/>";

page = string("/","<Page/>"); #web page containing the vulnerability
cgi_params = "<CGIParams/>"; #URL encoded parameter list
method = "<Method/>"; #GET | POST

#Test for web server capabilities
#1 test for server capability, 0 skip capability test
do_test_php = <TestPHPCap/>;
do_test_asp = <TestASPCap/>;
```

```
#Test the response body or also headers?
test_only_body = <BodyOnly/>;

#1 include the family of attack vectors in test
#0 exclude the family
test_dir_traversal = <TestTraversal/>;
test_sql_injection = <TestSQLInject/>;
test_xss = <TestXSS/>;

### End variable part ###

###
# Attack vectors
dir_traversal[0] = "/etc/passwd";
dir_traversal[1] = "../../../../../../../../etc/passwd";
dir_traversal[2] = "../../../../../../../../etc/passwd%00";

passwd_file[0]   = "root:";

sql_injection[0] = "'";
sql_injection[1] = "%27";
sql_injection[2] = " group by";

sql_error[0]     = "SQL Error : 1064";
sql_error[1]     = "ODBC Microsoft Access Driver";
sql_error[2]     = "SQLServer JDBC Driver";
sql_error[3]     = "Microsoft JET Database Engine error '80040e14'";

XSS[0]           = "<script>alert(document.cookie)</script>";
XSS[1]           = "%22%3E%3Cscript%3Ealert%28document.cookie%29%3C%2Fscript%3E";
XSS[2]           = "%22+onmouseover%3D%22javascript:alert%28%27foo%27%29%22+%22";

XSS_reply[0]     = "<script>alert(document.cookie)</script>";
XSS_reply[1]     = "javascript:alert('foo')";

#Build the attack vector list to the user's wishes
trigger_strings = make_list(user_trigger_string);
vulnerable_strings = make_list(user_vulnerable_string);
if(test_dir_traversal)
{
        trigger_strings = make_list(trigger_strings, dir_traversal);
    vulnerable_strings = make_list(vulnerable_strings, passwd_file);
}
if(test_sql_injection)
{
    trigger_strings = make_list(trigger_strings, sql_injection);
    vulnerable_strings = make_list(vulnerable_strings, sql_error);
}
if(test_xss)
{
    trigger_strings = make_list(trigger_strings, XSS);
    vulnerable_strings = make_list(vulnerable_strings, XSS_reply);
```

```
}

###
# Test mechanism starts here
port = get_http_port(default:80);
if (!get_port_state(port)) exit(0);

#If the user requested, check that the server is ASP/PHP capable
if(do_test_php && !can_host_php(port:port)) exit(0);
if(do_test_asp && !can_host_asp(port:port)) exit(0);

#First check for generic XSS and. Don't do other plugin't job
if (get_kb_item(string("www/", port, "/generic_xss"))) exit(0);

foreach d ( cgi_dirs() )
{
  if(is_cgi_installed_ka(item: string(d, page), port:port))
  {
  foreach trigger_string (trigger_strings)
  {
   attack_vector = ereg_replace(string:cgi_params,
                       pattern:vulnerable_param + "=[^&]*",
                       replace:vulnerable_param + "="+ trigger_string);

   if(method == "GET")
   {
    uri = string(d, page, "?", attack_vector);
    req = http_get(item: uri, port:port);
   }
   else if (method == "POST")
   { #Build a valid POST, with content length
    req = http_post(item: string(d, page), port:port);
    idx = stridx(req, '\r\n\r\n');
    req = insstr(req, '\r\nContent-Length: ' + strlen(data) + '\r\n' +
       'Content-Type: application/x-www-form-urlencoded\r\n\r\n' +
    attack_vector, idx);
   }

   #Send the request, and put in buf the response (body only or entire result)
   buf = http_keepalive_send_recv(port:port, data:req, bodyonly:test_only_body);
   if(buf == NULL) exit(0);

   #Try to detect a vulnerable reply
   foreach vulnerable_string (vulnerable_strings)
   {
    if(strlen(vulnerable_string) > 0 && vulnerable_string >< buf)
    {
         #Report to the user of our findings
         report = "By injecting: '" + trigger_string +
                  "' to the '" + vulnerable_param +
                  "' parameter of " + page + " via " + method +
                  ", we were able to trigger the following response '" +
                  vulnerable_string;
```

```
      security_warning(port:port, data:report);
      exit(0);
         }
    }
   } #foreach attack vector
  } #Is CGI installed
 } #foreach web dir
```

Master Craftsman…

The Work Is Never Over: Expanding Capabilities of the Web Application Template

The final template serves its goal, but it can be extended far more. The plugin can include cookie information or any other HTTP header information. By using Nessus' library functions the plugin can also accept authentication information and attempt brute-force attacks. The more ideas you come up with on weaknesses in the Web application, the more powerful the template can be. It is worthwhile to check the Nessus plugin archive to see examples for advanced Web application insecurities.

Rules of Thumb

In this section we have seen a method of creating a plugin and generalizing so that it can serve as a family template. Rules of thumb that you should follow are:

1. Allow different installation paths and different commands.
2. Use Nessus Knowledge Base items to see if the service you want to test is running on the target host.
3. Increase the amount of attack vectors and consider different encodings and different commands. Research for similar vulnerabilities in other products to add their attack vectors to yours.
4. Don't overtest! For example, if you are testing a Simple Mail Transfer Protocol (SMTP) server for a vulnerability in the AUTH command, consider checking the server capabilities before running the attack. This will save network traffic and increase plugin accuracy.
5. Consider using application banner information. Sometimes it is the simplest way to test for a vulnerability, and sometimes it's the only way. If you decide to use banner information, consider the consequences! A user can easily change banners. If there is no other way than checking in the banner, alert the user that according to its version the server is vulnerable to certain issues.

6. Alert the user about exactly what you found. This aids debugging false positives and helps the user to find a solution.
7. Avoid other people's mistakes. Use *script_dependencies* to include tests that increase accuracy (no404, for example).
8. Use library functions. Don't reinvent the wheel. Really, Nessus provides a wide interface to almost any known network protocol, so avoid hard-coded requests.
9. Divide and conquer. Separate the user variable part of the test from the mechanism. It will make life easier for other people to look in the final source.
10. Don't hide your code. Publishing your code as much as possible is the best way for it to become the best all-around code; the more people who see and use your code, the more stable and accurate it will be. Use Nessus' community to improve your code.

Using a CGI Module for Plugin Creation

Presented here is a simple and effective interface for filling plugin templates. The interface will be Web based, and we will use Perl's CGI module to create the page.

Apache's Web server (http://httpd.apache.org) is the most popular HTTP server in the world, and we will use the out-of-the-box installation of Apache 1.3.33, installed from the Debian Linux APT system (apt-get install apache).

The default configuration of Apache in Debian is enough for our purposes, so we will not go into details on how to configure Apache. If you wish to learn more on Apache's configuration file, see http://httpd.apache.org/docs/configuring.html.

CGI

The Common Gateway Interface is an agreement between HTTP server implementers about how to integrate such gateway scripts and programs. It is typically used in conjunction with HTML forms to build database applications. For more information see www.w3.org/CGI/.

HTML forms are sections of a document containing normal content, markup, special elements called controls (checkboxes, radio buttons, and menus), and labels on those controls. Users generally complete a form by modifying its controls (entering text, selecting menu items, and so on), before submitting the form to an agent for processing (for example, to a Web server or to a mail server). For a complete specification of form elements in the HTML standard see www.w3.org/TR/REC-html40/interact/forms.html.

Perl's CGI Class

Perl's CPAN repository includes a CGI library that supplies an interface to the CGI functionality. It also supports form elements for simplifying the creation of forms. The package's documentation can be found at http://search.cpan.org/~lds/CGI.pm-3.10/CGI.pm.

NOTE

CPAN is the Comprehensive Perl Archive Network, a large collection of Perl software and documentation. For more information see www.cpan.org.

Although the package can be installed from CPAN, we will install it via Debian's Advanced Package Tool (APT). The required package is apache-perl. This package includes Perl::CGI and the supplementary Apache support. Once all packages are installed, it's time to see what the CGI looks like.

Template .conf File

We would like to present the user with an HTML form that supplies all the template needs. We will also like to include several attributes to each customizable field, such as type and default value. We might also want to include a help item on each of the fields to explain to the user how to fill the form. To this end, we will create a configuration file for each of the templates in the system. The .conf file is an XML, containing information on each field that can be customized by the user:


```
<?xml version="1.0" encoding="utf-8"?>
<TemplateConf name="web_application_template">
 <Variables>
 <Variable name="UserTrigger" type="string" required="yes">
  <help>Custom trigger string, for example:
   &lt;SCRIPT a=">" SRC="javascript:alert('XSS');">&lt;/SCRIPT>
  </help>
 </Variable>
...
</Variables>
</TemplateConf>
```

For more information on XML see the section titled "Advanced Plugin Generation: XML Parsing for Plugin Creation" later in this chapter.

The example *Variable* element shows the attributes available for the *UserTrigger* field available in the *web_application_template.nasl* discussed in the previous section. The attributes used here are:

- **name** Parameter name as it appears in the .nasl template
- **type** Type of input the user submits. The types supported are:
  - **string** Free text *INPUT* control
  - **checkbox** Tickmark *CHEECKBOX* control
  - **select** Multiple option *SELECT* control
- **required** Specifies whether this is field essential to the result plugin
- **default** Default value of element

The .conf file XML can be extended by adding elements, for example by adding *label* and *language* attributes, to allow localization.

Plugin Factory

The Plugin Factory includes two files. One is the HTML template to be filled by the CGI, and the other is the Plugin Factory CGI itself. The HTML template allows maximal flexibility, separating data from style information. The HTML source follows:


```
<HTML>
<BODY>
 <FORM METHOD="GET" ACTION="pluginfactory.cgi">
  <TABLE BORDER="0" CELLPADDING="4">
   <TR>
    <TD CLASS="header" COLSPAN="2">Nessus Plugin Factory</TD>
   </TR>
   <TR>
    <TD>Plugin template</TD><TD><!-- #PluginTemplates# --></TD>
   </TR>
   <!-- #BEGINTemplateSelection# -->
   <TR>
    <TD><INPUT TYPE="Submit" Name="Action" Value="Choose Template"></TD>
   </TR>
   <!-- #ENDTemplateSelection# -->
  </TABLE>
 </FORM>
 <FORM METHOD="POST" ACTION="pluginfactory.cgi">
 <!-- #BEGINPluginDetails# -->
 <INPUT TYPE="Hidden" NAME="template" VALUE="<!-- #PluginTemplates# -->">
 <TABLE BORDER="0">
  <TR>
   <TD>Author's name</TD>
   <TD><INPUT TYPE="Text" NAME="Author" SIZE="50"></TD>
  </TR>
  <TR>
   <TD>Plugin name</TD><TD>
   <INPUT TYPE="Text" NAME="Name" SIZE="50"></TD>
  </TR>
  <TR>
   <TD>Plugin Summary</TD><TD>
   <INPUT TYPE="Text" NAME="Summary" SIZE="50"></TD>
  </TR>
  <TR>
   <TD COLSPAN="2" CLASS="header">Vulnerability Details</TD>
  </TR>
  <TR>
   <TD>Description</TD><TD>
   <TEXTAREA NAME="Description"  ROWS="6" COLS="70">
Here is the place to write a description of the vulnerability,
how the vulnerability is triggered,
and what damage an attacker might cause exploiting this vulnerability.
   </TEXTAREA></TD>
  </TR>
  <TR>
   <TD>Solution</TD><TD><TEXTAREA NAME="Solution"  ROWS="6" COLS="70">
Write down at least one solution available to the problem.
```

```
If the affected product did not release a patch or a newer version,
suggest a practical method to prevent the vulnerability,
for example filtering access to the port.</TEXTAREA></TD>
  </TR>
  <TR>
   <TD>Risk Factor</TD>
   <TD><SELECT NAME="RiskFactor">
    <OPTION VALUE="High">High</OPTION>
    <OPTION VALUE="Medium">Medium</OPTION>
    <OPTION VALUE="Low">Low</OPTION></SELECT></TD>
  </TR>
  <TR>
   <TD COLSPAN="2" CLASS="header">Plugin Settings</TD>
   <!-- #BEGINParams# -->
   <TR>
    <TD><!-- #ParamName# --></TD><TD><!-- #ParamInput# --></TD>
   </TR>
   <TR>
    <TD CLASS="help"><!-- #ParamHelp# --></TD>
   </TR>
   <!-- #ENDParams# -->
   <TR><TD COLSPAN="2" CLASS="header">Actions</TD></TR>
   <TR>
    <TD>Display plugin source</TD>
    <TD>Save generatred plugin to file.<BR>
    Filename: <INPUT TYPE="text" NAME="filename" VALUE=""></TD>
   </TR>
   <TR>
    <TD><INPUT TYPE="submit" NAME="Action" VALUE="Generate"></TD>
    <TD><INPUT TYPE="submit" NAME="Action" VALUE="Save"></TD>
   </TR>
 </TABLE>
 </FORM>
 <!-- #ENDPluginDetails# -->
 <!-- #BEGINResultNasl# -->
 <TABLE BORDER="0">
  <TR>
   <TD CLASS="header">Generated Plugin</TD>
  </TR>
  <TR>
   <TD><PRE><!-- #ResultNasl# --></PRE></TD>
  </TR>
 </TABLE>
 <!-- #ENDResultNasl# -->
</BODY>
</HTML>
```

The HTML file consists of three parts:

- **The template selection** The first part of the HTML requires users to choose which template they would like to use to generate the plugin.
- **Vulnerability details and template parameters** Once users have selected a valid template, they fill in the details regarding the vulnerability and complete the appropriate template parameters.
- **Generation actions** Users choose the format in which the resulting plugin will be generated. The CGI can either print the content of the generated plugin or generate a .nasl file and prompt the user to save it.

The HTML includes special tags that will be replaced with the appropriate text. Tags are simply HTML comments with pound (#) sign in each end.

The second Plugin Factory element, the CGI itself, uses the following helper subroutines:

- **getSection** Returns the contents of the text between two section tags (<!— #BEGINtagname# —> and <!— #ENDtagname# —>).
- **replaceSection** Replaces the contents of the block between two section tags and the tags themselves.
- **replaceTag** Replaces a simple tag in the format of <!— #tagname# —>.
- **replaceNaslTag** Replaces a single tag in the format of <tagname/> used in the plugin template.
- **sanitize_name** Returns a string that contains only allowed characters (-_a-zA-Z0-9.).
- **booleanFromString** Returns 1 from true/yes/on strings, 0 otherwise.
- **error_message** Prints an error message to the user and dies.

The CGI requires two Perl modules: Perl::CGI and XML::Simple. The CGI module is used to parse the CGI queries and generate appropriate HTML forms. XML::Simple is used to parse the template .conf XML file. An elaborate explanation of the XML::Simple module is given in the section titled "Advanced Plugin Generation: XML Parsing for Plugin Creation" later in this chapter.

Here is the CGI's code:

```
my $query = new CGI;
```

```
my $html_template = "";
 open HTML, "HTML/pluginFiller.html"
     or error_message("Could not open HTML file");
 while(<HTML>)
 {
  $html_template .= $_;
 }
 close HTML;
```

The code begins by trying to read the HTML file to be filled by the script. The code then separates two cases; an HTTP GET request is used to build the form and choose a valid plugin template:

```
 my $selected_plugin_template = sanitize_name($query->param('template'));

#The GET method is used to present the user the plugin form
if( $query->request_method() eq "GET")
{
 #If the user has not chosen a template yet,
 #Show the selection box, and hide the plugin details
 if(! $selected_plugin_template )
 {
  opendir TEMPLATES, "templates"
      or error_message("Could not open templates dir");

  my @plugin_templates = grep { /^(.*?).nasl$/ } readdir(TEMPLATES);
  closedir TEMPLATES;
  @plugin_templates or error_message("No valid plugin templates found");

  #Create a list of all the available plugin templates
  $selected_plugin_template = $query->scrolling_list(-name=>'template',
                                -values=>@{ @plugin_templates },
                                -multiple=>'false',
                                -labels => @{ @plugin_templates },
                                -default => [ $plugin_templates[0] ]);
  #Delete the Plugin Details section.
  $html_template = replaceSection($html_template, "PluginDetails");
 }
 else {
  $html_template = fillHTMLTemplateParams($html_template,
                                      $selected_plugin_template);
```

#Delete the template selection section.

```
  $html_template = replaceSection($html_template, "TemplateSelection");
 }

 #Show the selected template name or a list of available templates
 $html_template = replaceTag($html_template, "PluginTemplates",
                             $selected_plugin_template);
 #Show resulting plugin section
 $html_template = replaceSection($html_template, "ResultNasl");
```

```
 #Print the final HTML file
 print $query->header;
 print $html_template;
} #GET
```

If the user chooses a valid plugin template, the *fillHTMLTemplateParams* subroutine is called to build the form defined by the template .conf file. If the user has not yet chosen a template (the request did not contain a valid *template* parameter), a selection of the available templates is presented, and the user should choose one.

The other option is the POST method. If the script was called via a POST request, it expects to have all the parameters required to fill the template. It then takes the data provided by the user and generates a plugin.

```
#The POST method is used to actually generate the plugin
elsif( $query->request_method() eq "POST")
{
 my $result_filename = $query->param('filename');

 #Read the desired plugin template
 open PLUGIN, "templates/$selected_plugin_template"
     or error_message("Template file does not exist");
 my $plugin_template = "";
 while(<PLUGIN>)
 {
   $plugin_template .= $_;
 }
 close PLUGIN;


 my %formParams = $query->Vars; #Get the form parameters as hash
 delete $formParams{'template'}; #Previously used
 delete $formParams{'filename'};

 $plugin_template = fillNaslTemplate($selected_plugin_template,
                                     $plugin_template, %formParams);
```

The fillNaslTemplate generates a NASL plugin from the parameters supplied by the user. The template and filename parameters are deleted from the hash, as both were already used and there is no need to pass them to the function. Once we have successfully generated the plugin, we can either print the result or prompt the user to save the file:

```
 #Check what output should be done
 if( $query->param('Action') eq 'Save' and $result_filename)
 {
  #Allow 'Save as'
  print $query->header(-type => 'text/nasl',
                       -attachment => $result_filename);
  print $plugin_template;
 }
 else
 {
  #Delete the template selection section.
```

```
  $html_template = replaceSection($html_template, "TemplateSelection");
  #Delete the Plugin Details section.
  $html_template = replaceSection($html_template, "PluginDetails");
  #Show the selected template name or a list of avaliable templates
  $html_template = replaceTag($html_template, "PluginTemplates",
                              $selected_plugin_template);

  #Show resulting plugin
  $html_template = replaceTag($html_template, "ResultNasl",
                             $query->escapeHTML($plugin_template));
  #Print the final HTML
  print $query->header;
  print $html_template;
 }
}#POST

 #Tell Apache we're done.
 #No reason to keep the connection open more than needed
 exit 0;
```

Here are the two core subroutines used by the CGI. The first subroutine initializes the XML parser, reads the XML elements, and then fills in the HTML template accordingly. It generates controls according to the desired type as defined in the .conf file.


```
sub fillHTMLTemplateParams
{
 my ($html_template, $plugin_template_file) =@_;
 $plugin_template_file =~ s/\.nasl/.conf/; #Load the appropriate .conf file

 my @ForceArray = ("Variable", "option");
 my $xml = new XML::Simple (ForceArray => [@ForceArray],
                            KeyAttr => 0, #Don't fold arrays
                            );
 stat "templates/$plugin_template_file"
     or error_message("Template file does not exist");

 my $data = $xml->XMLin("templates/$plugin_template_file")
    or error_message("Selected template doesn't have a valid .conf file");

 my $param_template = getSection($html_template, "Params");
 my $temp_param = ""; #The filled params sections
 my $Variables = $data->{'Variables'};
 foreach my $Variable ( @{ $Variables->{'Variable'} } )
 {
   $temp_param .= $param_template;

   my $name = $Variable->{'name'};
   $temp_param = replaceTag($temp_param, "ParamName", $name);
   $temp_param = replaceTag($temp_param, "ParamHelp",
                            $query->escapeHTML($Variable->{'help'}));

   my $default = $query->escapeHTML($Variable->{'default'});
   my $input = "";
```

```
  if($Variable->{'type'} eq "checkbox")
  {
    $input = $query->checkbox(-name => "$name",
                              -checked => booleanFromString($default),
                              -label => $name);
  }
  elsif($Variable->{'type'} eq "string")
  {
    $input = $query->textfield(-name => "$name",
                               -value => $default,
                               -size => 50);
  }
  elsif($Variable->{'type'} eq "select" and $Variable->{'option'})
  {
    $input = $query->scrolling_list(-name => "$name",
                                    -values => $Variable->{'option'},
                                    -size => 1, -default => $default);
  }
  $temp_param = replaceTag($temp_param, "ParamInput", $input);
 }
 $html_template = replaceSection($html_template, "Params", $temp_param);
 return $html_template;
}
```

The second function fills in the NASL template. The function runs on every parameter defined in the .conf file and then checks to determine if the user filled in that parameter. If a required parameter is missing, the function raises an error message.


```
sub fillNaslTemplate
{
 my ($plugin_template_file, $plugin_template, %formParams) = @_;
 $plugin_template_file =~ s/\.nasl/.conf/;

 my @ForceArray = ("Variable");
 my $xml = new XML::Simple (ForceArray => [@ForceArray],
                            KeyAttr => 0, #Don't fold arrays
                            );
 my $data = $xml->XMLin("templates/$plugin_template_file")
    or error_message("Selected template doesn't have a valid .conf file");

 #Fill default plugin parameters
 $plugin_template = replaceNaslTag($plugin_template, 'Author',
                                   $formParams{'Author'});
 $plugin_template = replaceNaslTag($plugin_template, 'Name',
                                   $formParams{'Name'});
 $plugin_template = replaceNaslTag($plugin_template, 'Summary',
                                   $formParams{'Summary'});
 $plugin_template = replaceNaslTag($plugin_template, 'Description',
                                   $formParams{'Description'});
 $plugin_template = replaceNaslTag($plugin_template, 'Solution',
                                   $formParams{'Solution'});
 $plugin_template = replaceNaslTag($plugin_template, 'RiskFactor',
```

```
                                    $formParams{'RiskFactor'});

 my $Variables = $data->{'Variables'}
    or error_message("Error parsing XML .conf file");

 #Fill Optional parameters
 foreach my $Variable ( @{ $Variables->{'Variable'} } )
 {
   my $name = $Variable->{'name'};
   my $value = $formParams{$name};

   if(! $value and $Variable->{'required'} eq "yes")
   {
     error_message("Missing essential parameter: <B>$name</B>");
   }
   #Checkboxes in CGI are not sent if they are not checked,
   #so if there is no $formParams{$name} assume unchecked
   if($Variable->{'type'} eq 'checkbox')
   {
     $value = booleanFromString($value);
   }
   $plugin_template = replaceNaslTag($plugin_template, $name, $value);
 }

 return $plugin_template;
}
```

Final Setup

Copy the *pluginfactory.cgi* file to your cgi-bin directory (default in the Debian install is */usr/lib/cgi-bin*). Make sure it is executable by all (*chmod 755 pluginfactory.cgi*). The cgi-bin folder should include two subfolders: HTML and templates. In HTML, place the *pluginFiller.html* file and under templates copy the template .nasls and and their appropriate .conf files.

Once all the files are in the target directory, open a Web browser and visit the Plugin Factory page at http://127.0.0.1/cgi-bin/pluginfactory.cgi.

Example Run

As an example we will look at a vulnerability in Awstats, a popular open source Web statistics and log parsing utility. Awstats suffered from a remote command execution vulnerability in versions 5.7 through 6.2. Figure 6.3 shows the vulnerability information filled in the CGI form.

Now for the plugin configuration. We will test the vulnerability by running the exploit on the *configdir* parameter. The trigger will be the string: *|echo;cat+/etc/passwd;echo|*.

On vulnerable machines this will print the contents of the /etc/passwd file to the user (see Figure 6.4).

Figure 6.3 Awstats Remote Command Execution Vulnerability Details

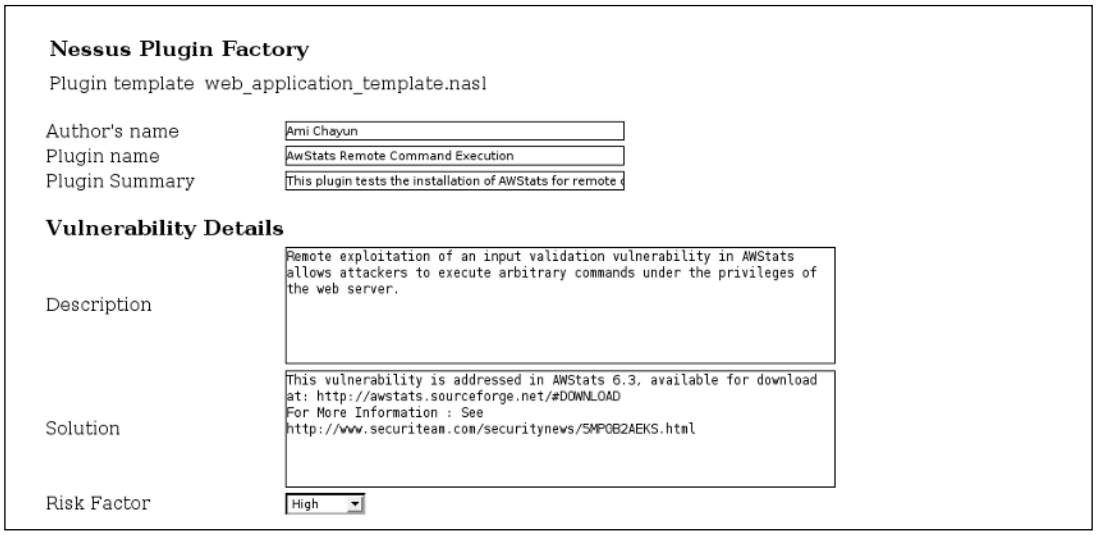
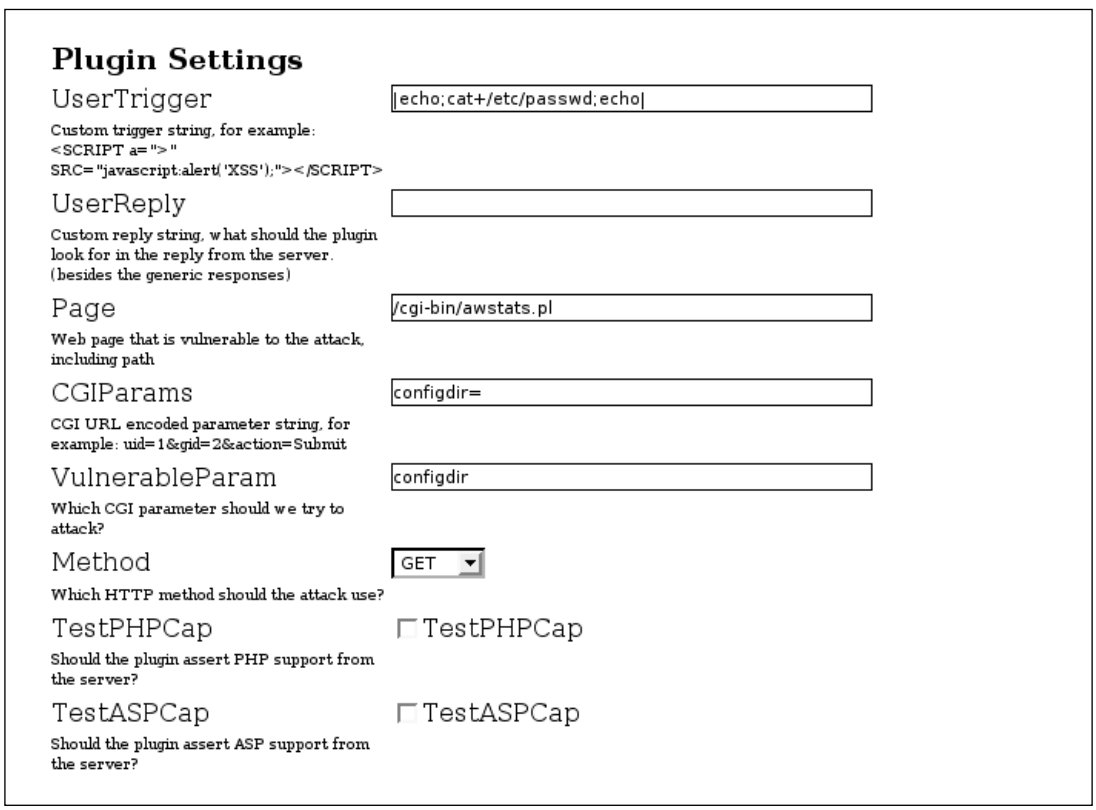
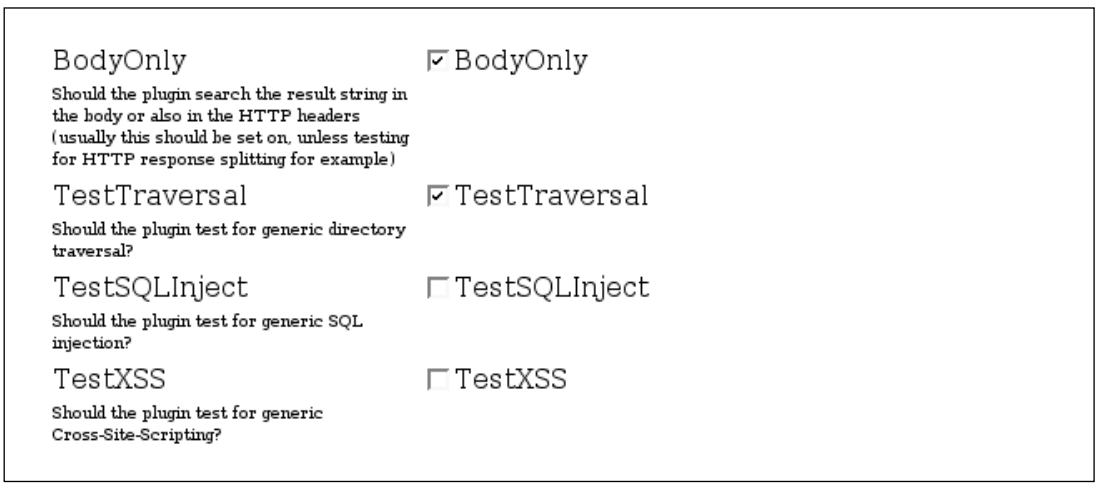


Figure 6.4 Awstats Remote Command Execution Plugin Configuration



Detecting if a server is vulnerable is quite simple. Because we already have a test that compares the result against /etc/passwd (when we test for directory traversal), we can check *TestTraversal*, and we do not have to supply a custom result string (see Figure 6.5).

Figure 6.5 Using Awstats to Detect If a Server Is Vulnerable



That's it. Now a plugin for the Awstats remote command execution vulnerability can be generated.

The CGI presented here supplies an easy way to create plugins from plugin templates. As the example shows, a security advisory can be easily turned into a plugin. This kind of plugin creation automation can help security analysis of a system because the analyst can generate plugins while testing, and after gaining some experience, the resulting plugins will be effective and reliable.

Advanced Plugin Generation: XML Parsing for Plugin Creation

In the previous section we introduced a method of creating generic plugin families with common templates. We are now going to approach the problem of efficient plugin creation from a different angle; namely, the data.

XML Basics

XML is a standard for keeping and parsing data. An introduction to XML can be found at www.w3.org/XML.

XML recent development news can be found through various XML interest groups such as http://xml.org/.

We will use the XML as a data holder for our plugin creation. Since XML can easily be parsed, we can use several readily available parsing tools to take the data from the XML and turn it to a usable plugin.

Because we will use a simple implementation of the XML standard, here is a crash course on the XML file structure that we will use.

To make the explanation less alien to people unfamiliar with XML, we will use examples from HTML. HTML can actually be parsed as an XML, and it is a special case of general XML.

In XML, a *document* is a block of characters that make the XML. In this context we will usually mean a physical file, but the document can be any character stream.

```
Header:

<?xml version="1.0" encoding="UTF-8"?>
```

The XML document (file) starts with a header line that indicates the client parser that the file type is XML. The line can also hold information about the file content, like charset information.

An *element* in XML is a name for a block of data (that can also hold child elements). Elements start with a tag; for example, <ThisIsAnElement>.

The tag name can is decided by the user and cannot contain spaces. The name is placed between *greater than* (<) and *less than* (>) signs. To mark an ending of an element, the block ends with an ending tag, such as </ThisIsAnElement>.

An element that has no child elements can also be written as <ThisIsAnotherElement />. Notice that before the closing *smaller than* sign there is a *forward slash* (/).

In XML, an *attribute* is a name-value pair that can describe an element; for example, <Work station ip="192.168.0.2" />.

The name of an attribute must not contain spaces, and the value must be enclosed in double quotation ("") marks.

Every XML document must have exactly one *top-level element*. For example, HTML files have the following as a top-level element:

```
 <html>
...
</html>
```

All the contents of the file (except the header) must be inside this element.

XML As a Data Holder

One common implementation of XML is a data holder. XML can be used to create data structures that can be parsed later by code. The official name for this use is *Document Object Model* (DOM). Here is a simple example:

```
<?xml version="1.0" encoding="UTF-8"?>

<PersonFile>
<Name>My first name</Name>
<Address>123 Main St.</Address>
```

```
<Occupation>IT manager</Occupation>
</PersonFile>
```

This very simple configuration structure holds the details of one person. The top-level element, PersonFile, contains three child elements: Name, Address, and Occupation. The same data structure can be written with attributes instead if child elements like this:

```
<?xml version="1.0" encoding="UTF-8"?>
<PersonFile>
<Person name="My first name" address="123 Main St." occupation="IT manager" />
</PersonFile>
```

The *Person* element contains the same data, but this time as attributes. Using elements is sometimes preferred over attributes, usually if the data spans over multiple lines.

The preceding configuration files can be parsed into a data structure; for example, in C the structure can be written as:

```
struct Person {
        char *name;
        char *address;
        char *occupation;
};
```

Using mssecure.xml for Microsoft Security Bulletins

Shavlik Technologies, LLC (http://shavlik.com/) created HFNetChkPro, a patch management tool for the Microsoft Windows platform. This tool uses an XML schema for storing the data of the automatic patching system. The file is called mssecure.xml and an updated version can be downloaded from http://xml.shavlik.com/mssecure.xml.

Because the rights for the tool belong to Microsoft, the mssecure.xml is now a part of the Microsoft Baseline Security Analyzer tool (www.microsoft.com/technet/security/tools/mbsa-home.mspx), Microsoft's patch management solution.

We will use mssecure.xml as an example of automatic plugin creation for Microsoft's security bulletins.

The mssecure XML Schema

The mssecure.xml top-level structure is described as follows:

```
<BulletinDatastore DataVersion="1.1.2.409" LastDataUpdate="4/15/2005" ...>
 + <Bulletins></Bulletins>
 + <Products></Products>
 + <ProductFamilies></ProductFamilies>
 + <ServicePacks></ServicePacks>
 + <RegKeys></RegKeys>
 + <Files></Files>
 + <Commands></Commands>
 + <Severities></Severities>
 + <MSSeverities></MSSeverities>
 + <SupercededBys></SupercededBys>
 + <WellKnownURLs></WellKnownURLs>
</BulletinDatastore>
```

NOTE

The plus (+) prefix before an element means its contents were not shown. It is not a part of the XML document, just an accepted abbreviation.

Here is a short description of the elements that contain information we use in our plugins:

- **BulletinDatastore** Top-level element. All data (except for document header) must be inside this element.
- **Bulletins** Information included in a security bulletin; for example, summary, effected platforms, patch information, and so on.
- **Products** Listing of all the known products. Products are referred by their ProductIDs.
- **ProductFamilies** List of general product families as pointed by Product.
- **ServicePacks** Information regarding software service pack updates.
- **MSSeverities** Microsoft's classification of risk levels in their bulletins.

We will use all the aforementioned elements to create a registry-based test for vulnerabilities affecting Microsoft Windows operating System.

The Plugin Template

The plugin is a simple NASL file that contains tags for replacement. Later we will see the command-line tool that fills these tags automatically. Here is the template we will use to generate our plugins:

```
# smb_nt_ms_template.nasl
#
# Automatically generated by MSSecure to NASL
#
if(description)
{
 script_id(<ScriptID/>);
 script_cve_id(<CVEID/>);
 script_version("$Revision: 1.0 $");

 name["english"] = "<ScriptName/>";
 script_name(english:name["english"]);

 desc["english"] = "
 <ScriptSummary/>
 Solution : <ScriptSolution/>
 Risk factor : <ScriptRiskFactor/>";
 script_description(english:desc["english"]);
 summary["english"] =
         "Determines if hotfix <ScriptHotfix/> has been installed";
```

```
 script_summary(english:summary["english"]);
 script_category(ACT_GATHER_INFO);

 script_copyright(english:
        "This script is Copyright (C) <Author/>");
 family["english"] =
        "Windows : Microsoft Bulletins";
 script_family(english:family["english"]);

 script_dependencies("smb_hotfixes.nasl");
 script_require_keys("SMB/Registry/Enumerated");
 script_require_ports(139, 445);
 exit(0);
}

include("smb_hotfixes.inc");
#Check if target has installed the Service Pack that includes the hotfix

nt_sp_version = <NTServicePack/>;
win2k_sp_version = <Win2kServicePack/>;
xp_sp_version = <XPServicePack/>;
win2003_sp_version = <Win2003ServicePack/>;

if ( hotfix_check_sp(   nt:nt_sp_version,
                        win2k:win2k_sp_version,
                        xp:xp_sp_version,
                        win2003:win2003_sp_version) <= 0 ) exit(0);

#Check if target has installed a hotfix that mitigates the vulnerability
if ( hotfix_missing(name: "<ScriptHotfix/>") > 0  )
        security_hole(get_kb_item("SMB/transport"));
```


NOTE

Although it is possible to automatically write plugins for MS security bulletins, these plugins cannot be redistributed because they include the text of advisories that are copyrighted by Microsoft.

Ins and Outs of the Template

As we can see, the plugin is divided into two sections. The *description* section contains the information to be displayed to the user in case we detect the vulnerability. Details that will be filled in are the CVE numbers for this security bulletin, the name, summary, solution, and more.

The description also states two prerequisites. First, the script requires that *smb_hotfixes.nasl* be run before launching the plugin. Second, we also must have access to the target host's registry; this is done via the *SMB/Registry/Enumerated* knowledge-base item.

The second part of the NASL tests for the vulnerability. A patch for a certain security bulletin can be applied in two ways: either install the hotfix issued in the security bulletin itself or install a Service Pack that already includes the hotfix.

To test if a certain Service Pack or hotfix is missing, we need to include the smb_hotfixes.inc file. This file contains functions we'll use later; namely, *hotfix_check_sp* and *hotfix_missing*.

Next, we need to test whether the target has installed a Service Pack that resolves the issue. This is done by the following code:

```
nt_sp_version = <NTServicePack/>;
win2k_sp_version = <Win2kServicePack/>;
xp_sp_version = <XPServicePack/>;
win2003_sp_version = <Win2003ServicePack/>;
```

For each affected operating system, we will fill a service pack number that includes the patch for the vulnerability. If no available Service Pack includes the hotfix, we will fill in here the upcoming service pack.

```
if ( hotfix_check_sp(   nt:nt_sp_version,
                        win2k:win2k_sp_version,
                        xp:xp_sp_version,
                        win2003:win2003_sp_version) <= 0 ) exit(0);
```

This line actually performs the test for installed Service Pack. The function can return the following values:

-1 The test does not affect the target host's operating system (for example, the vulnerability affects Windows 2003, but the target host is running Microsoft Windows 2000). This obviously means the host is not vulnerable to the security issue, so we end our test.

0 The service pack we tested for is installed. This means that the host installed a service pack that includes the hotfix. This means that the host is not vulnerable, and again, we end the test.

1 The service pack is missing on the target host. In this case, the host might be vulnerable to the security issue, and we need to test further if the hotfix itself is installed.

In case no relevant service packs were installed, we need to test for the actual hotfix:

```
if ( hotfix_missing(name: "<ScriptHotfix/>") > 0  )
        security_hole(get_kb_item("SMB/transport"));
```

If the *hotfix_missing* function return with a positive value, the target host is marked to be vulnerable.

Filling in the Template Manually

After we looked at how the plugin performs the test for the vulnerability, let's see how we get the data from the *MSSecure.XML* file. As an example, let's look at Microsoft's security bulletin MS03-026 (this vulnerability was the one exploited by the MSBLAST worm).

General Bulletin Information

Here is the beginning of the *Bulletin* element for the advisory. For the example, we listed here only the first patch in the structure:

```
<Bulletin BulletinID="MS03-026" BulletinLocationID="73" FAQLocationID="73"
FAQPageName="FQ03-026" Title="Buffer Overrun In RPC Interface Could Allow Code Execution
(823980)" DatePosted="2003/07/16" DateRevised="2003/07/16" Supported="Yes" Summary="Remote
Procedure Call (RPC) is a protocol used by the Windows operating system..." Issue="">
 <BulletinComments/>
 <QNumbers>
  <QNumber QNumber="Q823980"/>
  </QNumbers>
 <Patches>
  <Patch PatchName="Q823980i.EXE" PatchLocationID="1815" SBID="178" SQNumber="Q823980"
NoReboot="0" MSSeverityID="1" BugtraqID="8205" CVEID="CAN-2003-0352"
ShavlikPatchComment="This patch has been superseded by the patch for MS03-039">
   <PatchComments/>
   <AffectedProduct ProductID="2" FixedInSP="0">
    <AffectedServicePack ServicePackID="7"/>
   </AffectedProduct>
   <AffectedProduct ProductID="3" FixedInSP="0">
    <AffectedServicePack ServicePackID="7"/>
   </AffectedProduct>
   <AffectedProduct ProductID="1" FixedInSP="0">
    <AffectedServicePack ServicePackID="7"/>
   </AffectedProduct>
  </Patch>
 </Patches>
</Bulletin>
```

In the preceding example of code, we put the interesting data in bold text. *BulletinID* is the unique identifier for every bulletin. We will use it as a search key in the command-line tool presented later.

Title is the attribute we replace with our <*Name*/> tag, and *Summary* (appear in abbreviated form here) will replace the <*Summary*/> tag.

The *QNumber* element contains the name of the hotfix to be used in the plugin registry search. It's value, in this example, **Q823980** replaces the <*ScriptHotfix*/> tag.

From the patch information we draw the CVEID attribute, to replace the <CVEID/>.

That's it? Not exactly. There is one more piece of information we need to get to complete our plugin; the service pack that includes the hotfix. We will do this by looking in the *AffectedProduct* element.

The patch lists three affected products. All these products can use the patch executable to resolve the vulnerability. The affected product information is described like this:

```
<AffectedProduct ProductID="1" FixedInSP="0">
```

ProductID is a unique identifier in the XML to point to a specific version of a product (in our case a version of Microsoft Windows). The *FixedInSP* attribute equals 0, which means that there is no service pack that includes the hotfix. This is not entirely accurate, as we'll see later in this chapter.

How do we link the *ProductID* attribute to a version of Microsoft Windows? The answer is in the <*Product*> sections of the XML. The <*Products*> element contains a list of subelements named <*Product*>, each describing a specific product version.

Here is the <*Product*> element of *ProductID* 1, 2, and 3 we are looking for:

```
<Product ProductID="1" Name="Windows NT Workstation 4.0"
MinimumSupportedServicePackID="4" CurrentServicePackID="7" CurrentVersion="4.00.1381">
 ...
 </Product>
<Product ProductID="2" Name="Windows NT Server 4.0" MinimumSupportedServicePackID="4"
CurrentServicePackID="7" CurrentVersion="4.00.1381">
...
</Product>
<Product ProductID="3" Name="Windows NT Server 4.0, Enterprise Edition"
MinimumSupportedServicePackID="4" CurrentServicePackID="7" CurrentVersion="4.00.1381">
...
</Product>
```

The XML element provides plenty of information. In this example we look for the name of the product; in this case, Windows NT.

NOTE

Nessus does not separate different subversions of the same product, so both Windows NT Workstation 4.0 and Windows NT Server 4.0 belong to the Windows NT family.

If a more specific version detection is required, the user can use the library function supplied in *smb_hotfixes.inc* to check for NT /2000 Server - hotfix_check_nt_server.

We can also find from this element the service pack number to write in the plugin template. Since no service pack resolves the issue, we need to know what is the last supported service pack for Windows NT. This information can also be found in the XML, in the <*ServicePacks*> section:

```
<ServicePack ServicePackID="7" Name="Windows NT4 Service Pack 6a" URL =
"http://support.microsoft.com/support/servicepacks/WinNT/4.0/SP6a.asp"
ReleaseDate="1999/11/30"/>
```

The latest service pack issued to Windows NT 4.0 was Service Pack 6a. This means that a host with Service Pack 7 installed does not require an installation of the hotfix. Because Windows NT 4.0 is no longer supported by Microsoft, there is no plan to issue such a service pack. By looking for a missing Service Pack 7, we will actually catch all the Windows NT 4.0 machines with any service pack installed.

The Finished Template

After digging all the information required to fill the template, here is the final result:

```
# smb_nt_ms03_026_example.nasl
if(description)
{
 script_cve_id("CAN-2003-0352");

 script_version("$Revision: 1.0 $");

 name["english"] = "Buffer Overrun In RPC Interface Could Allow Code Execution (823980)";
 script_name(english:name["english"]);
 desc["english"] = "
 Remote Procedure Call (RPC) is a protocol used by the Windows operating system. RPC
provides an inter-process communication mechanism that allows a program running on one
computer to seamlessly execute code on a remote system. The protocol itself is derived
from the Open Software Foundation (OSF) RPC protocol, but with the addition of some
Microsoft specific extensions. There is a vulnerability in the part of RPC that deals with
message exchange over TCP/IP. The failure results because of incorrect handling of
malformed messages. This particular vulnerability affects a Distributed Component
ObjectModel (DCOM) interface with RPC, which listens on TCP/IP port 135. This interface
handles DCOM object activation requests that are sent by client machines (such as
Universal Naming Convention (UNC) paths) to the server. An attacker who successfully
exploited this vulnerability would be able to run code with Local System privileges on an
affected system. The attacker would be able to take any action on the system, including
installing programs, viewing changing or deleting data, or creating new accounts with full
privileges. To exploit this vulnerability, an attacker would need to send a specially
formed request to the remote computer on port 135.
 Solution : http://microsoft.com/technet/security/bulletin/MS03-026.mspx
 Risk factor : High";
 script_description(english:desc["english"]);

 summary["english"] =
         "Determines if hotfix Q823980 has been installed";
 script_summary(english:summary["english"]);

 script_category(ACT_GATHER_INFO);

 script_copyright(english:
        "This script is Copyright (C) 2005 Ami Chayun");
 family["english"] =
        "Windows : Microsoft Bulletins";
 script_family(english:family["english"]);

 script_dependencies("smb_hotfixes.nasl");
 script_require_keys("SMB/Registry/Enumerated");
 script_require_ports(139, 445);
 exit(0);
}
include("smb_hotfixes.inc");

#Check if target has installed the Service Pack that includes the hotfix
nt_sp_version = 7;
```

```
win2k_sp_version = NULL;
xp_sp_version = NULL;
win2003_sp_version = NULL;

if ( hotfix_check_sp(    nt:nt_sp_version,
                                win2k:win2k_sp_version,
                                xp:xp_sp_version,
        win2003:win2003_sp_version)
                        <= 0 ) exit(0);
#Check if target has installed a hotfix that mitigates the vulnerability
if ( hotfix_missing(name: "Q823980") > 0  )
        security_hole(get_kb_item("SMB/transport"));
```

NOTE

In this example we filled *win2k_sp_version* (and all *sp_version* parameters except Windows NT 4.0) to be NULL. This will cause *hotfix_check_sp* to return -1 for any operating system except Windows NT 4.0. Of course if we wanted to complete the plugin, we would need to look in the *Bulletin* element of the XML for all the *Patches* elements and dig the missing service pack numbers from them. We leave this dirty work for the automatic tool.

The Command-Line Tool

The tool we present here is command line based. It will read an XML file in the format of the MSSecure.XML described already in this chapter, and will generate a NASL plugin for a specific bulletin MSB-ID the user specifies as a parameter in the command line. Remember, the tool is meant to be extended, so almost all its parameters are in the source, rather than as command-line parameters.

XML::Simple

Grant McLean's XML::Simple (http://homepages.paradise.net.nz/gmclean1/cpan/index.html) is a Perl module that provides, as the name implies, a simple API (application program interface) to XML files. For the complete API see http://search.cpan.org/dist/XML-Simple/lib/XML/Simple.pm.For our purposes it's the perfect tool. It will convert the raw XML data to structured hashes and arrays. This is exactly what we need to dig out the required information.

To be able to run the script, first you need to make sure that the XML::Simple library is installed. This can be done either by downloading the sources from either of the links in the preceding paragraph, or preferably, installing it via CPAN.

The usage of XML::Simple is very straightforward:

```
use XML::Simple qw(:strict);
my $xml = new XML::Simple (); #<-- optional construction parameters
my $data = $xml->XMLin("file.xml");
```

After successful initialization, *$data* will hold the XML document in form of hashes and arrays.

XML::Simple allows the user to control some aspects of the data structure that will be created by passing instructions to the constructor. We will use a couple of these features:

```
my $xml = new XML::Simple (
         ForceArray => ["Bulletin", "QNumber"],
         KeyAttr => {Bulletin => "BulletinID"});
```

The *ForceArray* parameter tells the parser that all elements named *Bulletin* or *QNumber* will be in an array. The default behavior of XML::Simple is to store elements in an array only if they have siblings (for example, if a bulletin has only one *QNumber* item under the *QNumbers* element, it will be stored as a hash, and not an array). This instruction, by forcing elements to be in an array instead of a hash, makes it easier to handle because there will be no need to deal with the special case where there is only one element.

The *KeyAttr* instruction controls array folding. XML::Simple can fold an array into a hash, with any attribute acting as a key. By default the parser will fold arrays with the attributes *name*, *key* or *id*. In our XML each element has a different attribute for a unique identifier, so we can set it here. This feature is especially useful for the *Bulletin* element. Instead of iterating over the entire *Bulletins* array, we can access the desired element directly.

For example, without the instruction, data will be stored like this:

```
Bulletins {
 Bulletin => [0..n]
}
```

With array folding with *BulletinID* as key the data will be stored as:

```
Bulletins {
 Bulletin => MS98-001 => { } ...
}
```

NOTE

Any element used in array folding must also be included in the ForceArray list.

Tool Usage

To run the tool, get the latest version of mssecure.xml and make sure you have XML::Simple installed. The tool takes one obligatory parameter, the MSB-ID, which we will create a plugin for. Here is an example run:

```
<ami@Briareos [~]> Perlmssecure_dig.pl MS03-027
Reading XML file...
Extracting data...
Extracting patch information for: Unchecked Buffer in Windows Shell Could Enable System
Compromise (821557)
```

```
Product name: Windows XP Home Edition
NESSUSProductID: xp CheckForInstalledSP: 2
Product name: Windows XP Professional
NESSUSProductID: xp CheckForInstalledSP: 2
Product name: Windows XP Tablet PC Edition
NESSUSProductID: xp CheckForInstalledSP: 2
------

Product name: Windows XP Home Edition
NESSUSProductID: xp CheckForInstalledSP: 2
Product name: Windows XP Professional
NESSUSProductID: xp CheckForInstalledSP: 2
Product name: Windows XP Tablet PC Edition
NESSUSProductID: xp CheckForInstalledSP: 2
------

Filling NASL template.
Creating smb_nt_ms03-027.nasl
```

And the resulting NASL for this vulnerability is as follows:


```
#
# Automatically generated by MSSecure to NASL
#
if(description)
{
 script_id(90000);

 script_cve_id("CAN-2003-0306");

 script_version("$Revision: 1.0 $");

 name["english"] = "Unchecked Buffer in Windows Shell Could Enable System Compromise
(821557)";

 script_name(english:name["english"]);

 desc["english"] = "
 The Windows shell is responsible for providing the basic framework of the Windows user
interface experience. It is most fa
miliar to users as the Windows desktop. It also provides a variety of other functions to
help define the user's computing s
ession, including organizing files and folders, and providing the means to start programs.
An unchecked buffer exists in on
e of the functions used by the Windows shell to extract custom attribute information from
certain folders. A security vulne
rability results because it is possible for a malicious user to construct an attack that
could exploit this flaw and execut
e code on the user's system. An attacker could seek to exploit this vulnerability by
creating a Desktop.ini file that conta
ins a corrupt custom attribute, and then host it on a network share. If a user were to
browse the shared folder where the f
ile was stored, the vulnerability could then be exploited. A successful attack could have
the effect of either causing the
```

```
Windows shell to fail, or causing an attacker's code to run on the user's computer in the
security context of the user.
 Solution : http://www.microsoft.com/technet/security/bulletin/MS03-027.mspx
 Risk factor : Medium";
 script_description(english:desc["english"]);

 summary["english"] =
     "Determines if hotfix Q821557 has been installed";
 script_summary(english:summary["english"]);

 script_category(ACT_GATHER_INFO);
 script_copyright(english:
    "This script is Copyright (C) Ami Chayun");
 family["english"] =
    "Windows : Microsoft Bulletins";
 script_family(english:family["english"]);

 script_dependencies("smb_hotfixes.nasl");
 script_require_keys("SMB/Registry/Enumerated");
 script_require_ports(139, 445);
 exit(0);
}

include("smb_hotfixes.inc");

#Check if target has installed the Service Pack that includes the hotfix
nt_sp_version = NULL;
win2k_sp_version = NULL;
xp_sp_version = 2;
win2003_sp_version = NULL;

if ( hotfix_check_sp(   nt:nt_sp_version,
                        win2k:win2k_sp_version,
                        xp:xp_sp_version,
                        win2003:win2003_sp_version) <= 0 ) exit(0);

#Check if target has installed a hotfix that mitigates the vulnerability
if ( hotfix_missing(name: "Q821557") > 0  )
        security_hole(get_kb_item("SMB/transport"));
```

The Source

Here is the source code for generating a NASL that tests for a specific MS BID.


```
#!/usr/bin/perl -w
#############
# The script will generate a NASL that tests for a specific MS BID
# Copyright 2005 Ami Chayun

use strict;
use XML::Simple qw(:strict);

#http://xml.shavlik.com/mssecure.xml
```

```
my $MSSecure = "mssecure.xml";
my $template_file = "smb_nt_ms_template.nasl";
my $Author = "Ami Chayun";
my $ScriptID = "10000";

my %SeveritiesMap = (   1 => 'High',   #Critical
                        2 => 'Medium', #Important
                        3 => 'Medium', #Moderate
                        4 => 'Low',    #Low
                    );
#Product families list
my %ProductsMap = (     1 => "nt",
                        2 => "win2k",
                        3 => "win9x",
                        4 => "xp",
                        5 => "win2003",
                        );
#Servicepack tags in the nasl template
my %ProductTags = (     "nt"            =>      "NTServicePack",
                        "win2k" =>      "Win2kServicePack",
                        "win9x" =>      "Win9xServicePack",
                        "xp"            =>      "XPServicePack",
                        "win2003"       =>      "Win2003ServicePack",
                        );
#Get the MS_BID From the user
my $MS_BID = shift @ARGV or die "Usage: $0 MS??-???\n";

#Before parsing the XML, tell the parser which elements will !Always!
# be an array, even if there are no siblings.
#Rule of thumb: Everything we later use in a 'foreach'
#or in folding must be in the @ForceArrays list
my @ForceArrays = (     "QNumber", "Bulletin", "Patch", "Product",
                        "AffectedProduct", "ServicePack",
                        "ProductFamily", "Location", "RegChg", "RegChange", "RegKey"
                        );
#Items that will be enumerated into a hash, and what string is the key

my @FoldArrays = (      Bulletin => "BulletinID",
                        Product => "ProductID",
                        ServicePack => "ServicePackID",
                        Location => "LocationID",
                                        ProductFamily => "ProductFamilyID",
                                        RegChange => "RegChangeID",
                                        Location => "LocationID");
#Items that are overcomplicated can be simplified.
#We 'flatten' RegKeys in one level
my @GroupTags = (RegKeys => "RegKey");
#Construct a new XML::Simple object
my $xml = new XML::Simple (     ForceArray => [@ForceArrays],
                                        KeyAttr => {@FoldArrays},
                                                        GroupTags => {@GroupTags}
                                        #Notice that we use KeyAttr => { list } NOT
KeyAttr => [ list ]
```

```
                                  );
###
# 1. Read the template file
open TEMPLATE, $template_file
                  or die "Could not open template file: $!\n";
my $template = "";
while(<TEMPLATE>)
{
 $template .= $_;
}


###
# 2. Read XML file
print "Reading XML file...\n";
my $data = $xml->XMLin($MSSecure)
                  or die "Cannot open XML file:". $!."\n";

###
# 3. Start digging...
print "Extracting data...\n";

# Find and read the desired <Bulletin>...</Bulletin> section
my $BulletinXML = get_Bulletin($data, $MS_BID)
                  or die "Could not find bulletin: $MS_BID\n";

###
# 4. Get the data from the XML in a hash form
my %Bulletin = parse_MS_BID($BulletinXML);
$Bulletin{'AdvisoryURL'} =
     "http://www.microsoft.com/technet/security/bulletin/$MS_BID.mspx";

###
# 5. Replace tags
print "Filling NASL template.\n";
$template = replaceTag($template, "Author", $Author);
$template = replaceTag($template, "ScriptID", $ScriptID);

#Convert the CVE array to a comma separated string
my $CVEList = "CVE-NO-MATCH";
if(defined $Bulletin{'CVE'})
{
 $CVEList = "\"".join("\", \"", @{$Bulletin{'CVE'}})."\"";
}
$template = replaceTag($template, "CVEID", $CVEList);

$template = replaceTag($template, "ScriptHotfix", $Bulletin{'QNumber'});

$template = replaceTag($template, "ScriptName", $Bulletin{'Title'});
$template = replaceTag($template, "ScriptSummary", $Bulletin{'Summary'});
$template = replaceTag($template, "ScriptSolution", $Bulletin{'AdvisoryURL'});
$template = replaceTag($template, "ScriptRiskFactor", $Bulletin{'RiskFactor'});
```

```
#Fill in the missing service packs tags
while (my ($productName,$productTags) = each (%ProductTags) )
{
  my $ServicePackVer = $Bulletin{'ServicePacks'}{$productName};
  if(defined $ServicePackVer)
  {
   $template = replaceTag($template, $productTags, $ServicePackVer);
  }
  else
  {
   $template = replaceTag($template, $productTags, "NULL");
  }
}

###
# 6. Write target nasl
my $target_nasl_name = "smb_nt_".lc($MS_BID).".nasl";
print "Creating $target_nasl_name\n";
if(! -f $target_nasl_name)
{
 open NASL, ">$target_nasl_name" or die "Could not create target nasl $!\n";
 print NASL $template;
}
else
{
 print "Target nasl: $target_nasl_name already exist. Aborting\n";
}
#All done.
exit 0;

### SUBS ###
sub parse_MS_BID
{
 my ($Bulletin) = @_;

 my %MS_Bulletin; #Result hash

 #QNumber. Take only the first, as Windows advisories have only one
 my @QNumbers = @{$Bulletin->{'QNumbers'}->{'QNumber'}};
 $MS_Bulletin{'QNumber'} = $QNumbers[0]->{'QNumber'};

 my @AffectedProducts;
 #Patches. Check if the advisory contain at least one patch
 if($Bulletin->{'Patches'} && $Bulletin->{'Patches'}->{'Patch'})
 {
  print "Extracting patch information for: ".$Bulletin->{'Title'}."\n";
  my @CVEs;
  my @BulletinPatches;
  my $HighestSeverity;
  my %CheckForSPs;

  foreach my $Patch (@{$Bulletin->{'Patches'}->{'Patch'}})
  {
```

```
 my %PatchInfo;

 #Read the registry changes for this patch. The registry changes
 #can contain HOTFIX path and ServicePack information
 my @HotfixPathInRegistry;
 if($Patch->{'RegChgs'})
 {
      @HotfixPathInRegistry = parse_RegChgs($Patch->{'RegChgs'}, $data);
 }

 #Record the highest severity for the final `Risk Level` tag
 if($Patch->{'MSSeverityID'} )
 {
  my $SeverityID = $Patch->{'MSSeverityID'};
  if( !$HighestSeverity || $HighestSeverity > $Patch->{'MSSeverityID'})
  {
   $HighestSeverity = $SeverityID;
  }
 }

#Get the CVE, and if it does not already exist, add it
my $CVEID = $Patch->{'CVEID'};
if($CVEID && ! grep(/^\Q$CVEID\E$/, @CVEs)) #See /Note 1/
{
 push @CVEs, $CVEID;
}
if($Patch->{'AffectedProduct'}) #See /Note 2/
{
  #Go over each AffectedProduct, if the product is a version of
      #Microsoft Windows, get Service Pack information
  foreach my $AffectedProduct (@{$Patch->{'AffectedProduct'}})
  {
       #Get the Nessus product name and the latest service pack
   my ($NESSUSProductID, $CurrentSPID) =
            parse_ProductID($AffectedProduct->{'ProductID'}, $data);
   #Check if the patch is alreay included in a service pack
   my $CheckForInstalledSP =
            parse_SPID($AffectedProduct->{'FixedInSP'}, $data);

       #Try to see if the patch is part of a Service Pack
       if(! defined $CheckForInstalledSP)
       {
    foreach my $RegistryPath (@HotfixPathInRegistry)
    {
     if($RegistryPath =~ /\\SP(\d)\\/) #See /Note 3/
     {
      $CheckForInstalledSP = $1;
               last;
         }
    }
    if(! $CheckForInstalledSP && defined $CurrentSPID)
    {
     print "Patch is not included in any existing ServicePack.".
```

```
                "Setting CheckForInstalledSP to be the upcoming one\n";
       $CheckForInstalledSP = $CurrentSPID + 1;
      }
         }
     #If the patch is relevant to a Windows product,
     #set the global required service packs to the one we found
     if(defined $NESSUSProductID && defined $CheckForInstalledSP)
         {
       print "NESSUSProductID: $NESSUSProductID".
                 " CheckForInstalledSP: $CheckForInstalledSP\n";
       if( (! defined $CheckForSPs{$NESSUSProductID}) ||
        ($CheckForInstalledSP > $CheckForSPs{$NESSUSProductID}) )
       {
        $CheckForSPs{$NESSUSProductID} = $CheckForInstalledSP;
       }
      }
     }
    }#AffectedProduct
    push @BulletinPatches, %PatchInfo;
    print "------\n\n";
   } #foreach patch

   #Fill the target hash
   $MS_Bulletin{'Title'} = $Bulletin->{'Title'};
   $MS_Bulletin{'Summary'} = $Bulletin->{'Summary'};
   $MS_Bulletin{'RiskFactor'} = $SeveritiesMap{$HighestSeverity};
   $MS_Bulletin{'Patches'} = [@BulletinPatches];
   $MS_Bulletin{'CVE'} = [@CVEs];
   $MS_Bulletin{'ServicePacks'} = { %CheckForSPs };

  } #If Patches exist
  else
  {
   print "Bulletin ".$MS_BID. " has no Patch information\n";
  }
 return %MS_Bulletin;
}

sub get_Bulletin
{
 my ($xml_data, $MS_BID) = @_;
 my %Bulletins = %{$xml_data->{'Bulletins'}->{'Bulletin'}};
 my $Bulletin = $Bulletins{$MS_BID};
 return $Bulletin;
}
###
#Convert ServicePackID -> Nessus ServicePackID
sub parse_SPID
{
 my ($MSSP_ID, $data) = @_;
 my $SP_ID_String = "";
 my $SP_ID;
```

```
 my %ServicePacks = %{ $data->{'ServicePacks'}->{'ServicePack'} };
 my $SP = $ServicePacks{$MSSP_ID};

 if($SP)
 {
  $SP_ID_String = $SP->{'Name'};
  #Gold edition is service pack 0
  if($SP_ID_String =~ /Gold/)
  {
   $SP_ID = 0;
  }
  #Otherwise, get the number of the service pack (6a == 6)
  elsif($SP_ID_String =~ /Service Pack (\d+)/)
  {
   $SP_ID = $1;
  }
 }
 return $SP_ID;
}

###
# Convert Patch{ProductID} -> Nessus Product
sub parse_ProductID
{
my ($MSProductID, $data) = @_;
 my $NESSUSProductID;
 my $CurrentSPID;
 # Map products to a hash
 my %MSProductsMap = %{ $data->{'Products'}->{'Product'} };
 my $Product = $MSProductsMap{$MSProductID}
             or return ($NESSUSProductID, $CurrentSPID);

 print "Product name: ".$Product->{'Name'}."\n";
 $CurrentSPID = parse_SPID($Product->{'CurrentServicePackID'}, $data);
 #Map ProductFamilies to a hash
 my %ProductFamilies =
           %{ $Product->{'ProductFamilies'}->{'ProductFamily'} };
 #Try to find each of Nessus product names in the ProductFamilies hash
 foreach my $MSProductID (keys %ProductsMap)
 {
  if($ProductFamilies{$MSProductID})
  {
   $NESSUSProductID = $ProductsMap{ $MSProductID };
  }
 }
 return ($NESSUSProductID, $CurrentSPID);
}
#Try to find Service Pack information from registry changes
sub parse_RegChgs
{
my ($RegChgs, $data) = @_;
 my @RegistryChanges; #Resulting registry changes information
 my %Locations = %{ $data->{'Locations'}->{'Location'} };
```

```
 #Go over all the reg keys and look for ours
 foreach my $RegKeyList ( @{ $data->{'RegKeys'} })
 {
  #If the RegKey list contain any data
  if($RegKeyList->{'RegChanges'}->{'RegChange'})
  {
   my %RegKeysInstalled = %{ $RegKeyList->{'RegChanges'}->{'RegChange'} };
   foreach my $RegChg (@{ $RegChgs->{'RegChg'} })
   {
    my $RegChangeID = $RegChg->{'RegChangeID'};
    if( $RegKeysInstalled{$RegChangeID})
    {
     my $LocationID = $RegKeysInstalled{$RegChg->{'RegChangeID'}}->
                                          {'LocationID'};

     push @RegistryChanges, $Locations{$LocationID}->{'Path'};
    }
   }
  }
 }
 return @RegistryChanges;
}
#Replace a tag with contents. If there is no contents, delete the tag
sub replaceTag
{
 my ($template, $tag, $contents) = @_;
 if(defined $template and defined $tag and defined $contents)
 {
  $template =~ s/<$tag\/>/$contents/sgi;
 }
 else
 {
  $template =~ s/<$tag\/>//sgi;
 }
 return $template;
}
```

In the grep command: grep(/^\Q$CVEID\E$/, @CVEs) we require an exact match. This is done by anchoring the regular expression with ^ (start of string) and $ (end of string). The \Q and \E around the *$CVEID* variable escapes the content of the variable so that if it contains regular expression metacharacters; they are not being treated as such, but rather escaped. The loop for each *Patch->AffectedProduct* finds the missing service pack information. If an *AffectedProduct* matches a Windows version, we get the following:

- $CurrentSPID Latest supported service pack for this version of Windows.
- $CheckForInstalledSP A service pack containing the patch (if available).

If $CheckForInstalledSP is 0, no service pack contains the patch, and we will set the missing service pack to the upcoming service pack ($CurrentSPID + 1).

The method we usually use to detect if a patch is included in a service pack is looking in the *AffectedProducts* elements:

```
<AffectedProduct ProductID="7" FixedInSP="3">
```

If the *FixedInSP* attribute is set to 0, this can mean two things:

1. There is no service pack available for this hotfix. We discussed this option before, and in this case, we simply set the service pack number to the upcoming service pack.
2. There is a service pack that contains the hotfix, and it appears in the registry. To find out which service pack includes the hotfix, we need to look in the registry changes made by the patch, under the *Locations* section of the XML:

If we find a registry key in the form of:

<Location LocationID="824" Path="HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Hotfix\Q305399" AbsolutePath=""/>

this means that the patch is an independent hotfix, not included in any service pack.

However, if the patch installs a registry key like:

<Location LocationID="821" Path="HKLM\SOFTWARE\Microsoft\Updates\Windows 2000**SP3**\Q252795" AbsolutePath=""/>

then the patch is included in Service Pack 3 of Windows 2000.

This helps us find which service pack includes the hotfix, even without the specific *FixedInSP* attribute.

Swiss Army Knife…

Looking for Other Products

The information inside the mssecure.xml contains more than just information on Microsoft Windows operating systems. By using the registry changes and file changes of every patch, you can detect any installed patch on the system. Nessus provides a simple interface for checking the versions of executables (.dll and .exe files for example). This is also done via the smb interface used to access the registry.

This powerful extension can be used to check that even your Microsoft Office suites are patched to the latest version.

Conclusion

The command-line tool presented here provides a simple and automatic way to create a Nessus plugin from the mssecure.xml scheme. More important, this shows a general approach to vulnerability detection.

The idea is to separate the testing mechanism (in our case remote registry access) from the actual vulnerability assessment data (stored in mssecure.xml). XML is extremely versatile and can be used to store the data on any type of vulnerability.

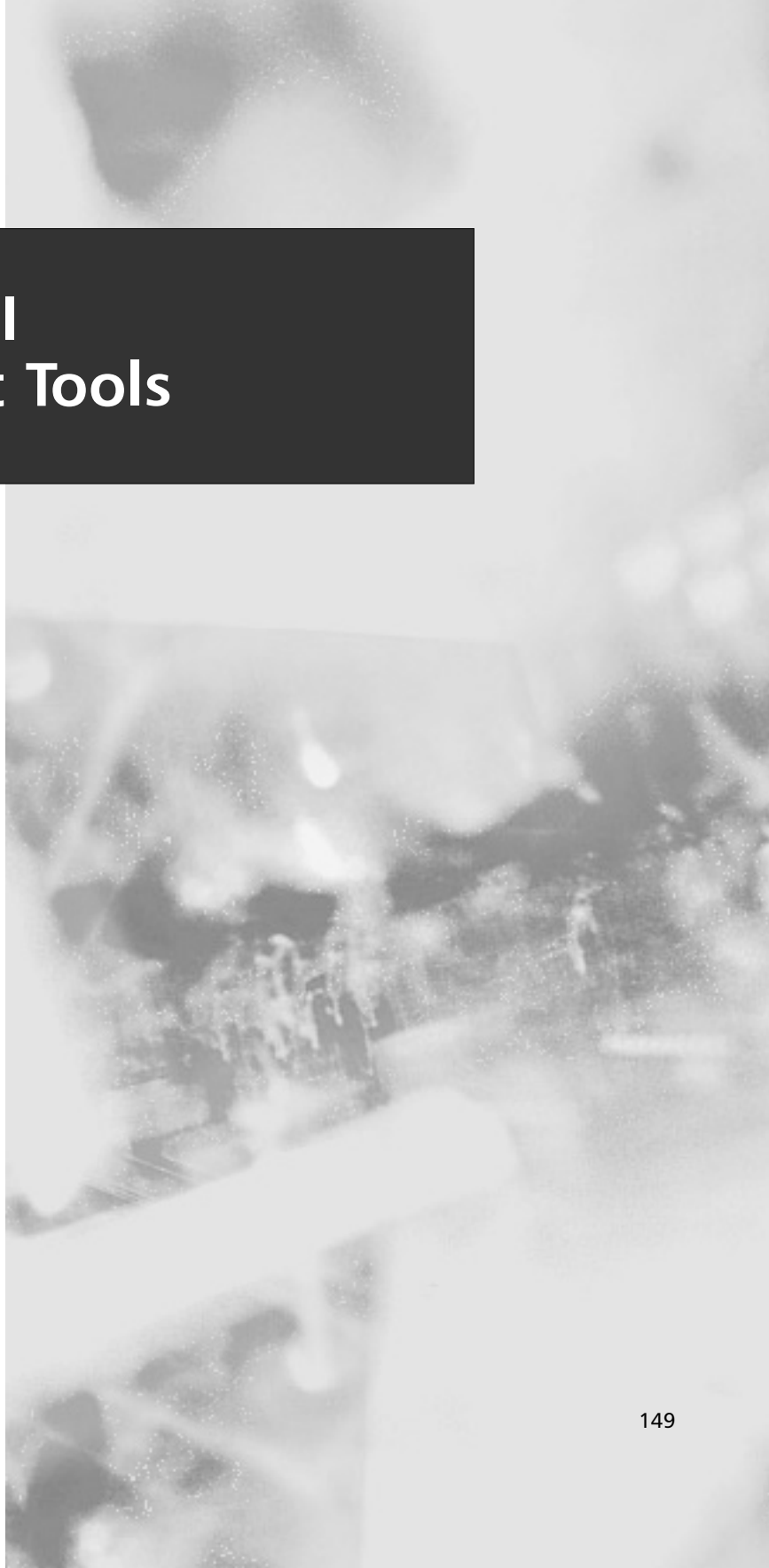
The benefits are quite obvious; here are just a few:

- **Multi-language support** The mssecure.xml file is supplied from Microsoft also in French, German, and Japanese. It is possible to create plugins in different language by parsing different XML versions.
- **Data syndication** XML is a magnificent tool to spread data. RSS feeds are simply a type of XML; there is no need to publish entire plugins if a suitable framework is built to spread the only the data required to detect the vulnerability.

Final Touches

In this chapter we've seen several approaches to simplifying Nessus plugin creation. The methods suggested can help you create plugins with little effort and benefit from the experience of others. Moreover, writing your own templates and data structures can help others extend your work without going into the details of the implementation.

Part II
Snort Tools



Chapter 7

The Inner Workings of Snort

Solutions in this chapter:

- **Initialization**
- **Decoding**
- **Preprocessing**
- **Detection**
- **The Stream4 Preprocessor**
- **Inline Functionality**

In This Toolbox

This chapter is aimed at people who have prior experience setting up and maintaining Snort source code. To reap the full benefits from the remaining chapters of this book, it will be helpful to have a firm understanding of the inner workings of Snort.

The best way to obtain an understanding of Snort is to read the source code. Snort source code is relatively straightforward and written in modular form, thereby allowing for easy reading and development.

This chapter aims to help readers understand Snort source code. It is suggested that readers download a copy of the Snort source code from www.snort.org to refer to throughout this chapter.

Introduction

To help develop an understanding of the inner workings of Snort, this chapter runs through the Snort engine and briefly explains the code involved in each part of the process.

This chapter also examines how Snort's inline capability works, and explains the various data structures Snort uses.

Master Craftsman

Vim + ctags Code Browsing Made Easy

The Vi IMproved (*vim*) text editor and the *ctags* utility form a partnership that makes browsing a semi-complex code tree like Snort, easy.

The vim editor has long been a favorite of UNIX system administrators and computer geeks. It features an (arguably) intuitive user interface with an enormous range of options available for navigating source code and manipulating text. Vim is available at www.vim.org.

The ctags utility generates an index (tag) file that stores the location of the symbols in a block of code, allowing for fast and easy browsing of the source code. Ctags supports languages such as C, C++, Common Business-Oriented Language (COBOL), Python, Perl, and Hypertext Preprocessor (PHP), and is available from http://ctags.sourceforge.net.

When combining the *ctags* utility with *vim*, you must first run the *ctags* utility in your chosen directory, using the **-R** option to make it recursively run through the entire source tree.

```
-[nemo@snortbox:~/snort-2.3.2]$ ctags -R .
```

Once the tags are generated, run *vim* as normal.

When a symbol such as a function call or a variable reference is used, position the cursor over the function call (see Figure 7.1).

Continued

With the *ParseCmdLine()* symbol selected, type **^] (control +])** to follow the symbol to its destination (see Figure 7.2).

To return to the previous position, type **^t (control + t)**.

This is only a small portion of the useful things that can be achieved using *ctags* and *vim*.

Figure 7.1 Selecting the Function Call

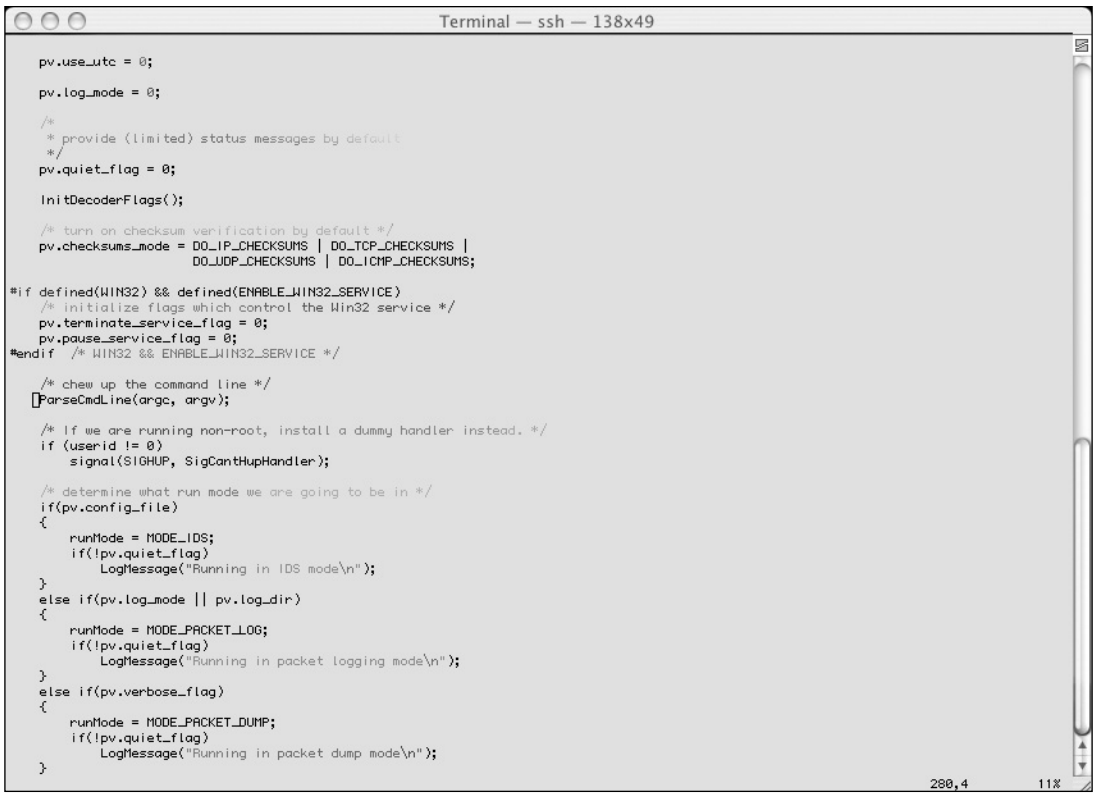
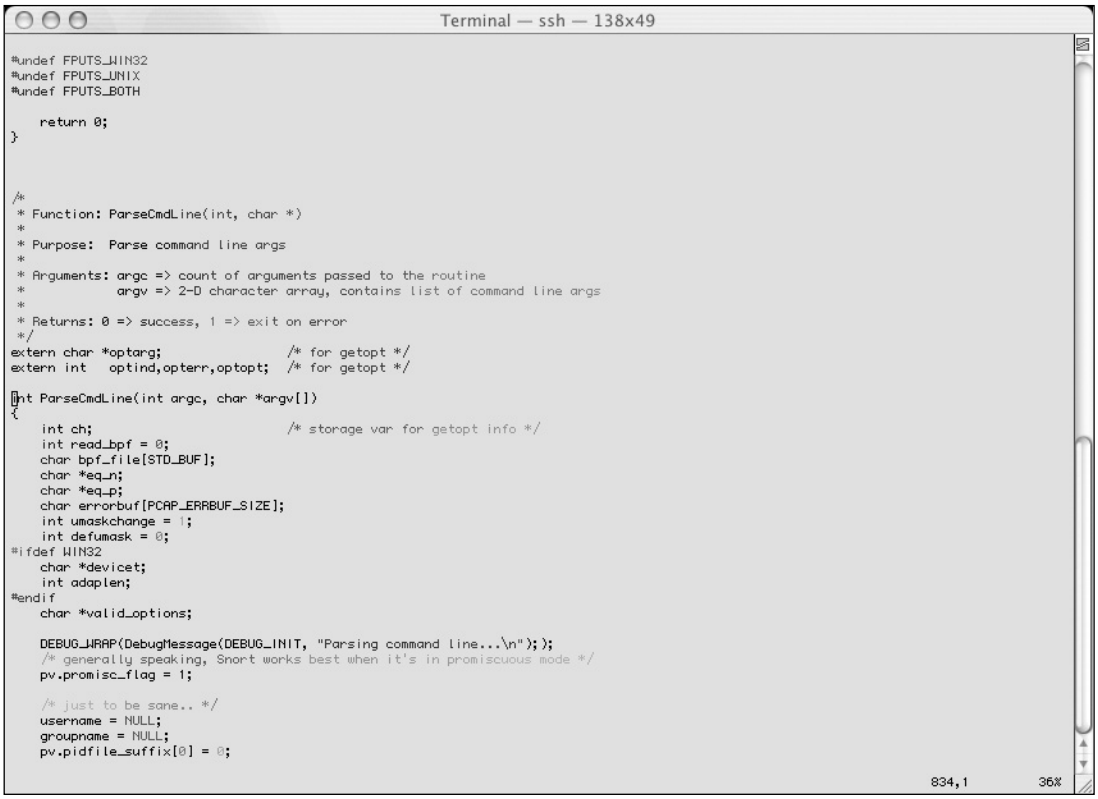


Figure 7.2 Running the *ParseCmdLine()* Function



Initialization

The first section of the Snort source code deals with initializing the Snort engine, which consists of setting up the data structures, parsing the configuration file, initializing the interface, and performing various other steps, depending on the mode selected by the user.

The following sections explain the initialization of the Snort engine.

Starting Up

Snort begins in the *main()* function; however, most of Snort's initialization takes place in the *SnortMain()* function. To start Snort as a Windows service, the *main()* function performs validation on the parameters passed to Snort, and checks for the **/SERVICE** keyword to see if Snort is compiled for Windows.

Next, the *SnortMain()* function is called. When *SnortMain()* finishes, the return value from this function is returned to the shell.

The *SnortMain()* function begins by associating a set of handlers for the signals Snort receives. It does this using the *signal()* function. A list of these signals, their handler, and what the handler does is shown in Table 7.1.

Table 7.1 Signal Handlers

Signal	Handler	Description
SIGTERM	*SigTermHandler()*	This handler calls the *CleanExit()* function to free up Snort resources and exit cleanly.
SIGINT	*SigIntHandler()*	This function calls the *CleanExit()* function.
SIGQUIT	*SigQuitHandler()*	The *CleanExit()* function is called by this handler to correctly shut Snort down.
SIGHUP	*SigHupHandler()*	The *SigHupHandler()* function calls the *Restart()* function. This frees all data required and closes the *pcap* object that was created. If Snort is compiled with the PARANOID variable defined, the *execv()* function is used to reexecute Snort. Otherwise, *execvp()* is used.
SIGUSR1	*SigUsr1Handler()*	The SIGUSR1 signal is used as a program-specific signal. The handler for this calls the *DropStats()* function to output the current Snort statistics. It then resumes program execution.

To remain portable, Snort checks the value of *errno* after each call to *signal()*. On Windows, some of these signals do not exist and *errno* is set. In this case, *errno* must be reset to **0** to avoid invalid results during later checks of *errno*.

Snort defines a structure *pv* in the *src/snort.h* file. This structure is used to store a set of global variables for Snort to use, including command-line arguments and various other global variables.

Snort instantiates a global instance of the *pv struct* to parse and store its arguments and various options. During the first half of the *SnortMain()* function, the *pv struct* is populated by various default settings. The following example shows the *pv struct*:

```
typedef struct _progvars

{

    int stateful;

    int line_buffer_flag;

    int checksums_mode;

    int assurance_mode;

    int max_pattern;

    int test_mode_flag;

    int alert_interface_flag;
```

```
    int verbose_bytedump_flag;
    int obfuscation_flag;
    int log_cmd_override;
    int alert_cmd_override;
    int char_data_flag;
    int data_flag;
    int verbose_flag;
    int readmode_flag;
    int show2hdr_flag;
    int showwifimgmt_flag;
#ifdef GIDS
    int inline_flag;
#ifndef IPFW
    char layer2_resets;
    u_char enet_src[6];
#endif
#ifdef IPFW
    int divert_port;
#endif /* USE IPFW DIVERT socket instead of IPtables */
#endif /* GIDS */
#ifdef WIN32
    int syslog_remote_flag;
    char syslog_server[STD_BUF];
    int syslog_server_port;
#ifdef ENABLE_WIN32_SERVICE
    int terminate_service_flag;
    int pause_service_flag;
#endif  /* ENABLE_WIN32_SERVICE */
#endif  /* WIN32 */
    int promisc_flag;
    int rules_order_flag;
    int track_flag;
    int daemon_flag;
    int quiet_flag;
```

```
    int pkt_cnt;
    int pkt_snaplen;
    u_long homenet;
    u_long netmask;
    u_int32_t obfuscation_net;
    u_int32_t obfuscation_mask;
    int alert_mode;
    int log_plugin_active;
    int alert_plugin_active;
    u_int32_t log_bitmap;
    char pid_filename[STD_BUF];
    char *config_file;
    char *config_dir;
    char *log_dir;
    char readfile[STD_BUF];
    char pid_path[STD_BUF];
    char *interface;
    char *pcap_cmd;
    char *alert_filename;
    char *binLogFile;
    int use_utc;
    int include_year;
    char *chroot_dir;
    u_int8_t min_ttl;
    u_int8_t log_mode;
    int num_rule_types;
    char pidfile_suffix[MAX_PIDFILE_SUFFIX+1]; /* room for a null */
    DecoderFlags decoder_flags; /* if decode.c alerts are going to be enabled */

#ifdef NEW_DECODER
    char *daq_method;
    char *interface_list[MAX_IFS];
    int interface_count;
    char *pcap_filename;
```

```
    char *daq_filter_string;

#endif  // NEW_DECODER
} PV;
```

It then uses the *ParseCmdLine()* function to break up the arguments that have been passed to it on the command line, and assigns the appropriate values in the *pv struct*. The outcome of this is used to determine if Snort is running Integrated Decision Support (IDS) mode, simple packet logging, or packet dumping in real time. The initialization of Snort differs depending on the mode selected.

If a configuration file is specified on the command line, Snort assumes that IDS mode is selected and sets the appropriate flag, unless specifically told otherwise.

NOTE

If no configuration file was provided on the command line and an IDS mode was requested, the *ConfigFileSearch()* function is used to try to locate a configuration file. This file checks (in order) */etc/snort.conf*, *./snort.conf*, and *~/.snortrc* before testing for *.snort.conf* in the current user's home directory.

If Snort is unable to find a specified mode to run in, it exits with the message "Uh, you need to tell me to do something...."

Finally, if Log mode is selected, Snort validates the log directory specified by the user by calling the *CheckLogDir()* function to make sure that the permissions specified on the log directory are acceptable.

WARNING

The *CheckLogDir()* test does not make it okay to set the Set User ID (SUID) bit on the Snort binary to allow other users to run it. This function tests the *CheckLogDir()* permissions using the *stat()* function, a one-off function that does not verify that the directory specified will not be removed and replaced with a symbolic link. This function is merely a convenience check and should not be considered secure.

Once Snort has finished verifying the command-line options, the *OpenPcap()* function is used to open the selected interface for packet capture. This is accomplished using the *libpcap* library.

Libpcap

The *libpcap* library (written by the Lawrence Berkeley National Laboratory) provides Snort with an easy and portable way to capture packets. Among other things, the *pcap* library is used by Snort to handle the opening of interfaces, packet capture, and filter parsing (e.g., src ip 192.168.0.123).

The *libpcap* library is free, and available for download at www.tcpdump.org. (*libpcap* is covered in detail in Chapter 1.)

In the *OpenPcap()* function, Snort begins by opening the interface as a *pcap* object. If a filter has been provided, it is applied while opening the interface, which limits the packets that are received by Snort.

Snort defines a global *pcap_t struct* named *pd* to hold this open *pcap* interface. This is initialized using the following function call:

```
/* get the device file descriptor */
        pd = pcap_open_live(pv.interface, snaplen,
                pv.promisc_flag ? PROMISC : 0, READ_TIMEOUT, errorbuf);
```

Following this, the *SnortMain()* function tests to see if it was invoked with the parameters required to run as a daemon. If this is the case, the *goDaemon()* function is used to *fork()* and begin daemon mode. It is also responsible for making the daemon "quiet" by redirecting all input and output to */dev/null*.

Depending on the parameters passed, Snort uses different methods for low-layer packet decoding. For ease of writing new decoders, Snort sets up a function pointer called grinder that points Snort at the appropriate decoders. The grinder function pointer is set using the *SetPktProcessor()* function.

```
typedef void (*grinder_t)(Packet *, struct pcap_pkthdr *, u_char *);  /* ptr to the packet
processor */

grinder_t grinder;
```

What happens after the packet processor is selected varies depending on the mode in which Snort was executed. For the purposes of this chapter, the initialization is run in IDS mode, which is the main mode in which Snort is usually executed.

Snort calls the *InitPreprocessors()* and *InitPlugins()* functions. These functions (discussed in detail in Chapter 9) are used to call the appropriate *Setup()* functions for each of the preprocessors and plugins. Each of these *Setup()* functions is responsible for associating the *plugins Setup()* function with the keyword that triggers it, and is also responsible for initializing any data needed by the plugin. These functions are found in the *src/plugbase.c* file.

The *InitTag()* function is also called to set up Snort's tagging functionality, which is found in the *src/tag.c* file.

Parsing the Configuration File

Once Snort has finished setting up its plugins and preprocessors, the next step is to call the *ParseRuleFile()* function to parse the selected configuration file.

This function (found in *src/parser.c*) reads in the configuration file line-by-line and passes it to the *ParseRule()* function for testing. If a \ is found on the line, the following lines are read from the configuration file and concatenated to the original line before the *ParseRule()* function is called.

The *ParseRule()* function tests the start of the rule to determine what type of rule has been passed.

ParsePreprocessor()

The *ParsePreprocessor()* function is called if the rule line is a preprocessor statement.

There are two structures used to store information about preprocessors. These structures are defined in the *src/plugbase.h* file. The list is made up of a series of *PreprocessKeywordEntry structs*, each containing a *PreprocessKeywordNode struct* and a pointer to the next item in the list.

```
typedef struct _PreprocessKeywordList
{
    PreprocessKeywordNode entry;
    struct _PreprocessKeywordList *next;

} PreprocessKeywordList;
```

Each *PreprocessKeyWordNode struct* within the list contains the keyword associated with the preprocessor, and a void function pointer to the *Init()* function for the preprocessor.

```
typedef struct _PreprocessKeywordNode
{
    char *keyword;
    void (*func)(char *);

} PreprocessKeywordNode;
```

The *ParsePreprocessor()* function goes through the list to determine if the preprocessor exists. (This list was initialized by the *InitPreprocessors()* function earlier.)

When an appropriate match is found for the given keyword, the function pointer that is stored in this *struct* is called to initialize the preprocessor. This entire process is accomplished using the following code:

```
PreprocessKeywordList *pl_idx;  /* index into the preprocessor
                                     * keyword/func list */
...

/* set the index to the head of the keyword list */
    pl_idx = PreprocessKeywords;

...

while(pl_idx != NULL)
    {
        DEBUG_WRAP(DebugMessage(DEBUG_CONFIGRULES,
                                "comparing: \"%s\" => \"%s\"\n",
                                funcname, pl_idx->entry.keyword););
        /* compare the keyword against the current list element's keyword */
        if(!strcasecmp(funcname, pl_idx->entry.keyword))
        {
            pl_idx->entry.func(pp_args);
            found = 1;
        }
        if(!found)
        {
            pl_idx = pl_idx->next;
```

```
        }
        else
            break;
    }
```

ParseOutputPlugin()

If the line in the configuration file being parsed describes an output plugin, the *ParseOutputPlugin()* function is called to set up the appropriate data structures.

The structures used in this function are defined in the *src/spo_plugbase.h* file. During the *InitOutputPlugins()* function's execution, a linked list of the *OutputKeywordList* data structure is defined.

```
typedef struct _OutputKeywordList
{
    OutputKeywordNode entry;
    struct _OutputKeywordList *next;

} OutputKeywordList;
```

Each of the members of this list consists of an *OutputKeywordNode* data structure and a pointer to the next element in the list.

The *OutputKeywordNode* consists of the keyword itself, the associated function pointer, and a character representing the type of node.

```
typedef struct _OutputKeywordNode
{
    char *keyword;
    char node_type;
    void (*func)(char *);

} OutputKeywordNode;
```

Much like the *ParsePreprocessor()* function, the *ParseOutputPlugin()* function uses a temporary pointer to the linked list of structures and goes through the list searching for the appropriate output plugin. However, it uses the *GetOutputPlugin()* function from the *src/plugbase.c file* to perform the search.

```
OutputKeywordNode *GetOutputPlugin(char *plugin_name)
{
    OutputKeywordList *list_node;

    if(!plugin_name)
        return NULL;

    list_node = OutputKeywords;

    while(list_node)
    {
        if(strcasecmp(plugin_name, list_node->entry.keyword) == 0)
            return &(list_node->entry);
```

```
        list_node = list_node->next;
    }
    FatalError("unknown output plugin: '%s'",
               plugin_name);

    return NULL;
}
```

Once the appropriate *OutputKeywordNode* has been retrieved, the *ParseOutputPlugin()* function tests the *node_type* variable and performs various actions based on it.

Regardless of *node_type*, the node pointer is *de-referenced* and the configuration function pointer is called.

Snort Rules

In cases where the line being evaluated in the *ParseRule()* function belongs to a typical Snort rule, (Pass, Alert, Log), a *struct* local to the *ParseRule()* function is populated and added to the list of rules.

The *ParseRule()* function defines a local instance of the *RuleTreeNode* structure called *proto_node*. It then populates this structure, depending on the type of rule being parsed.

```
typedef struct _RuleTreeNode
{
    RuleFpList *rule_func; /* match functions.. (Bidirectional etc.. ) */

    int head_node_number;

    int type;

    IpAddrSet *sip;
    IpAddrSet *dip;

    int not_sp_flag;     /* not source port flag */

    u_short hsp;          /* hi src port */
    u_short lsp;          /* lo src port */

    int not_dp_flag;     /* not dest port flag */

    u_short hdp;          /* hi dest port */
    u_short ldp;          /* lo dest port */

    u_int32_t flags;     /* control flags */

    /* stuff for dynamic rules activation/deactivation */
    int active_flag;
    int activation_counter;
    int countdown;
    ActivateList *activate_list;

    struct _RuleTreeNode *right;  /* ptr to the next RTN in the list */
```

```
    OptTreeNode *down;   /* list of rule options to associate with this
                            rule node */
    struct _ListHead *listhead;

} RuleTreeNode;
```

First, the protocol field is set, followed by the source Internet Protocol (IP) address range list, which is populated using the *ProcessIP()* function to expand the Classless Inter-Domain Routing (CIDR) notation form of the source IP address. Next, the source port and directional operator is parsed. Following this, a second call to *ProcessIP()* is used to parse the destination IP address before finally reaching the destination port.

NOTE

If the keyword "any" is used in the IP field, the IP and netmask fields are set to **0** to symbolize this.

The rest of the initialization of the *RuleTreeNode struct* differs depending on the type of rule.

The *ListHead* structure is used to organize the rules into their appropriate categories. It contains several *RuleTreeNode* lists, one for each protocol.

```
typedef struct _ListHead
{
    RuleTreeNode *IpList;
    RuleTreeNode *TcpList;
    RuleTreeNode *UdpList;s
    RuleTreeNode *IcmpList;
    struct _OutputFuncNode *LogList;
    struct _OutputFuncNode *AlertList;
    struct _RuleListNode *ruleListNode;
} ListHead;
```

The *src/parser.c* file declares several global instances of the *ListHead struct* to store each of the rules depending on their *rule_type*. These global variables are shown in the following example:

```
ListHead Alert;         /* Alert Block Header */
ListHead Log;           /* Log Block Header */
ListHead Pass;          /* Pass Block Header */
ListHead Activation;    /* Activation Block Header */
ListHead Dynamic;       /* Dynamic Block Header */
ListHead Drop;
ListHead SDrop;
ListHead Reject;
```

For each of the rules, the *RuleTreeNode* and the appropriate *ListHead* is passed (by reference) to the *ProcessHeadNode()* function, to populate the rules *OptTreeNode* pointer (down).

The *OptTreeNode struct* is used by the *RuleTreeNode struct* to store all of the options associated with a rule. The *struct* contains attributes about the rule, including some of the options that do not require a test such as the Threshold option and the Activates option.

```
typedef struct _OptTreeNode
{
    /* plugin/detection functions go here */
    OptFpList *opt_func;
    RspFpList *rsp_func;  /* response functions */
    OutputFuncNode *outputFuncs; /* per sid enabled output functions */

    /* the ds_list is absolutely essential for the plugin system to work,
       it allows the plugin authors to associate "dynamic" data structures
       with the rule system, letting them link anything they can come up
       with to the rules list */
    void *ds_list[64];   /* list of plugin data struct pointers */

    int chain_node_number;

    int type;            /* what do we do when we match this rule */
    int evalIndex;       /* where this rule sits in the evaluation sets */

    int proto;           /* protocol, added for integrity checks
                            during rule parsing */
    struct _RuleTreeNode *proto_node; /* ptr to head part... */
    int session_flag;    /* record session data */

    char *logto;         /* log file in which to write packets which
                            match this rule*/
    /* metadata about signature */
    SigInfo sigInfo;

    u_int8_t stateless;  /* this rule can fire regardless of session state */
    u_int8_t established; /* this rule can only fire if it is established */
    u_int8_t unestablished;

    Event event_data;

    TagData *tag;

    /* stuff for dynamic rules activation/deactivation */
    int active_flag;
    int activation_counter;
    int countdown;
    int activates;
    int activated_by;

    u_int8_t  threshold_type; /* type of threshold we're watching */
    u_int32_t threshold;    /* number of events between alerts */
    u_int32_t window;       /* number of seconds before threshold times out */

    struct _OptTreeNode *OTN_activation_ptr;
    struct _RuleTreeNode *RTN_activation_ptr;

    struct _OptTreeNode *next;
    struct _RuleTreeNode *rtn;
```

```
} OptTreeNode;
```

The *OptTreeNode struct's* most important members are two linked lists consisting of the *OptFPList* and *RspFPList* data structures. The *OptFPList* is responsible for holding a linked list of all of the detection plugins *Check()* functions that must be called in order for a rule to be considered a successful match.

```
typedef struct _OptFpList
{
    /* context data for this test */
    void *context;

    int (*OptTestFunc)(Packet *, struct _OptTreeNode *, struct _OptFpList *);

    struct _OptFpList *next;

} OptFpList;
```

The *RspFPList* is used to store a list of function pointers that are called when the rule performs a successful match.

```
typedef struct _RspFpList
{
    int (* ResponseFunc)(Packet *, struct _RspFpList *);
    void *params; /* params for the plugin.. type defined by plugin */
    struct _RspFpList *next;
} RspFpList;
```

In the *ProcessHeadNode()* function, the appropriate list in the *ListHead* is selected depending on the protocol field of the new rule. A new *RuleTreeNode* data structure is then allocated using the *calloc()* function, and then appended to the selected list .

The existing rule header from the temporary rule created during the *ParseRule()* function is copied into the new *RuleTreeNode (rtn_tmp*) using the *XferHeader()* function. This function copies the entire header between the two *RuleTreeNodes*.

```
void XferHeader(RuleTreeNode * rule, RuleTreeNode * rtn)
{
    rtn->type = rule->type;
    rtn->sip = rule->sip;
    rtn->dip = rule->dip;
    rtn->hsp = rule->hsp;
    rtn->lsp = rule->lsp;
    rtn->hdp = rule->hdp;
    rtn->ldp = rule->ldp;
    rtn->flags = rule->flags;
    rtn->not_sp_flag = rule->not_sp_flag;
    rtn->not_dp_flag = rule->not_dp_flag;
}
```

The *ProcessHeadNode()* function then sets the *RuleTreeNode* (*rtn_temp)*'s down pointer to null before passing it to the *SetupRTNFuncList()* function to be populated.

This function is responsible for changing the source and destination IP addresses and ports, and changing the directional operator into function calls and adding them to the *OptFpList* belonging to rule. This is achieved by using the *AddRuleFuncToList()* function, which adds a new member to the *OptFpList* and copies in the appropriate function pointer.

The *PortToFunc()* and *AddrFunc()* functions are used to convert the port and IP address values, respectively, into function pointers. It then adds them to the rule using the *AddRuleFuncToList()* function,.

The source code for the *SetupRTNFuncList()* function is shown in the following example:

```
void SetupRTNFuncList(RuleTreeNode * rtn)
{
    DEBUG_WRAP(DebugMessage(DEBUG_CONFIGRULES,"Initializing RTN function list!\n"););
    DEBUG_WRAP(DebugMessage(DEBUG_CONFIGRULES,"Functions: "););

    if(rtn->flags & BIDIRECTIONAL)
    {
        DEBUG_WRAP(DebugMessage(DEBUG_CONFIGRULES,"CheckBidirectional->\n"););
        AddRuleFuncToList(CheckBidirectional, rtn);
    }
    else
    {
        /* Attach the proper port checking function to the function list */
        /*
         * the in-line "if's" check to see if the "any" or "not" flags have
         * been set so the PortToFunc call can determine which port testing
         * function to attach to the list
         */
        PortToFunc(rtn, (rtn->flags & ANY_DST_PORT ? 1 : 0),
                   (rtn->flags & EXCEPT_DST_PORT ? 1 : 0), DST);

        /* as above */
        PortToFunc(rtn, (rtn->flags & ANY_SRC_PORT ? 1 : 0),
                   (rtn->flags & EXCEPT_SRC_PORT ? 1 : 0), SRC);

            /* link in the proper IP address detection function */
        AddrToFunc(rtn, SRC);

        /* last verse, same as the first (but for dest IP) ;) */
        AddrToFunc(rtn, DST);
    }

    DEBUG_WRAP(DebugMessage(DEBUG_CONFIGRULES,"RuleListEnd\n"););

    /* tack the end (success) function to the list */
    AddRuleFuncToList(RuleListEnd, rtn);
}
```

Finally, the *RuleListEnd()* function callback is appended to the list to indicate when a rule has finished matching and is successful.

Now that the rule has been set up with the basic set of functions in its *OptFPList* list, the other options need to be parsed and added. To do this, Snort uses the *ParseRuleOptions()*. This

function breaks up the rules options and adds the appropriate function pointers to the list. Several of the Snort rule options are hard-coded into this function. These parsing functions store the option in the appropriate attributes of the *OptTreeNode struct*. Table 7.2 includes a list of those options and their appropriate parsing functions.

Table 7.2 Hard-Coded Options

Option	Parsing Function
msg	*ParseMessage()*
logto	*ParseLogto()*
activates	*ParseActivates()*
activated_by	*ParseActivatedBy()*
count	*ParseCount()*
Tag	*ParseTag()*
Threshold	*ParseThreshold()*
Sid	*ParseSID()*
Rev	*ParseRev()*
reference	*ParseReference()*
Priority	*ParsePriority()*
classtype	*ParseClassType()*
Stateless	No function is used; however, the stateless attribute is set from within the *ParseRuleOptions()* function.

The *KeywordList* linked list is searched for any rule that contains detection options not listed in Table 7.2. The following code shows this:

```
kw_idx = KeywordList;
                found = 0;

                while(kw_idx != NULL)
                {
                    DEBUG_WRAP(DebugMessage(DEBUG_INIT, "comparing: \"%s\" => \"%s\"\n",
                                            option_name, kw_idx->entry.keyword););

                    if(!strcasecmp(option_name, kw_idx->entry.keyword))
                    {
                        if(num_opts == 2)
                        {
                            kw_idx->entry.func(option_args, otn_tmp, protocol);
                        }
                        else
                        {
                            kw_idx->entry.func(NULL, otn_tmp, protocol);
                        }
                        DEBUG_WRAP(DebugMessage(DEBUG_INIT, "%s->", kw_idx-
>entry.keyword););
                        found = 1;
                        break;
```

```
        }
        kw_idx = kw_idx->next;
    }
```

When a match is found, the initialization function is called to set up the detection option. The initialization function for each detection option is responsible for calling the *AddOptFuncToList()* to add its own *Check()* function to the list.

Event Queue Initialization

Now that the configuration file has been parsed and the appropriate data structures set up, execution returns to the *SnortMain()* function in the *src/snort.c* file.

The flowbits rules are sanity checked using the *FlowBitsVerify()* and then the *SnortEventqInit()* function. This function performs a few checks and then calls the *feventq_init()* function to start up the event queue. The source to this function is found in the *src/sfutil/sfeventq.c* file. This function allocates the memory required by the event queue to store *max_nodes* numbers of events in memory.

Final Initialization

The *SnortMain()* function finishes off by *chroot()*'ing Snort (if needed) and dropping privileges, outputting the banner and statistical information, and calling the *InterfaceThread()* to begin capturing packets.

The *InterfaceThread()* function uses the *pcap_loop()* function to associate a callback function pointer with a *pcap* interface. Because a newly created *pcap* interface (*pd*) was created by the user complete with any filters supplied, the *pd* interface is used. The callback function used is the *ProcessPacket()*. The *pcap_loop()* function sits and blocks until an error occurs (or a signal is received). This is where the main loop of Snort occurs. Whenever a packet is received, the *ProcessPacket()* function is called to process it.

Decoding

Now that Snort has finished initializing and the main body of the Snort engine is working, execution begins at the *ProcessPacket()* function when a new packet is received. It is at this point that all of the hard work spent setting it up pays off and you can use data structures that you spent so much time and effort setting up.

The definition of the *ProcessPacket()* function is shown in the following example:

```
void ProcessPacket(char *user, struct pcap_pkthdr * pkthdr, u_char * pkt)
```

When the *ProcessPacket()* function is called, it begins by incrementing the packet count and storing the time the packet was captured.

Following this, the grinder function pointer is called and the arguments to *ProcessPacket()* are passed to it.

```
 (*grinder) (&p, pkthdr, pkt);
```

A previous example in this chapter showed how the grinder function pointer was initialized to point to the selected decoder function, depending on the arguments that were provided to Snort by the user. This was done during the *SetPktProcessor()* function.

The possible decoders and their descriptions are shown in Table 7.3. Each of these decoders can be found in the *src/decode.c* file.

Table 7.3 Possible Decoders

Decoder	Description
DecodeIptablesPkt	This decoder is used to decode *Iptables* packets in Inline mode. It is basically a wrapper around the *DecodeIP()* function.
DecodeIpfwPkt	This decoder is used to decode packets from the Internet Protocol Firewall (IPFW) firewall; at the moment, this function is also a wrapper around the function.
DecodeEthPkt	This decoder checks the *ether_type* field of the Ethernet header, and calls the appropriate packet decoders to break the packet down further.
DecodeIEEE80211Pkt	This decoder examines 802.11 Wireless Local Area Network (WLAN) packets.
DecodeTRPkt	This decoder is used for Token Ring packets. It verifies the header fields according to Request For Comment (RFC) 1042. It is then passed to various other decoders such as *DecodeVlan()* or *DecodeIP()*, depending on the Ethernet-type header field.
DecodeFDDIPkt	This decoder is used to decode Fiber Distributed Data Interface (FDDI) packets.
DecodeChdlcPkt	This decoder is used to decode High-Level Data Link Control (HDLC) encapsulated packets. It tests the size of the packet and the various HDLC fields before passing to the *DecodeIP()* function.
DecodeSlipPkt	This decoder is used to decode SLIP traffic. A test is made to determine if the size of the packet is greater than or equal to the size of a SLIP header, before passing the packet to the *ParseIP()* function.
DecodePppPkt	This decoder is used to decode Point-to-Point Protocol (PPP) traffic. It does this using RFC 1661 standards.
decodepppserialpkt	This decoder is used to decode mixed PPP and HDLC traffic. It tests the length and second byte of the packet before passing it to either the *DecodePppPktEncapsulated()* or the *DecodeChdlcPkt()* decoder.
DecodeLinuxSLLPkt	This decoder is used to decode *LinuxSLL* (cooked socket) traffic. Once the *LinuxSLL* header is parsed, the packet is passed to the appropriate decoder for its network type.

Continued

Table 7.3 continued Possible Decoders

Decoder	Description
DecodePflog	This decoder is for *pflog* packets. It passes the packets to the *DecodeIP()* or *DecodeIPV6()* functions depending on the header.
DecodeNullPkt	This decoder is used for loopback devices. It tests the *caplen* before passing to the *DecodeIP()* function.
DecodeRawPkt	This decoder is basically a wrapper around DecodeIP(). It does not perform any checks.
DecodeI4LRawIPPkt	This decoder is for decoding packets that are coming in raw on Layer 2. It tests the packet length, and if it is less than 2, rejects it. The *DecodeIP()* function is then called.
DecodeI4LCiscoIPPkt	This decoder tests the length of the packet. A packet length of less than four is rejected. Otherwise, the *DecodeIP()* function is called.

At a basic level, each of these decoders parses its appropriate header data, validating certain fields before setting the packet pointer to the next header and passing the pointer to the next decoder.

To understand the life of a packet inside a typical decoder, trace through the source for the *DecodeEthPkt()* function.

```
void DecodeEthPkt(Packet * p, struct pcap_pkthdr * pkthdr, u_int8_t * pkt)
{
    u_int32_t pkt_len;      /* suprisingly, the length of the packet */
    u_int32_t cap_len;      /* caplen value */

    bzero((char *) p, sizeof(Packet));

    p->pkth = pkthdr;
    p->pkt = pkt;

    /* set the lengths we need */
    pkt_len = pkthdr->len;  /* total packet length */
    cap_len = pkthdr->caplen;   /* captured packet length */

    if(snaplen < pkt_len)
        pkt_len = cap_len;

    DEBUG_WRAP(DebugMessage(DEBUG_DECODE, "Packet!\n");
            DebugMessage(DEBUG_DECODE, "caplen: %lu    pktlen: %lu\n",
                (unsigned long)cap_len, (unsigned long)pkt_len);
            );

    /* do a little validation */
    if(cap_len < ETHERNET_HEADER_LEN)
    {
        if(pv.verbose_flag)
        {
```

```
            ErrorMessage("Captured data length < Ethernet header length!"
                         " (%d bytes)\n", p->pkth->caplen);
        }
        return;
    }

    /* lay the ethernet structure over the packet data */
    p->eh = (EtherHdr *) pkt;

    DEBUG_WRAP(
            DebugMessage(DEBUG_DECODE, "%X   %X\n",
                *p->eh->ether_src, *p->eh->ether_dst);
            );

    /* grab out the network type */
    switch(ntohs(p->eh->ether_type))
    {
        case ETHERNET_TYPE_PPPoE_DISC:
        case ETHERNET_TYPE_PPPoE_SESS:
            DecodePPPoEPkt(p, pkthdr, pkt);
            return;

        case ETHERNET_TYPE_IP:
            DEBUG_WRAP(
                    DebugMessage(DEBUG_DECODE,
                        "IP datagram size calculated to be %lu bytes\n",
                        (unsigned long)(cap_len - ETHERNET_HEADER_LEN));
                    );

            DecodeIP(p->pkt + ETHERNET_HEADER_LEN,
                    cap_len - ETHERNET_HEADER_LEN, p);

            return;

        case ETHERNET_TYPE_ARP:
        case ETHERNET_TYPE_REVARP:
            DecodeARP(p->pkt + ETHERNET_HEADER_LEN,
                    cap_len - ETHERNET_HEADER_LEN, p);
            return;

        case ETHERNET_TYPE_IPV6:
            DecodeIPV6(p->pkt + ETHERNET_HEADER_LEN,
                    (cap_len - ETHERNET_HEADER_LEN));
            return;
case ETHERNET_TYPE_IPX:
            DecodeIPX(p->pkt + ETHERNET_HEADER_LEN,
                    (cap_len - ETHERNET_HEADER_LEN));
            return;

        case ETHERNET_TYPE_8021Q:
            DecodeVlan(p->pkt + ETHERNET_HEADER_LEN,
                    cap_len - ETHERNET_HEADER_LEN, p);
            return;
```

```
        default:
            pc.other++;
            return;
    }

    return;
}
```

The *DecodeEthPkt()* function takes the following three arguments:

- **Packet * p** A pointer to storage for the Decoded packet.
- **struct pcap_pkthdr *** A pointer to the packet header.
- **pkthdr, u_int8_t * pkt** A pointer to the actual packet data.

The first thing the *DecodeEthPkt()* function does is *bzero()* the Packet *struct*. The *bzero()* function sets the values of the specified memory addresses to **0**. The Packet *struct* (defined in the *src/decode.h* file) is a long *struct* that contains attributes for all of the different decoder packet data Snort supports.

Next, the *pkth* field of the newly zeroed Packet *struct* is set to a pointer to the *pkthdr* argument and passed to the function. The *pkt* field of the *struct* is also set to the *pkt* argument.

Some validation is then done to make sure that the length of the captured packet is greater than or equal to the size of an Ethernet header. If this is not the case, the decoder ends and an error message is generated.

The current position of the *pkt* pointer that was passed to the decoder is then interpreted as an Ethernet header, and the location of this is stored in the Packet *struct* as the *eh* field.

This newly located Ethernet header is then tested to determine the type of Ethernet packet that is being decoded.

Depending on the type of Ethernet packet, the appropriate *Decode()* function is called to decode the next layer of the packet. The size of the Ethernet header is added to the *pkt* pointer to determine where the next header should be stored.

This is done until everything is decoded and all of the possible Packet *struct* fields are populated.

Preprocessing

After the packet decoding is finished, the *ProcessPacket()* function tests the mode in which Snort is running. If Snort is only running in Packet Log mode, the *CallLogPlugins()* function is used to log the packet accordingly. However, if Snort is running in IDS mode, the decoded Packet *struct* is passed to the *Preprocess()* to begin the preprocessing (and eventually detection) phase.

The *PreProcess()* function begins by declaring a temporary pointer (*idx*) to the linked list of *ProprocessFuncNode* structures called *PreprocessList*. This preinitialized list holds the function pointers to each of the *Check()* functions in the preprocessors that have been initialized by the configuration file.

The function then uses the *idx* pointer to go through the list de-referencing and calling the check functions for each of the preprocessors.

The Decoded Packet *struct* is passed to each of the preprocessors in turn.

```
int Preprocess(Packet * p)
{
    PreprocessFuncNode *idx;
    int retval = 0;

    /*
     *  If the packet has an invalid checksum marked, throw that
     *  traffic away as no end host should accept it.
     *
     *  This can be disabled by config checksum_mode: none
     */
    if(p->csum_flags)
    {
        return 0;
    }

    do_detect = 1;
    idx = PreprocessList;

    /*
    **  Reset the appropriate application-layer protocol fields
    */
    p->uri_count = 0;
    UriBufs[0].decode_flags = 0;

    /*
    **  Turn on all preprocessors
    */
    p->preprocessors = PP_ALL;

    while(idx != NULL)
    {
        assert(idx->func != NULL);
        idx->func(p);
        idx = idx->next;
    }

    check_tags_flag = 1;

    if(do_detect)
        Detect(p);

    /*
    ** By checking tagging here, we make sure that we log the
    ** tagged packet whether it generates an alert or not.
    */
    CheckTagging(p);

    retval = SnortEventqLog(p);
```

```
    SnortEventqReset();

    otn_tmp = NULL;

    /*
    **  If we found events in this packet, let's flush
    **  the stream to make sure that we didn't miss any
    **  attacks before this packet.
    */
    if(retval && p->ssnptr)
        AlertFlushStream(p);

    /**
     * See if we should go ahead and remove this flow from the
     * flow_preprocessor -- cmg
     */
    CheckFlowShutdown(p);

    return retval;
}
```

After all of the preprocessors have been called, the *PreProcess()* function checks the value of the *do_detect* variable set during the initialization of Snort. It calls the *Detect()* function if the *do_detect* variable is set. The Packet *struct* is passed to this function. The *do_detect* variable is a quick way to tell Snort not to process rules through the detection engine. If a preprocessor decides that a packet should not be examined, it can unset the *do_detect* variable.

Detection

The detection phase begins in the *Detect()* function. However, this function does nothing more than verify the existence of the packet and IP header before passing the packet to the *fpEvalPacket()* function for further testing.

The old detection algorithm involved calling the *EvalHeader()* function and going through the OTN list to test each option. This algorithm was slow and has been replaced with a faster and more complicated algorithm.

The *fpEvalPacket()* function tests the *ip_proto* field of the IP header to determine what to do next. If the packet is Transmission Control Protocol/User Datagram Protocol (TCP/UDP) or Internet Control Message Protocol (ICMP), then the *fpEvalHeaderTcp()*, *fpEvalHeaderUdp()*, and *fpEvalHeaderICMP()* functions are called. Otherwise, the *fpEvalHeaderIp()* function is used to check based on IP.

By checking ports and protocols up front for a given packet, Snort is able to limit the amount of rules that must be evaluated, greatly reducing the amount of work Snort would need to perform.

For all of the *fpEval()* functions except for the *fpEvalHeaderICMP()*, the first step is to call the *prmFindRuleGroup()* function. This is done to make sure a match exists for the source and destination port mentioned in the rule. This is a quick way to eliminate rules without complex pattern matching.

This function returns a number representing the appropriate rule group that requires more inspection. The block comment for this function defines the behavior for the return value as the following:

```
int -  0: No rules
       1: Use Dst Rules
       2: Use Src Rules
       3: Use Both Dst and Src Rules
       4: Use Generic Rules
```

Once a successful match for the ports is found, the *fpEvalHeaderSW()* function is entered. This function begins by testing if there are any Uniform Resource Identifier (URI) rules. If there are, the rule data is normalized first.

Eventually, the OTN and RTN lists are gone through to test the rest of the detection options. However, in this model, when a match is found an event is added to the appropriate queue using the *fpAddMatch()* function.

There are three event queues set up: alert, log, and pass. The order in which these queues are checked is based on the order specified by the user at runtime. By default, the alert queue is checked first, followed by the log queue and finally the pass queue.

Content Matching

To accomplish the complex pattern matching used in Snort rules, the Snort team has implemented a series of string matching and parsing functions.

These functions are contained in the *src/mstring.c* and *src/mstring.h* files in the Snort source tree. The functions shown in Table 7.4 are defined in these files.

Table 7.4 Content-Matching Functions

Function	Description
int mSearch(char *, int, char *, int, int *, int *);	The *mSearch()* function is also used to test for the occurrence of a substring within another string.
int mSearchCI(char *, int, char *, int, int *, int *);	The *mSearchCI()* function is a case-insensitive version of the *mSearch()* function.
int *make_skip(char *, int);	Creates a Boyer-Moore skip table.
int *make_shift(char *, int);	Creates a Boyer-Moore shift table.

Content matching implemented with the *mSearch()* function utilizes the Boyer-Moore algorithm to accomplish the match. The Boyer-Moore algorithm has an interesting property that the longer the pattern is, the more the algorithms performance improves.

This algorithm was invented in the 1970s by Bob Boyer and J. Strother Moore. It is used in many different applications today.

The Stream4 Preprocessor

The stream4 preprocessor was originally implemented to provide stateful functionality to Snort. It was directly created in response to the "Stick and Snot" tools, at which time both provided a dangerous attack vector against a non-stateful IDS. With the stream4 preprocessor enabled, Snort users are able to drop packets that are not associated with an established TCP stream. Because this applies to most traffic generated by these tools, this is a quick remedy for this problem. By doing this, however, you have to discard UDP and ICMP traffic.

Inline Functionality

The inline functionality of Snort is implemented utilizing the *iptables* or *ipfw* firewall to provide the functionality for a new set of rule types, Drop, Reject and SDROP.

The *./configure* script detects which firewall option you have available and will compile Snort with inline support.

Master Craftsman

The *ipqueue iptables* Module

In order for Snort to implement inline functionality via the *iptables* firewall, a kernel module called the *ipqueue module* must be installed and functional. This module allows packets to be scheduled before being dropped, or accepted.

The *IPTables::IPv4::IPQueue* Perl module provides an easy way to utilize this functionality in your own applications. Packets can be modified, accepted, or dropped in real time in a simple Perl script of less than 10 lines.

The *CPAN.*org documentation on this module will get you started.

In order for Snort to have any effect on the packets it can see, the packets must be selected and queued via the *ipqueue* module for *iptables*.

The following commands can be used to queue all of the network traffic that the IDS sensor can see.

```
iptables -A OUTPUT  -j QUEUE
iptables -A INPUT   -j QUEUE
iptables -A FORWARD -j QUEUE
```


Now we will take a look at the inline functionality in the Snort 2.3.3 source tree.

Inline Initialization

The *inline_flag* variable contained inside the *pv* structure is used to toggle the use of inline functionality in Snort. Snort defines the *InlineMode()* function to test the status of this variable.

```
int InlineMode()
{
        if (pv.inline_flag)
                return 1;

        return 0;
}
```

During the execution of the *SnortMain()* function, the *InlineMode()* function is tested and, if true, the *InitInline()* function is used to initialize the Snort inline functionality.

```
/* InitInline is called before the Snort_inline configuration file is read. */
int InitInline()
{
    int status;

#ifdef DEBUG_GIDS
    printf("Initializing Inline mode \n");
#endif

    printf("Initializing Inline mode \n");

#ifndef IPFW
    ipqh = ipq_create_handle(0, PF_INET);
    if (!ipqh)
    {
        ipq_perror("InlineInit: ");
        ipq_destroy_handle(ipqh);
        exit(1);
    }

    status = ipq_set_mode(ipqh, IPQ_COPY_PACKET, PKT_BUFSIZE);
    if (status < 0)
    {
        ipq_perror("InitInline: ");
        ipq_destroy_handle(ipqh);
        exit(1);
    }
#endif /* IPFW */

    ResetIV();

    /* Just in case someone wants to write to a pcap file
     * using DLT_RAW because iptables does not give us datalink layer.
     */
    pd = pcap_open_dead(DLT_RAW, SNAPLEN);

    return 0;
}
```

The *InitInline()* function begins by creating a new *ipqueue* handle with which to receive packets. This is accomplished using the *ipq_create_handle()* function. The *ipq_set_mode()* function is then used to change the mode of the *ipqh* handle.

Finally the *pd pcap_t struct* is initialized using *DLT_RAW*. As mentioned, this is done because *iptables* does not provide the Data Link layer data via *ipqueue*.

After the configuration file has been parsed, the *InlineMode()* function is used again to check for Inline mode. If Inline mode is selected, the *InitInlinePostConfig()* function is called to perform post-configuration initialization of the inline functionality.

Inline Detection

To receive packets from *ipqueue* or *ipfw*, calls to the *IpqLoop()* and *IpfwLoop()* functions are added to the *SnortMain()* function. These functions read packets from the appropriate source and inject them back into the Snort engine to be processed. This is accomplished via the *ProcessPacket()* function.

When an event is generated, the ruletype is checked to determine the appropriate action to take. The event classification code is used to check for the inline rule types.

If a *drop*, *sdrop* or *reject* rule is found, the *DropAction()*, *SDropAction*, and *RejectAction()* functions are called accordingly. The event classification code looks like this:

```
#ifdef GIDS
        case RULE_DROP:
            DropAction(p, otn, &otn->event_data);
            break;

        case RULE_SDROP:
            SDropAction(p, otn, &otn->event_data);
            break;

        case RULE_REJECT:
            RejectAction(p, otn, &otn->event_data);
            break;
#endif /* GIDS */
```

Swiss Army Knife

The Flawfinder Utility

For those of you who have less experience with code auditing and programming but wish to get some idea of the security of a piece of code before running it on your network, the Flawfinder tool can be a useful way to quickly assess some code for easily spotted vulnerabilities.

Flawfinder is a free tool that is available at www.dwheeler.com/flawfinder/; it can easily be run against any source tree.

Although the Flawfinder tool sometimes produces a large number of false positives, the output from this tool could make the difference between whether or not you run a new piece of code on a corporate network. Certain classifications of bugs, such as an inappropriate use of the *gets()* function or a format string bug, can easily be spotted, even by a novice.

Depending on the event type, the appropriate flags are set to allow the rule to be dropped later. Once the packet has been processed, the *HandlePacket()* function is called to test the outcome. This function tests the results of the packet and checks to see if action needs to be taken. In the case of *ipqueue*, the *ipq_set_verdict()* function is used to set the appropriate action for *ipqueue* to take with the packet. Snort uses the *NF_ACCEPT* and *NF_DROP* arguments of this function, depending on the desired result.

Final Touches

Now that you have finished this chapter, we hope that you have picked up enough information about the Snort engine to be able to read it yourself. This chapter provides enough background about Snort to enable you to continue with the chapters in this book and to understand how your rules, plugins, and preprocessors will be handled by the Snort engine. This will allow you to easily debug your creations and understand them on a much deeper level.

After seeing the volumes of code that are involved in a security tool like Snort, it can be theorized that a certain amount of risk is involved with running that code on your network. No programmer's source code is perfect and free of bugs; this is something that needs to be considered when implementing the latest security tool in a classified environment. Snort should be *chroot()*'ed using the **-t** option whenever possible.

Chapter 8

Snort Rules

Scripts and samples in this chapter:

- **Writing Basic Rules**
- **Writing Advanced Rules**
- **Optimizing Rules**
- **Testing Rules**

In This Toolbox

In this chapter you will learn how to write your own custom Snort rules. You will also learn methods of testing and optimizing the rules for speed and accuracy.

Writing Basic Rules

Snort uses a simple to learn rule format that is flexible enough to cater for even the most complex situations. Each rule comprises two logical sections, the rule header and the rule options. The header contains the appropriate action to take if the rule is triggered. Along with the protocol to match, the source and destination IP (Internet Protocol) addresses, netmasks, and the source and destination ports.

The rule options section contains the appropriate detection keywords, which describe how to inspect the packet. This section also includes options for what to display when the alert is triggered. The following example shows a sample rule:

```
alert tcp $EXTERNAL_NET any -> $HTTP_SERVERS $HTTP_PORTS (msg:"WEB-IIS scripts-browse
access"; flow:to_server,established; uricontent:"/scripts/ "; nocase; classtype:web-
application-attack; reference:nessus,11032; sid:1029; rev:8;)
```

The Rule Header

The first field of any rule is the *rule action*. The rule action describes what Snort should do when a valid match has been made for the signature.

Table 8.1 shows the name and descriptions of the default rule actions.

Table 8.1 Default Snort Rule Actions

Action	Description
Pass	The packet is ignored.
Alert	An alert is generated and the packet is logged.
Log	The packet is simply logged; no alert is generated.
Dynamic	A rule with dynamic actions remain dormant until triggered by an activate rule. Following this they act as a log rule.
Activate	An activate rule alerts and then turns on a dynamic rule.

Table 8.2 shows the actions that are available using the inline blocking functionality of Snort.

Table 8.2 Snort Inline Rule Actions

Action	Description
Drop	The packet is not allowed to pass through to the destination host.
Reject	The packet will be dropped by iptables and Snort will log it. A TCP (Transmission Control Protocol) "reset" will be returned if the protocol is TCP, and an ICMP (Internet Control Message Protocol) "port unreachable" packet will be sent if it is UDP (User Datagram Protocol).
Sdrop	The sdrop action silently drops the packet without logging it.

TIP

It is easy to define your own rule actions in the Snort config file. You can do this with the **ruletype** keyword. The syntax of this is:

```
ruletype <name> {   <body>   }
```

This is covered in greater detail in the output plug-in section of this book.

The next field in the rule header is the *protocol* field. This field dictates which protocol the rule should match. Currently, Snort supports only the following four protocols, but there are plans to support more options in the future:

- TCP
- UDP
- IP
- ICMP

Following the protocol field is the *IP address* and *port information* for the rule. The syntax of this section is as follows:

```
<1ST IP ADDRESS> <1ST PORT> <DIRECTION OPERATOR> <2nd IP> <2nd PORT>
```

IP addresses in this section are specified in Classless Inter-Domain Routing (CIDR) notation. In CIDR notation, a group of IP addresses are specified in the format A.B.C.D/netmask. The keyword "any" can be used to specify any IP address. The "!" operator can be used to negate the IP selection. For example, **!192.168.0.0/24** will match any IP address outside of the 192.168.0.0-192.168.0.255 range. A list of IP addresses can also be provided by delimiting the list using the comma (,) character and enclosing the list in square brackets.

Port numbers can be specified in several different ways. Table 8.3 lists each of these, along with an example and an English explanation of what will be matched.

Table 8.3 Methods of Specifying Port Numbers

Method	Example	Description
The "any" keyword will result in a match for any port number.	any	This will match ALL ports.
A static port can be specified such as 22 for SSH (Secure Shell) or 80 for HTTP (Hypertext Transfer Protocol).	22	This will match the SSH port 22.
Ranges of ports can be specified using the (:) operator.	8000:9000	This will match ports 800 to 9000.
	22:	This will match any port greater than or equal to 22.
	:100	This will match any ports with a number less than or equal to 100.
Negation (matches everything but the ports or range specified).	!22	This will match all ports except for port 22.

The *directional operator* is a symbol that describes the orientation of the traffic needed to trigger the alert. This operator can be one of the two possible options shown in Table 8.4

Table 8.4 The Directional Operator

Operator	Description
<>	The bidirectional operator. The rule will trigger on traffic flowing in either direction.
->	The traffic is flowing from the CIDR notation IP address (and port) on the left to the CIDR notation IP (and port) on the right.

WARNING

There is no <- operator. This was removed from Snort in version 1.8.7 so that rules read more consistently.

Rule Options

The main body of any Snort rule is composed of the rule options. The rule options allow you to specify exactly what you want to match and what you want to display after a successful match. They form a semicolon (;) delimited list directly after the rule header and are enclosed in parentheses ().

There are four main classifications of rule options. These are shown in Table 8.5.

Table 8.5 Classifications of Rule Options

Category	Description
Metadata	The metadata options provide information related to the rule, but do not have any effect on the detection itself.
Payload	As the name suggests, these options look for data inside the payload of a packet.
Nonpayload	These options look at data that is not in the payload.
Post-detection	Post-detection options are events that happen after a rule has been triggered.

We will now look at all of the available options, broken down into the appropriate categories.

Metadata Options

First, we'll look at the metadata options.

sid

The *sid* option is used to provide a unique identifier for Snort rules. The Snort manual suggests that the sid keyword should always be used with the *rev* option, and that the convention shown in Table 8.6 should be adopted when numbering the rules.

Table 8.6 sid Numbering Conventions

Category	Description
< 100	Reserved for future use.
100-1,000,000	Rules included with the Snort distribution.
> 1,000,000	Used for local (custom) rules.

The *sid rule* option uses the following syntax:

```
sid:<rule id number>;
```

rev

The *rev* option is used to provide a unique version number of the rule. This, combined with the sid field, makes it easier to update and maintain your signatures. The syntax of the rev option is as follows:

```
rev:<revision number>;
```

msg

The *msg* option can be used to specify the text string that should be printed along with an alert or packet log. The format of this option is simple.

```
msg:"<Message text>";
```

NOTE

Special characters that would otherwise be interpreted as Snorts rule syntax, such as the quote (") or semi-colon (;) characters must be escaped using a backslash (\).

reference

The *reference* option provides the rule author with a way to direct the end user to relevant information about the vulnerability that has triggered the alert. The reference system supports several of the most popular information security databases on the Internet by ID, along with the ability to enter unique URLs (Uniform Resource Locators). The options available are shown in Table 8.7.

Table 8.7 Support Reference Systems

Category	Description
URL	This keyword is used to specify a unique URL. The http:// prefix is appended to the URL.
Cve	The cve keyword indicates that the vulnerability has associated common vulnerabilities and exposures identified. Snort will then append the number provided to the URL: http://cve.mitre.org/cgi-bin/cvename.cgi?name=
Bugtraq	The bugtraq keyword takes a *Bug Track ID* argument and prepends the URL http://www.securityfocus.com/bid/ to it.
Nessus	This keyword takes the ID of a Nessus plugin used to detect the vulnerability. It then appends this to the URL: http://cgi.nessus.org/plugins/dump.php3?id=
Mcafee	The McAfee virus id is appended to the URL: http://vil.nai.com/vil/dispVirus.asp?virus_k=
Arachnids	The arachnids reference number is appended to: http://www.whitehats.com/info/IDS

Multiple references can be specified. The format of the reference option is shown in the following example:

```
reference: <id system>,<id>; [reference: <id system>,<id>;]
```

classtype

Snort provides a set of default classifications that are grouped into three priorities (high, medium, and low), which can be used to classify alerts. Table 8.8 shows a list of these (taken from the Snort manual).

Table 8.8 Snort Default Classifications

Classtype	Description	Priority
attempted-admin	Attempted Administrator Privilege Gain	High
attempted-user	Attempted User Privilege Gain	High
shellcode-detect	Executable code was detected	High
successful-admin	Successful Administrator Privilege Gain	High
successful-user	Successful User Privilege Gain	High
trojan-activity	A Network Trojan was detected	High
unsuccessful-user	Unsuccessful User Privilege Gain	High
web-application-attack	Web Application Attack	High
attempted-dos	Attempted Denial of Service	Medium
attempted-recon	Attempted Information Leak	Medium
bad-unknown	Potentially Bad Traffic	Medium
denial-of-service	Detection of Denial of Service xAttack	Medium
misc-attack	Misc Attack	Medium
nonstandard-protocol	Detection of a nonstandard protocol of event	Medium
rpc-portmap-decode	Decode of an RPC Query	Medium
successful-dos	Denial of Service	Medium
successful-recon-largescale	Large Scale Information Leak	Medium
successful-recon-limited	Information Leak	Medium
suspicious-filename-detect	A suspicious filename was detected	Medium
suspicious-login	An attempted login using a suspicious username was detected.	Medium
system-call-detect	A system call was detected	Medium
unusual-client-port-connection	A client was using an unusual port	Medium
web-application-activity	Access to a potentially vulnerable Web application	Medium
icmp-event	Generic ICMP event	Low
misc-activity	Misc activity	Low
network-scan	Detection of a Network scan	Low
not-suspicious	Not Suspicious Traffic	Low
protocol-command-decode	Generic Protocol Command Decode	Low
string-detect	A suspicious string was detected	Low
Unknown	Unknown Traffic	Low

The *classtype* option is used to categorize a rule. The format of this option is as follows:

```
classtype:<class name>;
```

NOTE

Class types are defined in the classifications.config file. To define your own classtype the following format is used:
config classification: <class name>,<class description>,<default priority>

priority

A *priority* option can be used to overwrite the default priority assigned to the rule via the classtype option. The syntax of this option is:

```
priority:<priority number>;
```

Payload Options

Snort rules use several payload options.

content

One of the most important options, the *content* option, is used to search a packet's contents for a particular pattern. The content option is implemented using a Boyer-Moore algorithm, which requires a relatively large computational load. The pattern supplied to this option can consist of ASCII or binary data (or both). Keep in mind that the content option performs case sensitive searching by default.

When matching binary data the values are specified in hexadecimal format and enclosed between two pipe (|) separators. Here is the syntax of the content option:

```
content:[!] "<content string>";
```

Here is an example of the content option being used with a mixed, binary and ASCII pattern.

```
alert tcp any any -> 192.168.0.1 1337 (msg:"Script Kiddies"; content:"|de ad be
ef|0WN3D";)
```

Several other options work in conjunction with the content option to modify its behavior:

- offset
- depth
- distance
- within
- nocase
- rawbytes

offset

The *offset* option changes the behavior of the previous content option in a rule. The offset value tells the rule how many bytes into the payload to start the content match. An offset of 50, for

example, will cause the content option to match the pattern if it exists anywhere after the first 50 bytes of the payload. The format of this option is as follows:

```
offset: <number>;
```

depth

The *depth* option is the opposite of the offset option. Again it acts on the previous content option in a rule; however, rather than starting the search at the depth value, the search starts from the start of the payload and stops at the number of bytes specified.

```
depth: <number>;
```

distance

When a content option matches, a cursor that is commonly referred to as the doe_ptr or detect offset end pointer is set to the location within the payload where the match occurred. By default, the cursor is always set to the beginning of the packet until the content match has occurred.

The *distance* option acts upon the previous content option in a rule. It allows the rule author to control the distance between the previous placement of the cursor and where the next content option should match in the payload. A distance of 10, for example, will cause the previous content to match 10 or more bytes after the content option before it. The format of this option is as follows:

```
distance: <number>;
```

Here is an example of the use of the distance option:

```
alert tcp any any -> 192.168.0.1 42 (content:"FOO"; content:"BAR"; distance:10;)
```

This rule will match any packet traveling to port 42 on 192.168.0.1 that contains the string "FOO" followed by 10 or more bytes of data, followed by the string "BAR".

within

The *within* option is used to modify the behavior of the previous content option. It is used to specify the maximum distance between the content option and the placement of the cursor (mentioned in the distance option description). The syntax of this option is:

```
within: <number>;
```

NOTE

The *within* and *distance* keywords are similar to the *offset* and *depth* keywords. The difference is that the *within* and *distance* keywords are relative to the last placement of the cursor (the doe_ptr).

nocase

The *nocase* option modifies the content option. It is used to specify that the content option should match the specific pattern regardless of the case. The syntax of the nocase option is shown here:

```
nocase;
```

rawbytes

The *rawbytes* option is also used to modify the content option's behavior. It causes the immediately preceding content option to match the raw bytes of the packet without additional decoding provided by the pre-processors. The syntax of this option is:
rawbytes;

uricontent

URLs can be written in many different ways. Because of this fact, it can be very difficult for an IDS (intrusion detection system) to match abnormalities in a URL. The *uricontent* option allows the rule author to perform a content match against a normalized URL. This means that directory traversals (../) and encoded values will be converted to ASCII before the match is made.

The syntax of the uricontent option is the same as the content option.

```
uricontent:[!] <pattern>;
```

isdataat

The *isdataat* option is used to verify that data exists at a particular location in the payload. If the keyword **relative** follows it, then isdataat verifies the existence of data relative to the end of the previous content match. The isdataat option uses the following syntax:

```
isdataat:<int>[,relative];
```

Nonpayload Options

Now let's discuss nonpayload options.

flags

The *flags* option is used to determine the status of various TCP flags (listed in Table 8.9).

Table 8.9 TCP Flags

Flag	Description
S	SYN
A	ACK
R	RST
P	PSH

Continued

Table 8.9 continued TCP Flags

Flag	Description
F	FIN
U	URG
1	Reserved bit 1
2	Reserved bit 2
0	No Flags Set

There are also three modifiers for this option. They are shown in Table 8.10.

Table 8.10 flags Modifiers

Modifiers	Description
+	Matches if all the specified bits are set.
*	Matches if any of the specified bits are set.
!	Matches if none of the specified bits are set.

The syntax of the flags option is shown here:

```
flags:[!|*|+]<FSRPAU120>[,<FSRPAU120>];
```

The second set of options following the comma is used to ignore the state of the specific bits provided. An example of this is **S,12**, which will match if the SYN bit , ignoring the two reserved bits, is the only bit set.

fragoffset

The *fragoffset* option is used to check the IP fragment offset field. The < and > operators can be used to determine if the fragoffset value is less than or greater than the decimal value provided.

```
fragoffset:[<|>]<number>
```

fragbits

The *fragbits* option allows the rule author to test for the presence of the fragmentation and reserved bits. The flags shown in Table 8.11 are used to select which bits to match.

Table 8.11 fragbits Flags

Bit	Description
M	More fragments
D	Don't fragment
R	Reserved bit
+	Match if the provided bits are set.
-	Match if any of the bits provided are set.
!	Match if the provided bits are NOT set.

The syntax of the fragbits option is:

```
fragbits:[+-*]<[MDR]>
```

ip_proto

The *ip_proto* option allows the rule author to test for a particular protocol name or number. The usage of this is:

```
ip_proto:[!><]<number or name>;
```

ttl

The *ttl* option tests the value in the time to live (TTL) field of the IP header. The conditional operators > > and = can be used. Also the range operator (min num-max num) can be used to specify the range.

```
ttl:[[<number>-]><=]<number>;
```

tos

The *tos* option is used to match the TOS field in the IP header.

```
tos:<number>;
```

id

The *id* option matches the ip-id field of the IP header.

```
id:<number>;
```

ipopts

The *ipopts* option is used to test for the presence of a specific IP option. Table 8.12 shows the possible IP options.

Table 8.12 IP Options

Option	Description
Rr	Record Route
Eol	End of list
Nop	No op
Ts	Time Stamp
Sec	IP Security Option
Lsrr	Loose source routing
Ssrr	Strict source routing
Satid	Stream identifier
Any	Any of the aforementioned options.

Here is the syntax for the ipopts option:

```
ipopts:<rr|eol|nop|ts|sec|lsrr|ssrr|satid|any>;
```

ack

The *ack* options checks for a given number in the TCP acknowledgement field of the TCP header.

```
ack:<number>;
```

seq

The *seq* option allows the rule author to test for a specific TCP sequence number. The usage is shown here:

```
seq:<number>;
```

dsize

The *dsize* option can be used to test if the size of the payload falls into a given range. The < and > operators can be used to provide the range.

```
dsize: [<>]<number>[<><number>]
```

window

The *window* option tests the TCP window size.

```
window:[!]<number>;
```

itype

The *itype* option is used to test the ICMP type field in the ICMP header for a specific value.

```
itype:[<|>]<number>[<><number>];
```

icode

The *icode* option is used to test the icode field in the ICMP header. The > and < operators can be used to determine if the icode option is greater or less than the value provided.

```
icode: [<|>]<number>[<><number>];
```

icmp_id

The *icmp_id* option is used to test the ID field of the ICMP header. Its syntax is shown here:

```
icmp_id:<number>;
```

icmp_seq

The *icmp_seq* option is useful for checking the ICMP sequence number field of the ICMP header. Its syntax is similar to many of the other options.

```
icmp_seq:<number>;
```

rpc

The *rpc* option is implemented to test the application number, version number, and procedure numbers of SUNRPC CALL requests.

```
rpc: <application number>, [<version number>|*], [<procedure number>|*]>;
```

WARNING

As the Snort manual notes, the *rpc* option keyword is actually slower than Snort's *fast pattern matching* functionality. For this reason rpc should not be used.

sameip

The *sameip* option simply checks to determine if the source and destination IP is the same in a packet.

```
sameip;
```

Post-detection Options

We'll now discuss post-detections options.

resp

The *resp* option can be used to respond to the alert in various ways in an attempt to close the session. The Snort team calls this a *flexible response*. Table 8.13 shows the various methods of response available.

Table 8.13 Methods of Response

Method	Description
rst_all	A spoofed TCP RST packet is sent to both the client and server.
rst_rcv	A spoofed TCP RST packet is sent to the socket that is receiving the packet that triggered the alert.
rst_snd	A spoofed TCP RST is sent to the sender of the packet that triggered the alert.
icmp_all	Three ICMP packets are sent to the sender of the packet that triggered the alert. These are a combination of the icmp_net, icmp_port, and icmp_host methods.

Continued

Table 8.13 continued Methods of Response

Method	Description
icmp_net	An ICMP_NET_UNREACH is sent to the sender of the packet that triggered the alert.
icmp_port	An ICMP_PORT_UNREACH is sent to the sender.
icmp_host	An ICMP_HOST_UNREACH packet is sent to the sender.

The syntax of this option is as follows:

```
resp: <resp_mechanism>[,<resp_mechanism>];
```

NOTE

Multiple flexible responses can be defined for a single alert.

react

The *react* option also provides a method of flexible response. Some of the functionality of the react option is not completely functional at this time. The most common use of this option is to block access to HTTP websites by using the *block* modifier. This will send a TCP FIN packet to both the client and the server. The ability to inform the user that a particular Web site has been blocked is being worked on using the *warn* modifier. The format of the react option is:

```
react: <react_basic_modifier[, react_additional_modifier]>;
```

NOTE

In order to enable the flexible response aspects of Snort it must be compiled using the **--enable-flexresp** flag to the ./configure script.

logto

The *logto* option allows the rule author to specify a separate output file for Snort to log the packets that triggered the alert. This option does not work when Snort is run using the binary logging mode.

```
logto: filename;
```

session

The *session* option is used capture the data from a TCP stream after an alert has occurred. The session option can use two modifiers; the *printable* modifier can be used to output only printable

ASCII characters, and if the *all* modifier is used, the ASCII values for nonprintable characters will be substituted in their place.

The session option is useful in conjunction with the *logto* option to output the data from a TCP stream to an evidence log file. The syntax for this rule is as follows:

```
session: [printable|all];
```

tag

The *tag* option is used to log additional packets after the packet that actually triggered the alert. Several arguments can be provided in order to select the type, number, and direction of the packets captured. The arguments and their descriptions are shown in Table 8.14.

Table 8.14 tag Arguments

Argument	Description
Type	The type argument is used to select between logging packets from a session (*session* keyword) or logging packets from an individual host (*host* keyword).
Count	The count argument specifies the number of units to capture.
Metric	The metric argument specifies the type of unit to capture. This is a choice between *packets* and *seconds*.
Direction	The optional direction argument is used to specify which host to log packets from, if the **type** field is set to **host**.

The syntax of the tag option is as follows:

```
tag: <type>, <count>, <metric>, [direction]
```

Writing Advanced Rules

Although the basic Snort detection options provide a wide range of functionality that can be utilized to write flexible custom rules, certain problems require the use of Snort's more advanced detection options. This section discusses the more advanced of Snort's options that give you the power to match even the most complex traffic.

PCRE

Since version 2.1.0, Snort has included support for PCRE (Perl-Compatible Regular Expressions). The PCRE library is an implementation of regular expression pattern matching. It shares the semantics and syntax of the native pattern matching used by the Perl programming language. Currently PCRE (release 5.x at the time of publication) implements the Perl 5.8 features. For more information about the features and use of the pcre library, visit www.pcre.org.

Regular expressions should be used in Snort rules when a complex pattern matching is needed (outside the limitations of the strcmp() function in libc).

Snort implements PCRE support in its rules via the **pcre** keyword. The syntax of the keyword is:

```
pcre:[!]"(/<regex>/|m<delim><regex><delim>)[ismxAEGRUB]";
```

The <regex> field denotes the regular expression string to match data against. The modifiers on the right are a series of options that determine the behavior of certain metacharacters or behaviors during the evaluation of the expression.

There are three different groups of modifiers supported by Snort's implementation of PCRE. The first is the Perl-compatible modifiers. These modifiers are the same as those available to a Perl programmer. These can be seen in Table 8.15. The second group includes additional modifiers, which are available in the current version of the PCRE library, and can be seen in Table 8.16. Finally, the third group (Table 8.17) includes modifiers specific to Snort that offer additional functionality.

Table 8.15 Perl-Compatible Modifiers

Modifier	Description
I	Case-insensitive matching (/foo/i will match for strings "foobar" and "FoObar").
S	Includes new-line characters in the dot (.) metacharacter.
M	Without the m modifier, a string is considered to be a single long line of characters. The ^ and $ metacharacters will match at the start and finish of the string. However, with m set, the ^ and $ characters match directly before and after a newline character in the buffer.
X	Permits whitespace and comments to be used in the expression in order to increase readability.

Table 8.16 PCRE-Compatible Modifiers

Modifier	Description
A	The pattern must match the start of the string (the same as the ^ metacharacter).
E	Causes the $ metacharacter to match only at the end of the string. Without the E modifier, $ will also match immediately before the final character when the last character is a newline.
G	Inverts the *greediness* of the quantifiers so that they are not greedy by default, but become greedy if followed by ?.

Table 8.17 Snort-Specific Regular Expression Modifiers

Modifier	Description
R	Match relative to the end of the last pattern match (similar to distance:0;).
U	Match the decoded URI buffers (similar to uricontent).
B	Do not use the decoded buffers (similar to rawbytes).

NOTE

The modifiers *R* and *B* should NOT be used together.

A regular expression itself is made up of two types of characters. These are literal characters, which are the characters themselves, and metacharacters, such as wildcards. The simplest example of a rule that contains a regular expression is a literal string matching rule. In the following example, the Snort rule will match on any traffic containing the word **foo**.

```
alert ip any any -> any any (pcre:"/foo/";)
```

Along with literal characters, metacharacters can be used to match particular patterns. Table 8.18 shows some of the basic metacharacters used in regular expressions, and their meanings.

Table 8.18 Basic Metacharacters

Metacharacter	Description
\	Quote the following metacharacter, causing it to be interpreted in its literal sense.
^	Match the start of the line, or when inside a character class becomes logical NOT.
.	Match all characters (except for the newline character).
$	Match the end of the line or directly before the final newline character (at the end).
|	Logical OR operator.
()	Grouping characters into a string.
[]	Character class.
-	Match a range of characters.

Table 8.19 shows the quantifiers that can be used to select the number of instances in a row that a subpattern and the pattern will match.

Table 8.19 Quantifiers

Quantifiers	Description
+	Match exactly one instance.
?	Match one or 0.
{n}	Match exactly n times.
{n,}	Match at least n times.
{n,m}	Match at least n, but no more than m times.

NOTE

Ordinarily, any subpattern that is quantified will match in a greedy fashion. This means that it will match the most times possible. To change this characteristic, a ? metacharacter can be appended to a specific quantifier. Also, as mentioned earlier, the *G* modifier can be appended to the expression, to invert all of the quantifiers in an expression.

When used together these metacharacters provide a flexible and powerful way to define what should be matched.

Escape characters can be used to match classes of characters or unprintable characters. These range from specific single escape characters like \n for newline, to groups of characters like \w for an alphanumeric or _ character. Table 8.20 shows the escape characters that are supported by C and PCRE. Table 8.21 shows the PCRE-specific escape characters.

Table 8.20 C Style Escape Characters

Escape Character	Description
\t	Tab
\n	Newline
\r	Return
\f	Form Feed
\a	Alarm Bell
\e	Escape
\033	Octal character
\x1B	Hexadecimal character
\x{263a}	Wide Hexadecimal character
\xc[	Control Character
\N{name}	Named Character

Table 8.21 PCRE-Specific Escape Characters

Escape Character	Description
\w	Matches any word character, consisting of alphanumeric and _ characters.
\W	Matches any non-word character (the opposite of \w).
\s	Matches a whitespace character.
\S	Matches any non-whitespace character (the opposite of \s).
\d	Match any digit character (0-9).
\D	Matches a non-digit character.

Many of the rules in Snort's default ruleset use regular expressions to achieve their goals. One of these is the *EXPLOIT CHAR IRC Ettercap parse overflow attempt* rule (GEN:SID 1:1382). We will now analyze the regular expression in this rule to get a better understanding of how they can be used to provide accurate matches.

```
alert tcp any any -> any 6666:7000 (msg:"EXPLOIT CHAT IRC Ettercap parse overflow attempt";
flow:to_server,established; content:"PRIVMSG"; nocase; content:"nickserv"; nocase;
content:"IDENTIFY"; nocase; isdataat:100,relative;
pcre:"/^PRIVMSG\s+nickserv\s+IDENTIFY\s[^\n]{100}/smi";
reference:url,www.bugtraq.org/dev/GOBBLES-12.txt; classtype:misc-attack; sid:1382; rev:9;)
```

The vulnerability that this signature alerts exists in Ettercap's parsing of the IRC traffic while logging in with a registered nickname. The advisory that is referenced by the signature (www.bugtraq.org/dev/GOBBLES-12.txt) shows the vulnerable section of code.

```
typedef struct connection        // connection list
  {
  char source_ip[16];
  char dest_ip[16];
  char source_mac[20];
  char dest_mac[20];
  u_long fast_source_ip;
  u_long fast_dest_ip;
  u_short source_port;
  u_short dest_port;
  u_long source_seq;
  u_long dest_seq;
  char flags;
  char proto;
  short datalen;
  char status[8];
  char type[18];          // from /etc/services
  char user[30];          // pay attention on buffer overflow !!
  char pass[30];
  char info[150];         // additional info... ( smb domain, http page ...)
  } CONNECTION;

...

  if ( !strncasecmp(collector, "IDENTIFY ", 9))
  {
    char nick[25] = "";
    char *pass = strstr(collector, " ") + 1;
    if (*pass == ':') pass += 1;
    strcpy(data_to_ettercap->pass, pass);
    strcat(data_to_ettercap->pass, "\n");
    Dissector_StateMachine_GetStatus(data_to_ettercap, nick);
    if (!strcmp(nick, "")) strcpy(nick, "unknown (reg. before)");
    sprintf(data_to_ettercap->user, "%s\n", nick);
    sprintf(data_to_ettercap->info, "/identify password");
  }
```

In this example it can be seen that in order to exploit this vulnerability, following the *IDENTIFY* string, more than 100 bytes will have to be passed in order to overwrite anything outside of the structure itself.

```
pcre:"/^PRIVMSG\s+nickserv\s+IDENTIFY\s[^\n]{100}/smi";
```

First, we can see that the regular expression uses the three modifiers s, m, and i. This means that it will match any case, the . metacharacter will include the newline character, and the ^ and $ characters match before and after the newline character.

The regular expression starts with the ^ metacharacter, which will match after a newline character. It then matches the literal string PRIVMSG followed by one or more whitespace characters. Following this must be the string *nickserv*, more whitespace, and the string *IDENTIFY*. The final section of this regular expression shows that following the *IDENTIFY* string there must be a single whitespace, followed by 100 (or more) characters that aren't the \n newline character.

A useful tool for testing PCRE is coincidentally named pcretest. It is installed with the PCRE library, and can be used to verify regular expressions against data. The usage of this tool is shown in the following example:

```
Usage:   pcretest [-d] [-i] [-o <n>] [-p] [-s] [-t] [<input> [<output>]]
  -C     show PCRE compile-time options and exit
  -d     debug: show compiled code; implies -i
  -i     show information about compiled pattern
  -o <n> set size of offsets vector to <n>
  -p     use POSIX interface
  -s     output store information
  -t     time compilation and execution
```

Without any arguments, the *pcretest* tool will read in a regular expression from stdin followed by a series of data. For each line of data entered, pcretest will output the value of the regular expression and what was matched with each () group.

Example 2.51 shows use of the pcretest tool in testing the regular expression from the EXPLOIT CHAT IRC regular expression. The regexp is simply pasted into the re> prompt. Following this, the data> prompt is given, and test data is provided.

The first example of test data shows a normal person identifying with Nickserv, so the regular expression doesn't match on this. The second test shows a malicious user providing a password with a length greater than 100 bytes. As expected, the regular expression matches this.

```
-[nemo@snortbox:~]$ pcretest
PCRE version 4.2 14-Apr-2003

  re> /^PRIVMSG\s+nickserv\s+IDENTIFY\s[^\n]{100}/smi


data> PRIVMSG Nickserv IDENTIFY testuser
No match

data> PRIVMSG Nickserv IDENTIFY
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
```

```
 0: PRIVMSG Nickserv IDENTIFY
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAA
data>
```

Swiss Army Knife

Utilizing the pcretest Tool

The pcretest tool can be a very valuable tool when dealing with PCRE. As well as the functionality demonstrated in this chapter, pcretest also has the ability to take files as input for the regular expression and test data. This allows us to easily test our regular expressions against packet capture files and other binary data. It can also display more information about the regular expression, such as compiled code, compile time options and even compilation and execution times. The optimization section in this chapter deals with optimizing and timing regular expressions in greater detail.

Now that we have dealt with understanding a prewritten rule using PCRE, we will try to write our own rule for a public vulnerability using PCRE. Sometimes more complex problems can call for some more advanced regular expressions. Some of the more advanced features of regular expressions are available through a set of extended patterns beginning with the (? characters.

Some of these extended patterns, along with their uses, are shown in Table 8.22.

Table 8.22 PCRE Extended Patterns

Pattern	Description
(?=pattern)	A zero-width positive look-ahead assertion. This pattern determines whether a match is found, without storing the match. This isn't typically used in Snort rules. An example of this is /foo(?=bar)/. This will match **foo** as long as it is followed by **bar**.
(?!pattern)	A zero-width negative look-ahead assertion. This will check to determine that a match is not found. An example of this is /foo(?!bar)/, This will match as long as **foo** is found and is NOT followed by the word **bar**.
(?<=pattern)	A zero-width positive look-behind assertion. This is almost the same as the (?=) pattern. However, it can be used to look behind, rather than ahead. For example, /(?<=foo)bar/ will match any instance of **bar** that is preceded by the word **foo**.
(?<!pattern)	A zero-width negative look-behind assertion. This is almost the same as the (?!) pattern. It differs in the fact it can be used to look behind rather than ahead. An example of this is /(?!foo)bar/. This will match any instance of **bar** that is NOT preceded by the word **foo**.

An example of a public vulnerability that has lately been released (at the time of publishing) is the *Ethereal Distcc Network Protocol Dissection Buffer Overflow Vulnerability*. An advisory for this vulnerability was published by Ilja van Sprundel from the Suresec security company. The advisory can be found at www.suresec.org/advisories/adv2.pdf.

In the following example, we can see the vulnerable code, taken from the Suresec advisory, which causes the problem. The *parameter* variable is read from the user-defined buffer using the sscanf() function. It is then passed to the dissect_distcc_argv() function, without validation, into a signed integer variable.

If the parameter variable is set to a negative number at this stage, it passes the argv_len=len>255?255:len; check. However, when it is passed to the memcpy() function it is interpreted as an unsigned integer, and therefore becomes a massive number, resulting in an overflow of the destination buffer.

```
static void dissect_distcc(tvbuff_t *tvb, packet_info *pinfo, proto_tree *parent_tree)
{
        char token[4];
        guint32 parameter;

        while(1){
                tvb_memcpy(tvb, token, offset, 4);
                ...
                sscanf(tvb_get_ptr(tvb, offset, 8), "%08x", &parameter);
                ...
                } else if(!strncmp(token, "ARGV", 4)){
                                offset=dissect_distcc_argv(tvb, pinfo, tree, offset,
                                                                        parameter);
                }
                ...
        }
}

static int dissect_distcc_argv(tvbuff_t *tvb, packet_info *pinfo _U_,
proto_tree *tree, int offset, gint parameter)
{
        char argv[256];
        int argv_len;
        gint len=parameter;
        argv_len=len>255?255:len;
        tvb_memcpy(tvb, argv, offset, argv_len);
        ...
}
```

Now that we understand the bug, we can begin to write a regular expression for it. The advisory states that the vulnerability exists in the parsing of the ARGV, SERR, and SOUT messages of the Distcc protocol.

From this information we can derive the start of the regexp: (ARGV|SERR|SOUT) to match packets containing any of those messages. From the sscanf() call we can see that directly following the message type, an ASCII representation of a negative hexadecimal number, 8 characters long, would be needed to exploit this vulnerability. Before we look at writing a regular

expression pattern to match this, we must first look at how negative numbers are stored in memory.

On 32-bit architecture such as IA32, both signed and unsigned integers are 32 bits (4 bytes). The only difference between the two is that signed integers use the first bit to represent the sign of the integer. If the first bit is set to 1 the integer will be negative and if the bit is set to 0 the integer will be positive.

In hex, this means that the first byte will have to be in the range 0x80-0xff for the first bit to be set. Since we are representing this in ASCII, this gives us the next part of the regular expression: [8-F]. This will give us a false positive with ASCII value 0x40 @, but at this stage if there is a @ character, there is something not quite right anyway.

In order for the first byte to be set, we need to make sure we have received 8 ASCII values (for the 32 bit value). We know the range of a hexadecimal character is 0-F, therefore we can complete the regular expression to match 7 characters in this range. The following pattern will match this: [0-F]{7}.

We can put this all together to produce the signature.

```
alert tcp any any -> any 3632 (msg:"EXPLOIT Ethereal Distcc Network Protocol Dissection
Buffer Overflow Vulnerability"; pcre:"/(ARGV|SERR|SOUT)[8-F][0-F]{7}/smi"; )
```

To test this signature out, we simply insert it into one of our Snort rule files and start Snort.

```
snort -c test.conf -A cmg -d
```

Then, in another terminal, we run one of the exploits for this vulnerability.

```
-[nemo@snortbox:/0day]$ ./etherealex

Doing shellcode packetstorm!
.....................................................................................
..........
Sending the evil packet
Waiting 5 second to let it take it's effect :)
******Remote root, w00t w00t
Linux snortbox 2.4.25-grsec #6 Tue Sep 2 17:43:01 PDT 2003 i686 unknown unknown GNU/Linux
uid=0(root) gid=0(root)
groups=0(root),1(bin),2(daemon),3(sys),4(adm),6(disk),10(wheel),11(floppy)
exit


If we look back at our first terminal, we should see that Snort triggers the appropriate
alert.
[**] [1:1000010:1] EXPLOIT Ethereal Distcc Network Protocol Dissection Buffer Overflow
Vulnerability [**]
[Classification: Attempted Administrator Privilege Gain] [Priority: 1]
04/22-22:36:33.740933 192.168.0.121:60201 -> 192.168.0.3:3632
TCP TTL:64 TOS:0x0 ID:5107 IpLen:20 DgmLen:364 DF
***AP*** Seq: 0x3B9878D1  Ack: 0x2C943E73  Win: 0xFFFF  TcpLen: 32
TCP Options (3) => NOP NOP TS: 1670115386 224280301
[Xref => http://www.suresec.org/advisories/adv2.pdf]
```

Of course, before we would even think about implementing this rule in a real world situation, we would want to make sure that this isn't going to alert every single time someone tries to use the Distcc protocol on a network. In addition, if we were writing a rule that was looking for

an attack on a normal TCP service, we would want to include additional checks such as *flow* to validate that Snort is looking at an established session. However, for the sake of this chapter we will finish with the rule here.

Byte_test and Byte_jump

The byte_test and byte_jump detection options are some of the most commonly used plugins in the official ruleset. They are also two of the most commonly misunderstood plugins. Because of this they are included here in the advanced section.

byte_test

The *byte_test* option is useful for testing a protocol field against a provided value. Operators for testing are provided by the rule author, as well as a variety of other arguments to describe where the bytes that require testing are, and how they should be interpreted.

The arguments are described in Table 8.23. The syntax of the option is:

```
byte_test: <bytes to convert>, [!]<operator>, <value>, <offset>  [,relative] [,<endian>]
[,<number type>, string];
```

Table 8.23 byte_test Arguments

Arguments	Description
Bytes to convert	This argument specifies the number of bytes in the payload to compare. This is a required argument.
Operator	The operator to test the value is provided with the *operator* argument. The possible options for this are: < Less than > Greater than = Equals & Bitwise AND ! NOT - Bitwise OR This argument is also required.
Value	The value to test the bytes against. Also a required argument.
Offset	The distance (in bytes) from the last placement of the cursor (or the start of the payload if the cursor has not yet been placed) at which to attempt the match. This argument must be supplied.
Relative	This argument causes the match to begin from the end of the last pattern match and is optional.
Endian	The optional endian argument lets the rule author select between little or big endian. (0xefbeadde OR 0xdeadbeef).
Number type	This argument allows the author to choose which type of number is being matched.

Continued

Table 8.23 continued byte_test Arguments

Arguments	Description
	There are three possibilities for this argument: hex The string is represented in a hexadecimal (base 16) format. dec The string is represented in a decimal (base 10) format. oct The string is represented in an octal (base 8) format.

NOTE

The ! operator is used to negate an operator. The behavior of the provided operator is reversed. This means you can specify !=, !&, etcetera. If a ! operator is used by itself, != is assumed.

byte_jump

The *byte_jump* option is a corollary function to *byte_test*. It can be used to analyze protocols that contain length encoded data. Length encoded data refers to a situation where the length of data is passed first, followed by the data itself. This is common in Remote Procedure Call (RPC) protocols and file sharing protocols such as Server Message Block (SMB) and Advanced Function Printing (AFP).

This option basically reads an offset from the payload, then jumps that distance and positions a cursor at that location. This allows fields following this variable-sized string to be tested relative to the placement of the cursor.

NOTE

The *cursor* mentioned in the preceding section is the same cursor or doe_ptr that was mentioned earlier during the explanation of the *within* and *distance* payload detection options.

Several arguments can be passed to the byte_jump option to control its behavior. These are shown in Table 8.24.

Table 8.24 byte_jump Arguments

Arguments	Description
bytes to convert	This argument specifies the number of bytes in the payload to compare. This option is required.
Offset	The distance (in bytes) into the payload to start matching. This option is required.

Continued

Table 8.24 continued byte_jump Arguments

Arguments	Description
Relative	This argument causes the match to begin from the end of the last pattern match.
Big	This causes the detection plugin to manipulate data in big endian format.
Little	This causes the detection plugin to manipulate data in little endian format.
Multiplier	Multiplies the number of bytes skipped by the value provided.
frpm_beginning	Start skipping relative to the start of the file instead of the last match.
Hex	The converted bytes are expressed in hexadecimal (base 16) format.
Dec	The converted bytes are expressed in octal (base 8) format.
Oct	The converted bytes are expressed in octal (base 8) format.
Align	The number of converted bytes is rounded to a 32-bit (word) boundary.
String	If this argument is provided, data is tested in string format.

The (long) syntax for this option is shown in the following example:

```
byte_jump: <bytes_to_convert>, <offset>
        [,relative] [,multiplier <multiplier value>] [,big] [,little][,string]
        [,hex] [,dec] [,oct] [,align] [,from_beginning];
```

To demonstrate the functionality of the byte_test and byte_jump options, we can look at a protocol where the details of a particular person are passed between a client and a server. In this particular protocol the length of the name of the person is passed through first in a short-sized value (2 bytes). This is followed by the actual name of the person. After this, the age of the person is sent as a short-sized value. This is shown in the breakdown of a packet payload in the following example.

```
0000000: 000d 4a6f 686e 6e79 2048 6163 6b65 7200  ..Johnny Hacker.
0000010: 16                                       .
```

In this example you can see the length of the name has been sent (0x000d), which is 13 in decimal. Following this, 13 bytes of ASCII values have been sent, Johnny Hacker, representing the name of the person. Finally the age of the person (0x0016) has been sent.

For the sake of this example, let's assume that a wraparound exists when values greater than 0x7fff (the maximum positive value that can be stored in a signed short before it wraps around to negative) are sent as the age of the person, which can be used to exploit the server. When trying to write a rule that will detect if this vulnerability is being exploited, we are required to understand where the string representing the name finishes and where the age begins.

Because we know the payload will begin with the size of the name field, we can use this in a byte_jump to effectively jump over the name string and perform our test against the age field. The example rule is constructed to do just that.

```
alert tcp any any -> any 493 (msg:"EXPLOIT Person has grown too old."; byte_jump: 2,0;
byte_test:2,>, 32767,0,relative;)
```

By writing a small C program to send a name and age using this protocol, we can test that our rule works. The small C program listed in the following example will take a name and age as arguments. It then generates a payload using the protocol described in the preceding example and outputs to standard out. The following code and additional Snort rules discussed in this section are available on the Syngress Web site:


```
/*
 * sendname.c
 * nemo 2005
 */

#include <stdio.h>
#include <stdlib.h>

int main(int ac, char **av)
{
        char *name;
        short length;
        short age;

        if(ac != 3) {
                printf("usage: %s <name> <age>\n",av[0]);
                exit(1);
        }

        name   = av[1];
        length = strlen(name);
        age    = atoi(av[2]);

        write(1,&length,2);
        write(1,name,strlen(name));
        write(1,&age,2);

        return 0;
}
```

By combining this with Hobbit's netcat utility, we can direct the output from this to our Snort sensor. The command shown in the following example can be used to send a payload that our rule will trigger on (by running this program with an age that is greater than 32767).

```
-[nemo@gir:~]$ ./sendname "Johnny Hacker" 32768 | nc snortbox 493
```

Now in our Snort alert file, the alert is generated:

```
[**] [1:0:0] EXPLOIT Person has grown too old. [**]
[Priority: 0]
05/29-18:48:41.284494 XXX.XXX.XXX.XXX:53396 -> XXX.XXX.XXX.XXX:493
TCP TTL:49 TOS:0x0 ID:40300 IpLen:20 DgmLen:69 DF
***AP*** Seq: 0xA0201238  Ack: 0xB5E73652  Win: 0xFFFF  TcpLen: 32
TCP Options (3) => NOP NOP TS: 820937957 36844216
```

Swiss Army Knife

Netcat—the Ultimate Swiss Army Knife

For anyone who is unfamiliar with hobbit's *netcat* tool, it is definitely one of the most useful tools in the arsenal of any Snort rule developer. Netcat allows the user to bind the standard input and output of a process to a network socket. This functionality is a godsend for rule developers because it allows any program that outputs to standard out to be redirected down the network in order to trigger a rule. Files can also be redirected with the < and > operators in order to send them down the network. GNU netcat is available from: http://netcat.sourceforge.net. However, the original version of this tool was written by Hobbit from @stake.

The Flow Options

The flow options utilize the functionality of the flow preprocessor. In order to use these options the flow preprocessor must be enabled. They are used for connection tracking.

flow

The *flow* option is used to select which directions of traffic flow to alert on in a TCP stream. The flow option accepts several modifiers as parameters to dictate the direction of the flow. The modifiers are shown in Table 8.25.

Table 8.25 flow Modifiers

Modifiers	Description
to_client	Matches on server response to the client.
to_server	Matches on requests from the client to the server.
from_client	Internally this modifier works identically to the to_server modifier. The difference exists only in the readability. from_client indicates that an attempt to exploit the client is occurring, and to_server indicates that an attempt to exploit the server is taking place.
from_server	The from_server modifier internally operates the same as the to_client modifier. to_client should be used when alerting on client bugs. The from_server modifier should be used when alerting on vulnerabilities in the server.
Established	Matches on established TCP connections.
Stateless	Matches regardless of the state of the stream processor.
no_stream	Do not match reassembled stream packets.
only_stream	Exclusively match reassembled stream packets.

Here is the syntax of the flow option:

```
flow: [(established|stateless)]
      [,(to_client|to_server|from_client|from_server)]
      [,(no_stream|only_stream)]
```

flowbits

The *flowbits* option is used to utilize the conversation tracking feature of the flow preprocessor. It can be used to set or check a user-defined state variable. It is typically used to make sure a specific packet has been seen before the current alert triggers, usually in a very protocol-specific fashion. An example of this is a user logging in to an FTP (File Transfer Protocol) server before issuing a vulnerable command that requires the user to be logged in.

Table 8.26 shows the modifiers that can be used with this option.

Table 8.26 flowbits Modifiers

Modifiers	Description
Set	Sets the bit of the name provided by the rule author.
Unset	Unsets the provided bit.
Toggle	Toggle the bit. If the bit is set, unset it; otherwise, set it.
Isset	Tests that the bit has previously been set.
Isnotset	Tests that the bit has NOT previously been set.
Noalert	Causes the rule not to provide an alert. This is useful when the whole purpose of the rule is to set the flowbit for use by another rule.

The syntax of the flowbits option is:

```
flowbits: [set|unset|toggle|isset,reset,noalert][,<STATE_NAME>];
```

Another example of a situation that requires the flow and flowbits options is that which occurs when looking for vulnerable JPEG code. JPEG files have be larger than a single packet, however if we only match the small amount of JPEG data that triggers the offset, we might open ourselves to a variety of false positives. To limit this, we can set a flowbits bit when a valid JPEG header is seen. In the official Snort ruleset there exists a rule to do just that is shown.

```
alert tcp $EXTERNAL_NET $HTTP_PORTS -> $HOME_NET any (msg:"WEB-CLIENT JPEG transfer";
flow:from_server,established; con tent:"image/"; nocase; pcre:"/^Content-
Type\s*\x3a\s*image\x2fp?jpe?g/smi"; flowbits:set,http.jpeg; flowbits:noalert;
classtype:protocol-c
ommand-decode; sid:2706; rev:2;)
```

Once this rule has been triggered we can search for the vulnerable JPEG data. The rule in the following example will search for this data when the flowbits bit http.jpeg has been set by the rule in the preceding example.

```
alert tcp $EXTERNAL_NET $HTTP_PORTS -> $HOME_NET any (msg:"WEB-CLIENT JPEG parser
multipacket heap overflow"; flow:from_server,established; flowbits:isset,http.jpeg;
content:"|FF|"; pcre:"/\xFF[\xE1\xE2\xED\xFE]\x00[\x00\x01]/"; reference:bugtraq,11173;
```

```
reference:cve,2004-0200;
reference:url,www.microsoft.com/security/bulletins/200409_jpeg.mspx; classtype:attempted-
admin; sid:2707; rev:2;)
```

Activate and Dynamic Rules

The *activate* and *dynamic* rule actions allow the rule author to trigger a second rule after the first rule's criteria is met. Although this behavior is being phased out of Snort in the later releases, it is still useful to understand how it works. In most cases, the activate and dynamic rules can be replaced using the *flowbits* option. This feature may be removed from Snort altogether in the future, but for now it is best to understand how it works when looking at older rules.

In an *activate* rule, the **activates:** detection option is used to select another rule to activate upon a successful match. The chosen rule must be a *dynamic* rule.

An example in which the activate/dynamic options could be used is when capturing some of the conversation to a TCP backdoor on port 1337. The conversation is only worth monitoring after the LOGIN details have been received. The following example shows an activate rule that will activate the dynamic rule.

```
activate tcp !$HOME_NET any -> $HOME_NET 1337 (flags: PA; content: "LOGIN "; activates: 1;
msg: "Backdoor Login Detected";) ?
```

When this rule is triggered it activates any dynamic rule that contains the *activated_by: 1* option. The main use for this is to log a number of packets after an attack has occurred. The *count* option is used in a dynamic rule to specify the number of packets to collect. In this case, when the dynamic rule is activated by the rule in the preceding example, it will log 50 packets. To check, use the following:

```
dynamic tcp !$HOME_NET any -> $HOME_NET 1337 (activated_by: 1; count: 50;)
```

This rule will log 50 packets from any ip address which is not the $HOME_NET, inbound to the $HOME_NET on port 1337, capturing the backdoor traffic.

Optimizing Rules

While Snort provides a mechanism for creating custom rules to fit a given situation, this can also cause its own problems. A few poorly thought out rules can quickly bring your IDS to its knees.

When writing your own rules it is usually best to analyze the problem in detail first. A good Snort rule is written to detect the vulnerability itself, not just a single exploit. Whenever possible it is best to write your rule targeting anomalies in the underlying application's protocol. However, sometimes doing this can result in too many false positives for it to be a feasible approach.

Ordering Detection Options

Snort detection options are evaluated in the same order that they are provided by the rule author. This can be both a blessing and a curse. This characteristic allows the rule author to order his rules in a way that can increase the efficiency of the rule. However, a poorly ordered rule can end up recursively checking an invalid packet for a much longer period of time.

Pattern matching detection plugins such as regular expressions and the content detection plugin are very costly in relation to some of the other options. Because of this it is often best to be as specific as you can with the discrete Snort options before the content option. This way, packets can quickly be passed if they do not meet the less expensive criteria, without ever reaching the pattern matching options.

Checks that are not repeatedly used, such as the *dsize* option, will greatly improve the speed of the rule.

An example of this is while matching an HTTP exploit, first we would make sure that we have a TCP packet on port 80. We might then use **flow:to_server,established;** to make sure we have a valid TCP session before finally using a content option to limit it further.

Here is a real example of a rule doing just that:

```
alert tcp $EXTERNAL_NET any -> $HTTP_SERVERS $HTTP_PORTS (msg:"WEB-ATTACKS wget command
attempt"; flow:to_server,established; content:"wget%20"; nocase; classtype:web-application-
attack; reference:bugtraq,10361; sid:1330; rev:6;)
```

NOTE

The content detection plugin uses a recursive algorithm in order to provide an accurate evaluation of certain situations where a portion of the pattern is matched directly before the full pattern match.

Choosing between Content and PCRE

Sometimes the choice between the content and PCRE detection plugins isn't clear-cut, as neither will provide any additional required functionality to the signature. When choosing between the two, the better of the two depends entirely on the situation.

When matching a single string match in a rule it makes very little difference which plugin you choose. In this case both PCRE and the content option use the Boyer-Moore algorithm. Because the PCRE detection plugin uses the libpcre library, there is an additional function call overhead that means the content option is slightly faster in this case.

When matching a single string in multiple rules, PCRE is much faster than the content option. This is because it eliminates the function call overhead involved with evaluating multiple rules. An obvious problem with this is that only one message will be generated for all of the patters that the PCRE comprises.

Finally, when using multiple rules, each matching a single string, and using other detection plugins, the content option wins hands down because of the function overhead involved with PCRE.

If the Snort default rule set is being used, then the content option will have a significant speed improvement due to the vast number of other rules using this option.

Merging CIDR Subnets

Merging CIDR subnets is a useful way to save resources. Whenever possible, CIDR subnets should be merged in order to improve Snort's efficiency.

A Perl module (Net::CIDR) is available on CPAN (Comprehensive Perl Archive Network) and can be used to easily merge CIDR masks. To install this module, you can use the **perl –MCPAN –eshell** command, then simply type **i Net::CIDR** to install the module.

The following example shows some sample code that will merge any CIDR subnets passed to it on the command line.

```
#!/usr/bin/perl
# -[ cidrmerge.pl ]-
# (c) nemo 2005
#
# Merge subnet masks provided on
# the command line.

use strict;
use warnings;
use Net::CIDR;
@ARGV or die("usage: $0 <list of CIDR subnets>\n");
print "$_\n" for Net::CIDR::cidradd(@ARGV);
```

The following example shows some sample output of the program:

```
-[nemo@snortbox:~]$ ./cidrmerge.pl
usage: ./cidrmerge.pl <list of CIDR subnets>
-[nemo@snortbox:~]$ ./cidrmerge.pl 192.168.0.12/32 192.168.0.20/26
192.168.0.0/26
```

Optimizing Regular Expressions

Using PCRE in your rules can be a very expensive option. If rules can be easily created without using heavy content matching and regular expressions, then it is best to avoid them. The subject of optimizing regular expressions alone is large enough to fill an entire book. For this reason, this section will simply highlight some general optimization concepts and show some examples.

Optimizing regular expressions follows the same principles as optimizing Snort rules. The aim when optimizing regular expressions is to write the expression in a way that results in the least work and time consumption for the engine. We will look at some ways to do this.

An example optimization that shows one method to reduce the amount of work the engine needs to do to test a match is shown in the following example. One way to match the two words **mum** and **mom** is shown in the following regular expression:

```
/^capitalize|capitalise$/
```

Although this is a valid expression and will still perform the same task, rephrasing it as shown in the following example will result in a significant increase in speed, as only one byte requires more than a single check.

```
/^capitali[zs]e$/
```

Regular expressions are checked in the exact order of the units (literal character, quantifiers, etc.) provided. Because of this, arranging the units in an order that is more likely to be rejected, or matched earlier in the evaluation, will cause the regular expression to be evaluated faster. An example of this would be seen when writing a regular expression to match the strings **optimize**

and **optimise**. Since the more common spelling is **optimize**, it makes sense to test for that spelling first. For example;

```
/^optimi[zs]e$/
```

This way the more likely match is evaluated first, speeding up the regular expression. When multiple options are provided in a regular expression, the PCRE engine uses a technique called *backtracking* in order to make sure each option is evaluated. This method involves choosing the first option and remembering the location of the branch. This is deemed a backtrack. The engine then continues evaluating the expression until the match succeeds or fails. In the case of a failed match, the engine resumes matching at the previous backtrack. Because of this, it is best to optimize your regular expressions to avoid backtracks whenever possible and to order your backtracks for maximum efficiency.

Greediness can play a factor in the speed of a regular expression. Whenever you are given the choice it's best to make operands non-greedy (via the "?" operator). This way the match can be accomplished earlier and the regular expression can, ultimately, finish earlier. Conveniently, PCRE supports the G modifier, which inverts the greediness of all the operands.

Regular expressions should be anchored to the beginning and end of a line, using the ^ and $ operands whenever possible. This will improve both the accuracy and speed of the rule. By doing this, Snort can quickly end if the first character does not match. Almost every rule in the Snort default rule set that uses the PCRE detection option anchors their patterns for these reasons, however in some cases it is not needed.

In order to demonstrate the optimization of a regular expression, we will use the Snort signature that was created earlier in the regular expression section.

```
alert tcp any any -> any 3632 (msg:"EXPLOIT Ethereal Distcc Network Protocol Dissection
Buffer Overflow Vulnerability"; pcre:"/(ARGV|SERR|SOUT)[8-F][0-F]{7}/smi";
reference:url,www.suresec.org/advisories/adv2.pdf; classtype:attempted-admin; sid:1000010;
rev:1;)
```

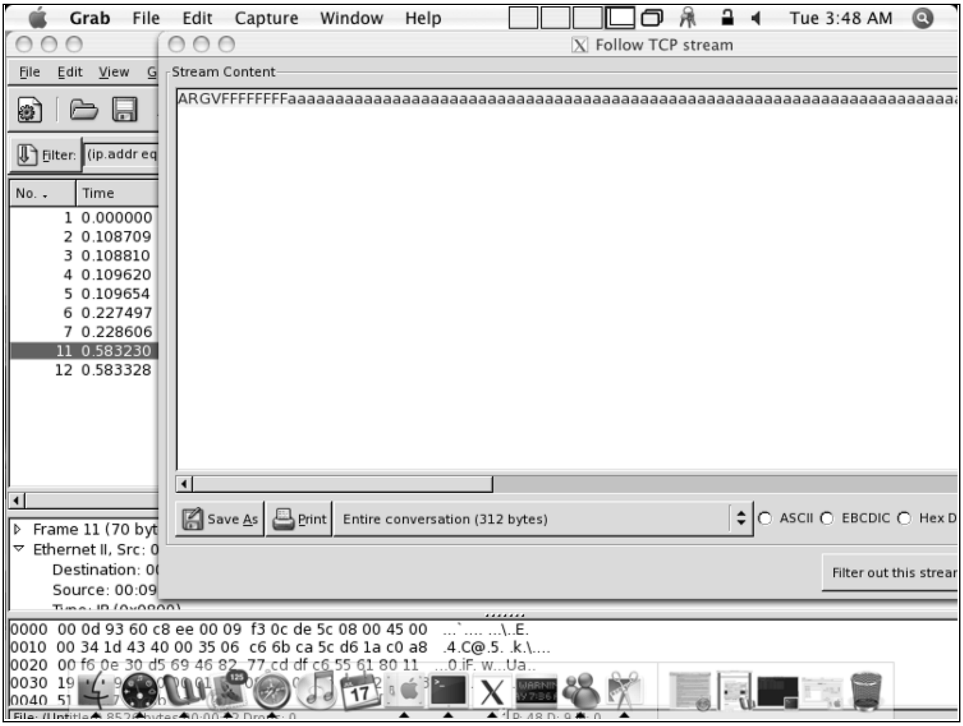
The PCRE test tool, which was discussed earlier in the PCRE section of this chapter, can be used to time PCRE compilation and execution. It does this when the **–t** option is passed to it. We can use this to measure our regular expression efficiency and optimize them to make a better rule. Unfortunately the pcretest tool does not support the Snort-specific modifiers.

In order to test our rule against some sample packet data, we can use the Ethereal program to capture the packets generated by our exploit. To do this we simply fire up Ethereal and start a new capture. While this is running we run the exploit, to generate the appropriate traffic. At this stage we can also load the distcc program to generate some legitimate traffic to help with our testing.

Once we have captured packets from the exploit, we right click on the TCP packet we wish to save. We then right-click and select **Follow TCP Stream**. Select **Raw** output mode, and then save the file. Figure 8.1 shows this process.

To verify that our packet is intact, we can use the xxd tool. The xxd tool can be used to dump the contents of binary files in various formats. By default it will dump a hexadecimal format, along with the ASCII values. The xxd tool is used to dump the contents of the packet capture.

Figure 8.1 Using Ethereal to Capture Exploit Packets




```
-[nemo@snortbox:~]$ xxd distccdump
0000000: 4152 4756 4646 4646 4646 4646 6161 6161  ARGVFFFFFFFFaaaa
0000010: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000020: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000030: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000040: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000050: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000060: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000070: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000080: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000090: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
00000a0: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
00000b0: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
00000c0: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
00000d0: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
00000e0: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
00000f0: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000100: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000110: 6161 6161 6161 6161 6161 6161 6161 6161  aaaaaaaaaaaaaaaa
0000120: 6161 6161 0814 a848 0814 a848 0814 a848  aaaa...H...H...H
0000130: bfff fff8 0000 0000                      ........
```

In this dump we can see the ARGV string that we will match, followed by the length (-1) and then a long string of a's. Our regular expression should match this easily.

Once we have a saved copy of our packets we can run the pcretest program. We specify the **–t** flag to time the run of our regular expression. The pcretest program can take a command line argument that specifies an input file. To run our packet dump using our pre-made regular expression we use the following piece of code:

```
-[nemo@snortbox:~]$ (echo /\(ARGV\|SERR\|SOUT\)\[8-F\]\[0-F\]\{7\}/smi; cat distccdump) >
tst.rxp; pcretest -t tst.rxp
PCRE version 5.0 13-Sep-2004

/(ARGV|SERR|SOUT)[8-F][0-F]{7}/smi
Compile time 0.004 milliseconds
ARGVFFFFFFFFaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaa???H????Execute time 0.001 milliseconds
 0: ARGVFFFFFFFF
 1: ARGV
```

In the preceding example, we can see that a successful match has been made, as expected. The regular expression compiled and ran relatively fast with no real problems. However, there is a problem with this rule. What if we append the packet dump to the string "ARGARGARGARGARGSERSERARGSOUTFFFFFFFFFFFF?" The regular expression will follow each of its options the entire way through, using backtracks for each. The following example shows this string being added:

```
-[nemo@snortbox:~]$ ( echo -n ARGARGARGARGARGSERSERARGSOUTFFFFFFFFFFFF; cat distccdump ) >
distccdump2
```

Now if we run this modified packet dump through **pcretest –t**, we can see that the execution time for the regular expression has become much higher.

```
-[nemo@snotbox:~]$ (echo  /\(ARGV\|SERR\|SOUT\)\[8-F\]\[0-F\]\{7\}/smi; cat distccdump2) >
tst.rxp; pcretest -t tst.rxp
PCRE version 5.0 13-Sep-2004

/(ARGV|SERR|SOUT)[8-F][0-F]{7}/smi
Compile time 0.004 milliseconds
ARGARGARGARGARGSERSERARGSOUTFFFFFFFFFFFFARGVFFFFFFFFaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa???H????Execute time 0.013
milliseconds
 0: SOUTFFFFFFFF
 1: SOUT
```

On top of the fact that it slowed down dramatically, this regular expression also has a match. So how can we fix this problem? This regular expression (as with most of the Snort rules) requires its PCRE to be anchored to the start of the payload. In order to do this we can insert a ^ caret character into the start of the regular expression. This leaves us with the following rule:

```
alert tcp any any -> any 3632 (msg:"EXPLOIT Ethereal Distcc Network Protocol Dissection
Buffer Overflow Vulnerability"; pcre:"/^(ARGV|SERR|SOUT)[8-F][0-F]{7}/smi";
reference:url,www.suresec.org/advisories/adv2.pdf; classtype:attempted-admin; sid:1000010;
rev:1;)
```

If we test this rule in the same way, we can see that the execution time has dropped right off again. Also no match was made. This is now a much better rule.

```
-[nemo@snortbox:~]$ (echo  /^\(ARGV\|SERR\|SOUT\)\[8-F\]\[0-F\]\{7\}/smi; cat distccdump2)
> tst.rxp; pcretest -t tst.rxp
PCRE version 5.0 13-Sep-2004

/^(ARGV|SERR|SOUT)[8-F][0-F]{7}/smi
Compile time 0.004 milliseconds
ARGARGARGARGARGSERSERARGSOUTFFFFFFFFFFFFARGVFFFFFFFFaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa???H????Execute time 0.002
milliseconds
No match
```

Testing Rules

A similar method to the one we used to test our regular expressions can be used to test custom Snort rules. By looking at the parameters that can be passed to Snort, we can see that the **–r** parameter can be used to replay a saved packet capture

```
-[neil@snortbox:~]$ snort -?

   ,,_     -*> Snort! <*-
  o"  )~   Version 2.3.0RC1 (Build 8)
   ''''    By Martin Roesch & The Snort Team: http://www.snort.org/team.html
           (C) Copyright 1998-2004 Sourcefire Inc, et al.

USAGE: snort [-options] <filter options>
Options:
        -A         Set alert mode: fast, full, console, or none  (alert file alerts only)
                   "unsock" enables UNIX socket logging (experimental).
        -b         Log packets in tcpdump format (much faster!)
        -c <rules> Use Rules File <rules>
        -C         Print out payloads with character data only (no hex)
        -d         Dump the Application Layer
        -D         Run Snort in background (daemon) mode
        -e         Display the second layer header info
        -f         Turn off fflush() calls after binary log writes
        -F <bpf>   Read BPF filters from file <bpf>
        -g <gname> Run snort gid as <gname> group (or gid) after initialization
        -h <hn>    Home network = <hn>
        -i <if>    Listen on interface <if>
        -I         Add Interface name to alert output
        -k <mode>  Checksum mode (all,noip,notcp,noudp,noicmp,none)
        -l <ld>    Log to directory <ld>
        -L <file>  Log to this tcpdump file
        -m <umask> Set umask = <umask>
        -n <cnt>   Exit after receiving <cnt> packets
        -N         Turn off logging (alerts still work)
        -o         Change the rule testing order to Pass|Alert|Log
```

```
        -O          Obfuscate the logged IP addresses
        -p          Disable promiscuous mode sniffing
        -P <snap>   Set explicit snaplen of packet (default: 1514)
        -q          Quiet. Don't show banner and status report
        -r <tf>     Read and process tcpdump file <tf>
        -R <id>     Include 'id' in snort_intf<id>.pid file name
        -s          Log alert messages to syslog
        -S <n=v>    Set rules file variable n equal to value v
        -t <dir>    Chroots process to <dir> after initialization
        -T          Test and report on the current Snort configuration
        -u <uname>  Run snort uid as <uname> user (or uid) after initialization
        -U          Use UTC for timestamps
        -v          Be verbose
        -V          Show version number
        -w          Dump 802.11 management and control frames
        -X          Dump the raw packet data starting at the link layer
        -y          Include year in timestamp in the alert and log files
        -z          Set assurance mode, match on established sesions (for TCP)
        -?          Show this information
<Filter Options> are standard BPF options, as seen in TCPDump
```

We can also use the **-P** option to make sure our snaplen is the same as the MTU we used to capture the packets.

In order to sufficiently test our custom rule, we need to make sure that it produces no false negatives. To do this we can use Ethereal to capture sample packets from the exploit. It is also best to think about what exactly can exploit the bug, what kind of protocol anomalies can occur and the entire scope of the bug, and make sure that you capture several different packet captures for each.

NOTE

The objective of this stage is to make sure that it is impossible to trigger the bug without your rule detecting it.

The next thing to be done is to test a custom rule is to make sure that normal, everyday traffic of the same protocol doesn't regularly trigger the alert. To do this we can again fire up Ethereal, and this time capture valid session traffic for the appropriate protocol. Once again we can use the **-r** option to Snort to read our captures in and modify our rules accordingly.

The final aspect when testing rules is to ensure that other protocol traffic doesn't trigger it. Because Snort cannot differentiate (easily) between two different types of protocols running on the same port, it can be useful to change the rule's destination port option to *any* and see if any new false positives appear while running this rule on an active network (preferably a staging box can be used). Doing this for a planned period of time should show any noticeable false positives that can be cleared up.

During this stage it is useful to run the perf-mon preprocessor. This preprocessor allows you to specify an interval in which to log, and log performance information. You can enable this plugin by adding the following line to your snort.conf file.

```
preprocessor perfmonitor: time 60 file <log file name> pktcnt 500
```

Once a log file has been collected the perfmon-graph utility (available from http://people.su.se/~andreaso/perfmon-graph/) can be used to output an easily visible graph of Snort performance over time. This graph can be correlated with alert logs, and the pcap dump file in order to locate problems with your rule.

Final Touches

Hopefully after reading this chapter, you are familiar with the basic and advanced Snort detection options. You should also have gained the knowledge needed to create efficient rules without hindering your Snort performance. Finally you should be able to test your rules for performance, false positives, and false negatives in a productive and thorough way. If you develop any rules that you find beneficial, it's good practice to share them with the rest of the Snort community whenever possible. To see some of the rules that other people have created, visit http://bleedingsnort.com/.

Chapter 9

Plugins and Preprocessors

Solutions in this chapter:

- **Writing Detection Plugins**
- **Writing Preprocessors**
- **Writing Output Plugins**

In This Toolbox

In this chapter you will learn how to navigate the Snort source tree. You will also learn how to create new detection plugins, output plugins, and preprocessors, and modify existing plugins in order to add new functionality to Snort.

Introduction

Plugins and preprocessors can be used to vastly alter the behavior and functionality of Snort. Before starting out and creating your own plugin or preprocessor, it is usually best to try and make sure that someone else has not already written what you desire. As the famous saying goes, "Why reinvent the wheel?"

If there is not an exact implementation of what you need, perhaps there is one that is close, and even if there is not, it's usually best to take a prewritten plugin and strip the code that you don't need rather than writing one from scratch.

Each of the different types of plugins has its own directory in the Snort source tree. Because Snort is released under an open source license, the following license block comment should be inserted into the top of newly written custom plugins. It also should *not* be removed from other plugins when modifying them. However, the name can be changed to reflect the author of the plugin.

```
/*
** Copyright (C) 2005 Neil Archibald <neil@suresec.org>
**
** This program is free software; you can redistribute it and/or modify
** it under the terms of the GNU General Public License as published by
** the Free Software Foundation; either version 2 of the License, or
** (at your option) any later version.
**
** This program is distributed in the hope that it will be useful,
** but WITHOUT ANY WARRANTY; without even the implied warranty of
** MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
** GNU General Public License for more details.
**
** You should have received a copy of the GNU General Public License
** along with this program; if not, write to the Free Software
** Foundation, Inc., 59 Temple Place - Suite 330, Boston, MA 02111-1307, USA.
*/
```

Writing Detection Plugins

Detection plugins make up the body of the Snort ruleset. Each of the options that we have used in the previous chapter has an associated detection plugin that provides the functionality of the option.

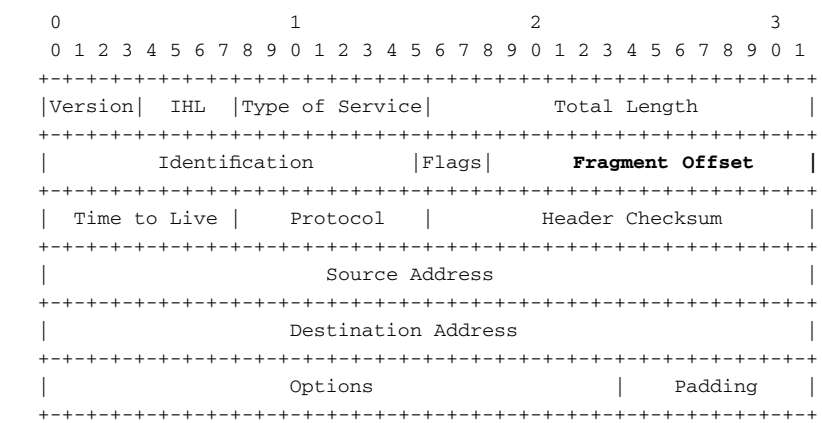
The code for these detection plugins is found in the src/detection-plugins/ folder relative to the source tree. The following example shows a listing of the files in this directory:

```
Makefile.am          sp_dsize_check.c     sp_icmp_type_check.c sp_ip_tos_check.c
sp_react.c           sp_tcp_flag_check.c
Makefile.in          sp_dsize_check.h     sp_icmp_type_check.h sp_ip_tos_check.h
sp_react.h           sp_tcp_flag_check.h
sp_asn1.c            sp_flowbits.c        sp_ip_fragbits.c     sp_ipoption_check.c
sp_respond.c         sp_tcp_seq_check.c
sp_asn1.h            sp_flowbits.h        sp_ip_fragbits.h     sp_ipoption_check.h
sp_respond.h         sp_tcp_seq_check.h
sp_byte_check.c      sp_icmp_code_check.c sp_ip_id_check.c
sp_isdataat.c        sp_rpc_check.c       sp_tcp_win_check.c
sp_byte_check.h      sp_icmp_code_check.h sp_ip_id_check.h
sp_isdataat.h        sp_rpc_check.h       sp_tcp_win_check.h
sp_byte_jump.c       sp_icmp_id_check.c   sp_ip_proto.c        sp_pattern_match.c
sp_session.c         sp_ttl_check.c
sp_byte_jump.h       sp_icmp_id_check.h   sp_ip_proto.h        sp_pattern_match.h
sp_session.h         sp_ttl_check.h
sp_clientserver.c    sp_icmp_seq_check.c  sp_ip_same_check.c
sp_pcre.c            sp_tcp_ack_check.c   sp_clientserver.h    sp_icmp_seq_check.h
sp_ip_same_check.h   sp_pcre.h            sp_tcp_ack_check.h
```

In this listing you can see that along with the Makefiles, this directory contains a separate file for most of the detection options. Some of the options share a file, such as the *fragoffset* and *fragbits* options. These are grouped together in the file sp_fragbits.c.

RFC 3514: The Evil Bit

On April 1, 2003, a startling RFC (request for changes) was released on the Internet. This RFC documented the previously unknown usage for the high-most bit of the Frag offset field in the IP (Internet Protocol) header. The following example shows the IP header and the aforementioned Frag offset field:



The RFC describes the high-most bit of the Frag offset field as an *evil bit*, which dictates the ethical intent of the packet. If the bit is set to 0 the packet is without evil intent and is safe to allow into the network. However, if the bit is set to 1, the packet is deemed evil and any well-configured network should drop the packet.

Unfortunately, at the time the Snort community didn't take this warning seriously enough, and Snort rules are still missing this crucial option, which should be enabled on every single Snort rule. In the following section we will run through the process of creating a Snort detection option that can be used to detect or block the evil packets on the Internet.

Detecting "Evil" Packets

To test the status of the evil bit, we can create a new detection plugin that uses the keyword *evil*. The *fragoffset* plugin already exists, and since this is the field we are concerned with, modifying this plugin to suit our needs seems appropriate.

First, we can copy the file sp_ip_fragbits.c in the /src/detection-plugins directory and name our copy sp_ip_evilbit.c in order to maintain snort standard file naming conventions. Next, we can remove all of the fragbit-related functionality from the file, as we need to modify only the fragoffset functions for this plugin.

All Snort plugins usually begin with the same block comment section. This section indicates the author of the plugin and clearly states its purpose and usage. The block comment section of our evil bit detection plugin is as follows. The following code and additional Snort rules discussed in this section are available on the Syngress Web site:


```
/* sp_ip_evilbit
 *
 * Purpose:
 *
 * Test the status of the evil bit. (The high order bit in the frag offset
 * field of the IP header).
 *
 * Arguments:
 *
 * The '!' operand can be used to test if the bit has NOT been set.
 *
 * Effect:
 *
 * Indicates if the evil bit has been set.
 *
 * Comments:
 *
 * Saving the internet from evil packets.
 *
 */
```

All the detection plugins typically include a standard set of headers. These define the Snort functions and data that we use in our plugin. The standard headers that are included or will be included in our sp_ip_evilbit plugin are:

```
#ifdef HAVE_CONFIG_H
#include "config.h"
#endif

#include <sys/types.h>
#include <stdlib.h>
#include <ctype.h>
```

```
#include <string.h>

#include "rules.h"
#include "plugbase.h"
#include "decode.h"
#include "parser.h"
#include "debug.h"
#include "util.h"
#include "plugin_enum.h"
```

Detection plugins define their own data structure, which contains each of the global variables required by the plugin. In the evil bit plugin we can define the following structure for our data:

```
typedef struct _EvilBitData
{
    u_int8_t  notset;
} EvilBitData;
```

The *notset* variable can be used to determine if the "!" operand is provided as an argument to our plugin. If this is the case, we return true when the evil bit is *not* set.

There are typically four core functions used to implement the fundamental functionality of detection plugins. These fundamental functions serve the following purposes:

- Map the chosen keyword to the appropriate function.
- Initialize the plugin.
- Parse the parameters provided by the rule author.
- Perform the appropriate tests required by the option.

In the case of our evil bit plugin, the following four functions are used to provide this functionality:

- void SetupEvilBit(void);
- void EvilBitInit(char *, OptTreeNode *, int);
- void ParseEvilBit(char *, OptTreeNode *);
- int CheckEvilBit(Packet *, struct _OptTreeNode *, OptFpList *);

SetupEvilBit()

The setup function has the purpose of associating a provided keyword with the function that is used to initialize it. The SetupEvilBit() function is added to the plugbase.c file in the Snort src directory in order to set up the detection option when Snort starts.

In order to perform this association, Snort provides the RegisterPlugin() function. This function takes two parameters: the keyword that should be used to use the detection options, and a function pointer to the initialization function for the plugin (in our case the EvilBitInit() function).

In our setup function we also use the DebugMessage() function to output a debug message. The DEBUG_WRAP macro is used to wrap the DebugMessage() function call in an #ifdef DEBUG statement. The full function is shown in the following example:

```
void SetupEvilBit(void)
{
    /* map the keyword to an initialization/processing function */
    RegisterPlugin("evil", EvilBitInit);

    DEBUG_WRAP(DebugMessage(DEBUG_PLUGIN, "Plugin: EvilBit Setup\n"););
}
```

EvilBitInit()

The *init* function is called when a rule containing the detection option is found. It is used to allocate the data structure needed by the option. In the case of our EvilBitInit() function this is done using the calloc() function. This function allocates a block of data on the heap and sets it to zero bytes (\x00).

The parse function is then called to evaluate the arguments passed to the option from the rule. Finally, the AddOptFuncToList() function is called. This function is used to add the function pointer for the check function to a list of function pointers associated with the current rule. This is part of the OptTreeNode.

The PLUGIN_EVIL_BIT value is taken from an enum data type, which is declared in the plugin_enum.h file in the Snort src/ directory. This is discussed later. Here is code for the EvilBitInit() function:


```
void EvilBitInit(char *data, OptTreeNode *otn, int protocol)
{
    /* allocate the data structure and attach it to the
       rule's data struct list */
    otn->ds_list[PLUGIN_EVIL_BIT] = (EvilBitData *) calloc(sizeof(EvilBitData),
                                                           sizeof(char));

    /* this is where the keyword arguments are processed and placed into the
       rule option's data structure */
    ParseEvilBit(data, otn);

    /* finally, attach the option's detection function to the rule's
       detect function pointer list */
    AddOptFuncToList(CheckEvilBit, otn);
}
```

NOTE

Although we used the ds_list method of storing our arguments here, this is generally being phased out and replaced with the OTN method. By using the ds_list we limit ourselves to a single instance of the specified plugin per rule.

An example of the use of the OTN struct to store rule option arguments can be seen in the PCRE plugin found in *src/detection-plugins/sp_pcre.c*. The initialization function for this plugin is as follows:

```
void SnortPcreInit(char *data, OptTreeNode *otn, int protocol)
{
    PcreData *pcre_data;
    OptFpList *fpl;

    /*
     * allocate the data structure for pcre
     */
    pcre_data = (PcreData *) SnortAlloc(sizeof(PcreData));

    if(pcre_data == NULL)
    {
        FatalError("%s (%d): Unable to allocate pcre_data node\n",
                   file_name, file_line);
    }

    SnortPcreParse(data, pcre_data, otn);

    fpl = AddOptFuncToList(SnortPcre, otn);

    /*
     * attach it to the context node so that we can call each instance
     * individually
     */
    fpl->context = (void *) pcre_data;

    return;
}
```

ParseEvilBit()

The *parse* function typically parses the arguments passed to the option by the rule author. It uses the values provided to populate the data struct values to be used later by the check function when testing the match.

In the case of our evil bit plugin, the only argument that can be provided is the "!" operand. When this operand is found, the *notset* variable in the data structure is set. If this operand is not found, the function simply returns, leaving the *notset* variable set to 0.

The following example shows the code for the ParseEvilBit() function:


```
void ParseEvilBit(char *data, OptTreeNode *otn)
```

```
{
        char *fptr;

        EvilBitData *ds_ptr;  /* data struct pointer */

        /* set the ds pointer to make it easier to reference the option's
        particular data struct */
        ds_ptr = otn->ds_list[PLUGIN_EVIL_BIT];

        /* manipulate the option arguments here */
        fptr = data;

        /* Initialize the notset variable to false */
        ds_ptr->notset = 0;

        /* If no options are provided return */
        if(!fptr)
                return;

        /* remove the whitespace from the options */
        while(isspace((u_char) *fptr))
                fptr++;

        /* If there is nothing but whitespace return */
        if(strlen(fptr) == 0)
                return;

        /* If a '!' operand is provided, set the notset flag */
        if(*fptr == '!')
        {
                ds_ptr->notset = 1;
                return;
        }
}
```

CheckEvilBit()

The *check* function is where the main functionality of a detection plugin is implemented. This function performs the actual check on the packet to determine the success of failure of the rule.

A linked list of function pointers is passed to the function as the fp_list parameter. This list is set to the current option. The list contains all the function pointers that are required to be called successfully for a rule to prove true. If the check function fails, it must immediately return the value 0. This way the rule is known to fail. If the check is successful, the next function pointer in the list is called in order to perform the next check in the rule.

In the case of our CheckEvilBit() function, the IP field frag_offset is bitwise AND'ed with the hexadecimal value 0x1000 (using the & operator). This value is such that the evil bit is 1 and the rest of the bits are 0. Thus, when AND'ed with any value, if the evil bit is set the result will be greater than 0. However, if the evil bit is unset the result will be zero.

Once the status of the evil bit is checked, the *notset* variable, which was set by the parsing of the arguments to the option, is checked. If the variable is false and the evil bit is set, the next function pointer is called. However, if the variable is true, the evil bit should not be set for a successful match. This is also reflected in the else { } statement. If the evil bit is unset, the notset variable needs to be true for a successful match to occur.

```
#define EVILMASK 0x1000

int CheckEvilBit(Packet *p, struct _OptTreeNode *otn, OptFpList *fp_list)
{
        EvilBitData *ipd;  /* data struct pointer */

        ipd = otn->ds_list[PLUGIN_EVIL_BIT];

DEBUG_WRAP(
    DebugMessage(DEBUG_PLUGIN,
                "[!] EvilBit is %s\n", (p->frag_offset & EVILMASK) ? "set" : "unset"));

        /* If the evil bit is set, test the notset value */
        if(p->frag_offset & EVILMASK)
        {
                return ipd->notset ? 0 :
                fp_list->next->OptTestFunc(p, otn, fp_list->next);
        }
        else {
                DEBUG_WRAP(DebugMessage(DEBUG_PLUGIN,"No match\n"););
                        return ipd->notset ? fp_list->next->OptTestFunc(p, otn,
                                    fp_list->next) : 0;
        }
}
```

Setting Up

In order for the detection plugin to be compiled during the compilation of the Snort source, the filename must be added to the src/detection-plugins/Makefile.am file. This instructs the configure tool to create makefiles that include the appropriate files.

The file src/plugbase.c must be modified in order to include the setup function for the detection plugin in the InitPlugins() function. This function is called when Snort is initialized and is used to initialize each of the detection plugins in turn. The modified function in this case is shown in the following example:

```
void InitPlugIns()
{
    if(!pv.quiet_flag)
    {
        LogMessage("Initializing Plug-ins!\n");
    }
    SetupPatternMatch();
    SetupTCPFlagCheck();
    SetupIcmpTypeCheck();
    SetupIcmpCodeCheck();
```

```
    SetupTtlCheck();
    SetupIpIdCheck();
    SetupTcpAckCheck();
    SetupTcpSeqCheck();
    SetupDsizeCheck();
    SetupIpOptionCheck();
    SetupRpcCheck();
    SetupEvilBit();
    SetupIcmpIdCheck();
    SetupIcmpSeqCheck();
    SetupSession();
    SetupIpTosCheck();
    SetupFragBits();
    SetupFragOffset();
    SetupTcpWinCheck();
    SetupIpProto();
    SetupIpSameCheck();
    SetupClientServer();
    SetupByteTest();
    SetupByteJump();
    SetupIsDataAt();
    SetupPcre();
    SetupFlowBits();
    SetupAsn1();
#ifdef ENABLE_RESPONSE
    SetupReact();
    SetupRespond();
#endif
}
```

We also need to add our *enum* identified to the src/plugin_enum.h file to allow our setup function to add the appropriate pointer to our data structure. Once this is done, the Snort source can be compiled in the usual way (**./configure; make**). Before we test a detection plugin, however, we obviously need to create a rule that uses it.

Testing

To test our detection plugin we can create the simple rule shown in the following example:

```
alert ip any any -> any any (msg:"Evil packet detected"; evil;)
```

WARNING

This rule will trigger on any packets that have the evil bit set. If you are on an open network with lots of malicious Internet hackers, this may flood your system with alerts.

Once this rule is in our snort rules file, we can start Snort to test it. In order to test this rule we can use a custom Perl script to generate traffic with the evil bit set. The Perl module

Net::Rawip can be used to generate raw IP traffic easily. The script seenoevil.pl is listed in the following example:


```
#!/usr/bin/perl
#
# seenoevil.pl
# -( nemo )-
# 2005
#
# Send evil packets to a host.

use Net::RawIP;
use Time::HiRes;

if(!$ARGV[0]) {
        die "usage: $0 <count>\n";
}

$pkt = new Net::RawIP;

$pkt->set({
        ip => {
                saddr    => '192.168.0.254',
                daddr    => '192.168.0.1',
                frag_off => 0x1000
        },
        tcp=> {
                dest => 80,
                syn  => 1,
                seq  => 0,
                ack  => 0
        }
});

for(1..$ARGV[0]){ $pkt->set({tcp=>{source=>int(rand(65535))}});Time::HiRes::sleep(2);
$pkt->send; };
```

Swiss Army Knife

The Net::Rawip Module

The Perl module Net::Rawip provides a quick and easy interface that allows you to create custom packets in almost any shape or form. It was written by Sergey Kolychev and the latest version can be found at http://www.ic.al.lg.ua/~ksv/index.shtml.

There is documentation available on CPAN for this module or with the command **perldoc Net::Rawip**.

By running this script, you can specify a packet count on the command line while Snort is running with this rule enabled. We can see that the following alerts are generated:

```
[**] [1:0:0] Evil packet detected [**]
[Priority: 0]
06/04-10:52:26.021775 192.168.0.254 -> 192.168.0.1
TCP TTL:64 TOS:0x10 ID:24590 IpLen:20 DgmLen:40
Frag Offset: 0x1000   Frag Size: 0x0014
```

So now we can use our *evil* option in any rules we want, in conjunction with other options to make our rules more accurate, and provide a safer Internet for all.

WARNING

For those of you who didn't pick up on the tongue-in-cheek humor in this section, I will point out again that the RFC regarding the evil bit was released on *April 1, 2003*. Although this RFC is a joke, I personally feel that it provides a clear situation with which to demonstrate the methods and code required to implement a custom detection plugin.

Writing Preprocessors

Preprocessors are modular pieces of code that are handed packet data after Snort has parsed the packets and broken them down into their appropriate fields. However, this occurs before the rules are matched against the packet. This leaves room for a preprocessor to perform such tasks as flow control and protocol anomaly-based detection, as well as miscellaneous tasks.

The modular design of preprocessors enables new functionality to be easily added to the Snort source and disabled by default. This allows Snort to be minimal and stable, while still providing end users with a wide variety of complex and useful functionality at their fingertips.

Many preprocessors are shipped with the Snort source. The code for these is available in the Snort src/preprocessors directory. The next example includes a full directory listing.

```
HttpInspect              perf.h                  spp_conversation.c       spp_portscan.h
spp_xlink2state.c
Makefile.am              portscan.c              spp_conversation.h       spp_portscan2.c
spp_xlink2state.h
Makefile.in              portscan.h              spp_flow.c               spp_portscan2.h
str_search.c
flow                     sfprocpidstats.c        spp_flow.h               spp_rpc_decode.c
str_search.h
perf-base.c              sfprocpidstats.h        spp_frag2.c
spp_rpc_decode.h         stream.h
perf-base.h              snort_httpinspect.c     spp_frag2.h
spp_sfportscan.c         xlink2state.c
perf-event.c             snort_httpinspect.h     spp_httpinspect.c
spp_sfportscan.h         xlink2state.h
perf-event.h             spp_arpspoof.c          spp_httpinspect.h        spp_stream4.c
perf-flow.c              spp_arpspoof.h          spp_perfmonitor.c        spp_stream4.h
```

```
perf-flow.h              spp_bo.c                spp_perfmonitor.h
spp_telnet_negotiation.c
perf.c                    spp_bo.h                spp_portscan.c
spp_telnet_negotiation.h
```

The amount of time required for the design and implementation of a Snort preprocessor can vastly fluctuate depending on the magnitude of the problem and the skill level of the programmer attempting the task. This time period usually ranges from a day or two to a couple of weeks.

In order to learn about preprocessors, we will look at the process of designing and coding one now.

IP-ID Tricks

The IP datagram header contains a field called the *IP-ID* field. This field (As defined by RFC 791) "is used to distinguish the fragments of one datagram from those of another. The originating protocol module of an Internet datagram sets the identification field to a value that must be unique for that source-destination pair and protocol for the time the datagram will be active in the Internet system."

Around five years ago, a security researcher named Salvatore Sanfilippo reported some interesting uses for this field in the information gathering aspects of information security. The basis of most of his tricks revolved around machines that would increment the IP-ID field for each packet sent, in a predictable manner. These techniques ranged from stealthily scanning a host to enumerating firewall rules and guessing the throughput of a host.

NOTE

Salvatore's papers on these subjects can be found at www.kyuzz.org/antirez/papers.html.

Idle Scanning

Possibly the most useful, and definitely the most well known, of Salvatore's IP-ID tricks is the technique termed *idle scanning*. Idle scanning is a port scanning technique that utilizes a machine with a predictable IP-ID field in order to scan another remote machine without sending any packets from the original host.

This section presents a rough overview of the technique. This technique is more thoroughly documented in a paper at http://www.insecure.org/nmap/idlescan.html and is also implemented by the nmap security scanner.

To illustrate this scanning technique we will look at the process an attacker goes through in order to test if a port is open on a given target machine. For the sake of this example we will refer to the attacker's machine as *A*, the idle zombie machine with the predictable IP-ID as *Z*, and the target machine as *T*.

To begin the attack the attacker sends a packet from machine A to machine Z and records the IP-ID of the response. This can be done using the *hping2* tool, which was written by Salvatore.

Swiss Army Knife

Hping2

Hping2 is a command-line ping replacement utility that provides a flexible way to create custom packets with an almost endless supply of options and functions. The tool is available via a free download from http://www.hping.org/. Hping2 is a valuable asset in the toolkit of any security professional's arsenal.

In the following example we can see the output from the hping2 command being used to probe the current IP-ID field from the zombie machine:

```
-[nemo@snortbox:~]$ sudo hping -c 1 -1 zombiebox
HPING zombiebox (eth0 192.168.0.10): icmp mode set, 28 headers + 0 data bytes
len=28 ip=192.168.0.1 ttl=64 id=48485 icmp_seq=0 rtt=0.1 ms
len=28 ip=192.168.0.1 ttl=64 id=48486 icmp_seq=1 rtt=0.2 ms
len=28 ip=192.168.0.1 ttl=64 id=48487 icmp_seq=2 rtt=0.1 ms
--- zombiebox hping statistic ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 0.1/0.1/0.2 ms
```

From this output we can see that the machine *zombiebox* has a predictable IP identification field. The machine will continue to increment the IP-ID field each time a new packet is sent. We also can see in this output that the current value of the IP-ID field is set to *48487*.

Once this value has been identified, the attacker can use this information. A packet can be crafted that looks like it has originated from Z, and can be sent to T.

Depending on the open/closed status of the target port on T, the zombie box will respond in different ways. If the port on T is closed, it will respond to Z with a TCP RST. Z will not react to this. However, if the target port is open, a SYN/ACK packet will be sent back to Z. Because Z was not expecting this packet, it responds to T, incrementing its IP-ID in doing so.

By querying the IP-ID status of Z before and after the spoofed packet is sent, it is possible to determine if the port on T is open or closed. All this is done without sending a single packet from the attacker's machine.

The *nmap security scanner*, as mentioned earlier, can automate this entire process. Because this attack can incriminate a machine on your own network, it is best to locate machines on your network with predictable IP-IDs and patch them to remove the problem. Snort provides an excellent framework for implementing this functionality. The process of designing and implementing this as a preprocessor is discussed in the next section of this chapter.

Predictable IP-ID Preprocessor

The layout of a preprocessor is very similar to that of a detection plugin, the main difference being that the main body of the plugin consists of a function that takes only a packet struct as input rather than a list of other functions to call. Like a detection plugin, a preprocessor consists of four main functions in order to implement most of its functionality. These functions should do the following:

- Map the chosen keyword to the appropriate function.
- Initialize the plugin.
- Parse the parameters passed to the preprocessor via the snort.conf file.
- Perform the main functionality of the preprocessor on a packet struct passed in as input.

For the Predictable IP-ID preprocessor, the following functions will be used to achieve this:

- void SetupIPID()
- void IPIDInit(u_char *)
- void IPIDParse(char *portlist)
- void RecordIPID(Packet *p)

Several other functions will be defined and discussed in order to provide clarity to the program. For the sake of this book, efficiency will be sacrificed in order to achieve more readable code. For this reason a linked list will be used to store data instead of a more complex hashing function.

For clarity the options passed to the preprocessor are parsed and stored in a user-defined structure. In the case of the IP-ID preprocessor the arguments shown in Table 9.1 will be implemented.

Table 9.1 Preprocessor Options

Option	Description
threshold	The threshold option is used to supply the number of packets to capture from a single IP address before testing the IP-IDs for sequential predictability. A higher value will provide more accurate results, however may pose the risk of interference from other sources or the inability to capture enough packets to formulate a result. A good value for this option is typically *10*.
timeout	The timeout option is used to specify the amount of time (in seconds) to withhold from re-checking an IP address after the packet threshold has been reached. A value of 0 will maintain the blacklist of IPs forever.

To store these variables, we define the following data structure:

```
typedef struct _IPIDData
{
        u_int threshold;        /* Number of ip-id's to sample */
        time_t timeout;         /* Length of time to ignore tested IPs */
} IPIDData;
```

As well as the options for our preprocessor, a data structure must be defined in order to hold information about the IP-IDs gathered so that they can be evaluated. The following example shows the structure that has been defined for this:

```
typedef struct _ip {
        struct _ip *next;       /* Pointer to the next ip    */
        u_long  ipaddr;         /* IP address */
        u_long *ipids;          /* An array of ipids         */
        time_t ignored;         /* Time the ip was ignored   */
} ip;
```

Some global variables also have to be declared:

```
ip *ips;                        /* global list of ips */
ip *blacklist;                  /* list of blacklists */
IPIDData *ipdata;               /* parsed arguments   */
u_long  pcount;                 /* packet count */
```

Now we will discuss the various functions that provide the functionality of this preprocessor.

SetupIPID()

The SetupIPID() function is used to register the appropriate keyword to be used in the snort.conf file and associate this with an initiation function. In this case we chose the ipid_predictable keyword.
The source code for this function is:

```
void SetupIPID()
{
    RegisterPreprocessor("ipid_predictable", IPIDInit);

    DEBUG_WRAP(DebugMessage(DEBUG_PLUGIN, "Preprocessor: Predictable IP-ID Detection
Preprocessor is setup...\n"););
}
```

A debug statement is also provided to make things easier. This function is called once upon Snort initialization.

IPIDInit()

The IPIDInit() function is called when the appropriate keyword is found in the snort.conf file; the arguments from snort.conf are passed to this function. IPIDInit() is also responsible for initializing the data structures that are required by the preprocessor. The source code for this function is shown in the following example:

```
void IPIDInit(u_char *args)
{
        IPIDParse(args);
        pcount = 0;             // init packet counter

        /* Allocate space for the first IP */
        ips = calloc(1, sizeof(ip));

        /* Allocate space for the first blacklist */
        blacklist = calloc(1,sizeof(ip));

        /* Allocate space for the ipids  */
        ips->ipids = calloc(ipdata->threshold + 1, sizeof(u_long));

        /* Set the preprocessor function into the function list */
        AddFuncToPreprocList(RecordIPID);

        if(!(ips && blacklist && ips->ipids))
                FatalError("Error, not enough memory to allocate space for the IP-ID
Detection Preprocessor\n");


        DEBUG_WRAP(DebugMessage(DEBUG_PLUGIN, "Preprocessor: Predictable IP-ID Detection
Initialized\n"););
}
```

First, the IPIDParse() function is called to parse the arguments and store them in a newly created structure. After this we can see that the calloc() function is used to allocate data for the initial elements of the linked lists and initialize the data to be filled with zeroes (0). The ips list is used to store the relevant IPIDs of the IPs seen. The blacklist list is used to store information about IPs that have previously been checked.

IPIDParse()

As mentioned in the previous section, it is the IPIDParse() function's responsibility to break up the argument string provided in the snort.conf file and store it in the appropriate data structure for later use. It achieves this functionality by using the strtok() function. This function breaks up the string based on a delimiter provided (in this case the possible delimiters are the tab character and the space character). It then compares the key with the static strings *threshold* and *timeout* to store the appropriate value in the struct.

This function also uses calloc() in order to allocate memory for the stored arguments.

```
void IPIDParse(char *args)
{
        char *key, *value;
        char *myargs = NULL;
        const char *delim = " \t";

        if(!(ipdata = calloc(1, sizeof(IPIDData)))) {
                 FatalError("An error occured allocating space for options.");
        }
```

```
        if(args) {
                myargs = strdup(args);

                if(myargs == NULL)  {
                    FatalError("Out of memory parsing flow arguments\n");
                }
        } else
                FatalError("Error, invalid arguments passed to the IP-ID Detection
Preprocessor\n");

        key = strtok(myargs, delim);

        while(key != NULL) {
                value = strtok(NULL, delim);

                if(!value) {
                    FatalError("%s(%d) key %s has no value\n", file_name, file_line,value);
                }

                if(!strcmp(key,"threshold")) {
                        ipdata->threshold = atoi(value);
                        if(ipdata->threshold < 3)
                                FatalError("The threshold value specified is too low. (<
3)\n");
                }

                if(!strcmp(key,"timeout")) {
                        ipdata->timeout = atoi(value);
                }

                key = strtok(NULL, delim);
        }

        if(myargs)
                free(myargs);

        if(!ipdata->threshold || !ipdata->timeout)
                FatalError("Error, invalid arguments passed to the IP-ID Detection
Preprocessor\n");

        return;
}
```

RecordIPID()

This function is where it all happens! When Snort receives a packet and decodes it, the packet is passed directly to this function as a pointer to a Packet struct. It is here that we can pull the IP-ID out and store it in our linked list.

We begin by testing that the IP header data we have been passed is valid; we can never be too careful here. After this, the function checks a packet count to see if it should try to clean up

the blacklist (using the ipunlink() function) and expire entries that have timed out. It is more efficient to do this here than fork() and poll it.

We then run through the ips list and check if the current packet's source IP address has already been seen. If it has, then the ip_id is stored in the appropriate field. If it hasn't, a new entry in the ips list is created for the IP.

Once the threshold number of packets has been captured for a particular IP address, the IP address is added to the blacklist and removed from the ips list using the ipunlink() function. The full code listing for the RecordIPID() function is shown in the following example:

```
void RecordIPID(Packet *p)
{
        ip *c_bl,*curr_ptr = ips;
        int n;
        u_long tempip ;

        /* Make sure we have a valid packet */
        if(!p || !p->iph || !(tempip = ntohl((uint32_t)(p->iph->ip_src.s_addr)))) {
                return;
        }
        /* Do we need to cleanup our blacklist? (cleaner than forking imo) */
        if(pcount && ipdata->threshold && ipdata->timeout && !(pcount % ipdata->threshold
* 2)) {
                cleanup_blacklist();
        }
        do {
                n = -1;
                if(curr_ptr->ipaddr == tempip) {
                        while(curr_ptr->ipids[++n]);
                        if(n == (ipdata->threshold - 1)) {
                                curr_ptr->ipids[n] = p->iph->ip_id;
                                TestIPID(curr_ptr->ipids);

                                if(!(c_bl = calloc(1,sizeof(ip)))) {
                                        FatalError("Error, not enough memory to allocate
space for the IP-ID Detection Preprocessor\n");
                                }

                                if(ipdata->timeout) {
                                        /* BLACKLIST */
                                        curr_ptr->ipaddr = c_bl->ipaddr;
                                        c_bl->next    = blacklist;
                                        c_bl->ignored = time(NULL);
                                        blacklist = c_bl;
                                }
                                /* Remove IP */
                                lunlink(curr_ptr->ipaddr,&ips);

                                return;

                        } else {
                                curr_ptr->ipids[n] = p->iph->ip_id;
                                return;
```

```
                        }
                }
        } while((curr_ptr=curr_ptr->next));

        curr_ptr = blacklist;
        do {
                if(curr_ptr->ipaddr == tempip)
                        return;
        } while((curr_ptr=curr_ptr->next));

        /* add ip here */
        if(!(c_bl = calloc(1,sizeof(ip)))) {
                FatalError("Error, not enough memory to allocate space for the IP-ID
Detection Preprocessor\n");
        }
        c_bl->ipaddr = ntohl(p->iph->ip_src.s_addr);
        c_bl->next = ips;
        if(!(c_bl->ipids = calloc(ipdata->threshold + 1, sizeof(u_long)))) {
                FatalError("Error, not enough memory to allocate space for the IP-ID
Detection Preprocessor\n");
        }
        ips = c_bl;
}
```

The ipunlink() function provides the ability to search through a linked list based on an IPaddress and unlink the associated entry. This is used to remove entries from both the ips and blacklist lists. It simply runs through the list until it finds a match, then replaces the previous next pointer to skip the entry. It then frees the memory:

```
void ipunlink(u_long ipkey,ip **list)
{
        ip *prev_ptr,*curr_ptr;
        u_int n=0;

        if(!list || !*list) return;

        curr_ptr = *list;

        prev_ptr = curr_ptr;
        do {
                if(curr_ptr->ipaddr == ipkey) {
                        if(!n) {
                                *list = (*list)->next;
                                return;
                        }
                        prev_ptr->next = curr_ptr->next;
                        free(curr_ptr);
                        return;
                }
                prev_ptr = curr_ptr;
                n++;
        } while((curr_ptr=curr_ptr->next));
}
```

The TestIPID() function is called once the threshold is reached for a particular IP. This function runs through the array of IP-IDs and notes the differences between each one. If the difference remains the same throughout the whole list, a Snort alert is generated.

This is done by using the SnortEventqAdd() function, available when the *event_queue.h* header is included.

```
void TestIPID(u_long *ipids)
{
        u_int n, diff=0;

        for(n=1 ; n <= (ipdata->threshold-1) ; n++) {
                if(n==1) {
                        diff = ipids[n] - ipids[n-1];
                        continue;
                }
                if(diff != (ipids[n] - ipids[n-1]))
                        return;
        }

        SnortEventqAdd( GENERATOR_SPP_IPID_PREDICTABLE,
                        IPID_PREDICTABLE,
                        1,
                        0,
                        3,
                        IPID_PREDICTABLE_DETECT,
                        0
        );
}
```

The #define values that are passed to SnortEvendqAdd() are defined in the src/generators.h file.

Setting Up

Setting up a preprocessor is much the same as setting up a detection plugin. The src/plugbase.c file must be modified to include a function call to your *setup* function. However, this call must be appended to the InitPreprocessors() function instead of InitPlugins(). The following example shows the modified InitPreprocessors() function:

```
void InitPreprocessors()
{
    if(!pv.quiet_flag)
    {
        LogMessage("Initializing Preprocessors!\n");
    }
    SetupPortscan();
    SetupPortscanIgnoreHosts();
    SetupRpcDecode();
    SetupBo();
    SetupTelNeg();
    SetupStream4();
    SetupFrag2();
```

```
    SetupARPspoof();
    SetupConv();
    SetupScan2();
    SetupHttpInspect();
    SetupPerfMonitor();
    SetupFlow();
    SetupPsng();
    SetupIPID();
}
```

Also, the Makefile.am in the src/preprocessors/ directory must be modified to include a reference to any files which contain your preprocessor. Once this is done Snort can be compiled as normal.

To load the preprocessor we must insert our keyword into the snort.conf file. Passing in the correct arguments to initialize it is also a must. The following is a sample entry that was used in our snort.conf:

```
preprocessor ipid_predictable:timeout 5000 threshold 10
```

Finally Snort can be run. When connections are made to or from a machine with a predictable IP-ID within the visible scope of the Snort sensor, the following alerts are triggered:

```
[**] [123:1:1] (spp_ipid_predictable) Predictable IP-ID detected on network [**]
06/06-17:33:32.787172 192.168.0.246:443 -> 192.168.0.1:52410
TCP TTL:64 TOS:0x10 ID:53049 IpLen:20 DgmLen:1240 DF
***AP*** Seq: 0x768318BE  Ack: 0xB10EF383  Win: 0x31E0  TcpLen: 32
TCP Options (3) => NOP NOP TS: 37164675 451370217
```

Prevention

Once idle machines are detected on your network with predictable IP-IDs, it makes sense to try and remedy the problem to counteract the situations mentioned earlier in this chapter. There are many different ways to combat this problem. The easiest way is to simply install a kernel patch such as grsecurity and enable the IP-ID randomization features.

NOTE

The grsecurity kernel patch is available for Linux, and can be downloaded from www.grsecurity.net.

Writing Output Plugins

There are many reasons why you might want to roll out your own Snort output plugin. The company you work for might use a proprietary output format, or maybe you just want to use Snort as a personal IDS (Intrusion Detection System) on your notebook. Whatever the reason, the Snort development team has created an API (application program interface) that makes creating your own custom output plugin as painless as possible.

As with the other types of plugins, it's usually best to try and modify an existing plugin rather than creating your own from scratch. There is already a wide variety of output formats to choose from, so make sure you search thoroughly before committing to writing your own.

The current Snort distribution at the time of this writing (version 2.3.3) ships with many useful output plugins. These are stored in the src/output-plugins directory of the Snort source. A full directory listing of these are shown in the following example:

```
Makefile.am           spo_alert_full.c      spo_alert_syslog.c
spo_csv.c              spo_log_ascii.c       spo_log_tcpdump.c
Makefile.in           spo_alert_full.h      spo_alert_syslog.h
spo_csv.h              spo_log_ascii.h       spo_log_tcpdump.h
spo_alert_fast.c      spo_alert_sf_socket.c spo_alert_unixsock.c  spo_database.c
spo_log_null.c         spo_unified.c
spo_alert_fast.h      spo_alert_sf_socket.h spo_alert_unixsock.h  spo_database.h
spo_log_null.h         spo_unified.h
```

These plugins provide Snort with the ability to log alerts in various formats such as the pcap format or to an SQL database. Writing a Snort output plugin is very similar to writing a detection plugin or a preprocessor. In order to demonstrate the process of designing and writing a Snort output plugin we will run through the implementation of a GTK output plugin for Snort.

GTK+

The Gimp Tool Kit (GTK+) is a free multiplatform library that can be used to create graphical user interfaces (GUIs). GTK+ was originally developed for use by the GIMP (Gnu Image Manipulation Program) tool, which is an open source graphics manipulation program of similar design to Adobe Photoshop. GIMP is available from http://www.gimp.org/ and supports Linux, Windows, and Mac OS X.

GTK+ is based on a combination of three libraries. These are shown in Table 9.2.

Table 9.2 GTK+ Libraries

Library	Description
Glib	The Glib library provides a low level core of functions ranging from threads and event loops to C structure handling and a functional object system.
Pango	Pango is a library designed to cater to the rendering and layout of text. It is especially designed around internationalization.
ATK	ATK is used to provide accessibility options to the interface. This can be in the form of magnification, readers, and other input devices.

GTK+ supports a variety of languages such as C, C++, C#, Perl, and many others. In our case the C interface is used as this is the language of choice for Snort. The source and binaries for GTK+ can be downloaded from www.gtk.org.

An Interface for Snort

The output plugin shown in this section implements a GTK interface for which the Snort engine can output alerts in real time. Another way this problem could have been solved is to create a script that constantly reads and parses the Snort alert file; however this wouldn't have made a very good output plugin, now would it?

In order to keep the plugin simple for the purposes of this writing, a very limited functionality has been provided by the interface. The interface will simply present the source and destination IP addresses as well as the name of the alert. Next to each alert a checkbox will be provided. Once alerts are selected they can be acknowledged by clicking a button at the bottom of the form.

When GTK+ is initialized the program sits in a loop waiting for GUI events. Because this behavior would result in Snort being unable to process any more alerts, we need to use threads in order to process GUI events and allow Snort to raise new events at the same time.

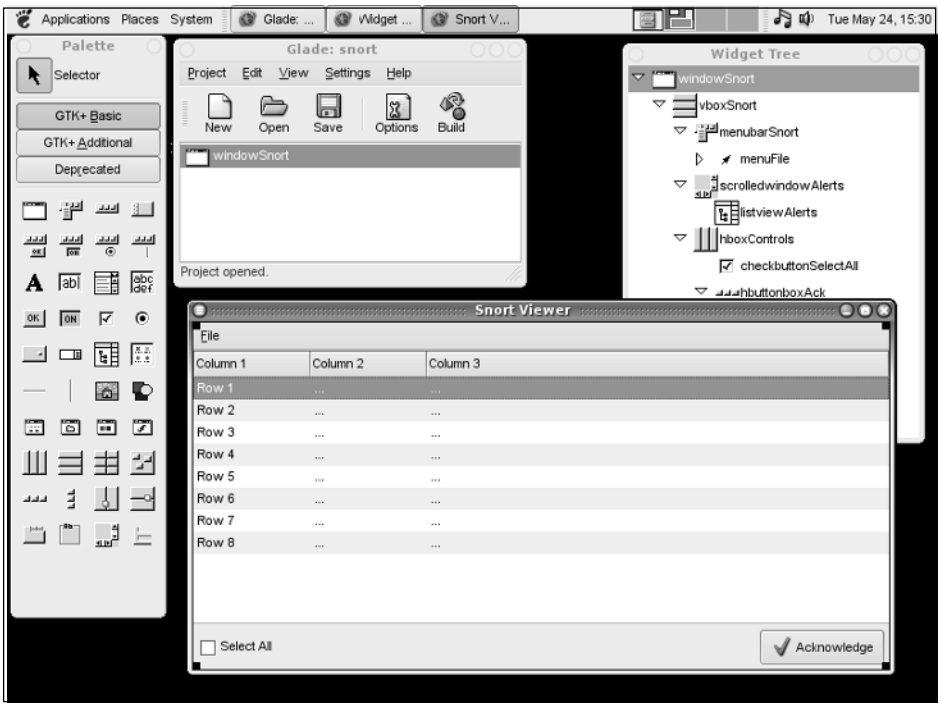
For the sake of keeping code small, the POSIX thread interface was used. This means that this plugin will only compile successfully on a POSIX-compliant operating system such as Linux or Mac OS X. In order to improve the portability of this code, *#define* statements could be used to utilize the appropriate thread implementation for the desired operating system.

Glade

To design the GUI, a tool called Glade was used. Glade is a free user interface builder developed by members of the Gnome team. It allows a user to simply drag and drop widgets onto the form and instantly create a user interface. The tool can be downloaded for free from the Gnome Web site, http://glade.gnome.org, and is easy to install and set up. An excellent tutorial for beginners can be found at http://writelinux.com/glade/index.php.

To begin designing our interface, the window icon (top left on the **Palette** toolbar) is selected to create our new window. A *vbox* is created in order to position our widgets correctly inside the window. We then simply drag the required widgets onto the window, change their properties, and save our changes. Figure 9.1 shows the Glade interface at work creating our Snort GUI.

Figure 9.1 Using a Glade Interface to Create a Snort GUI



Once the design is finished there are two options. We can either use the Glade program to generate C source code, or import the generated XML from within the program using a library called *libglade*.

To contain this plugin in a single file, we will generate C source and cut and paste this into our program. We do this by clicking **Build** on the toolbar. We then cut and paste the generated code into it's own function, *create_windowSnort()*, in our Snort plugin. The generated code is shown in the following example:


```
GtkWidget* create_windowSnort(void)
{
        GtkWidget *vboxSnort;
        GtkWidget *menubarSnort;
        GtkWidget *menuFile;
        GtkWidget *menuFile_menu;
        GtkWidget *menuQuit;
        GtkWidget *scrolledwindowAlerts;
        GtkWidget *listviewAlerts;
        GtkWidget *hboxControls;
        GtkWidget *hbuttonboxAck;
        GtkWidget *buttonAck;
        GtkWidget *alignmentAck;
        GtkWidget *hboxAck;
        GtkWidget *imageAck;
        GtkWidget *labelAck;
```

```
        GtkAccelGroup   *accel_group;
        GtkCellRenderer *columnAck;
        GtkCellRenderer   *columnSrc;
        GtkCellRenderer   *columnDst;
        GtkCellRenderer   *columnAlert;

        accel_group = gtk_accel_group_new();

        windowSnort = gtk_window_new(GTK_WINDOW_TOPLEVEL);
        gtk_window_set_title(GTK_WINDOW(windowSnort), "Snort-GTK");
        gtk_window_set_default_size(GTK_WINDOW(windowSnort), 600, 300);

        vboxSnort = gtk_vbox_new(FALSE, 0);
        gtk_widget_show(vboxSnort);
        gtk_container_add(GTK_CONTAINER(windowSnort), vboxSnort);

        scrolledwindowAlerts = gtk_scrolled_window_new(NULL, NULL);
        gtk_widget_show(scrolledwindowAlerts);
        gtk_box_pack_start(GTK_BOX(vboxSnort), scrolledwindowAlerts, TRUE, TRUE, 0);
        gtk_scrolled_window_set_policy(GTK_SCROLLED_WINDOW(scrolledwindowAlerts),
GTK_POLICY_NEVER, GTK_POLICY_AUTOMATIC);
        gtk_scrolled_window_set_shadow_type(GTK_SCROLLED_WINDOW(scrolledwindowAlerts),
GTK_SHADOW_IN);
        listviewAlerts = gtk_tree_view_new();
        columnAck = gtk_cell_renderer_toggle_new();
        g_object_set(columnAck, "activatable", TRUE, NULL);
        gtk_tree_view_insert_column_with_attributes(GTK_TREE_VIEW(listviewAlerts), -1,
"Ack", columnAck, "active", COL_ACK, NULL);
        columnSrc = gtk_cell_renderer_text_new();
        gtk_tree_view_insert_column_with_attributes(GTK_TREE_VIEW(listviewAlerts), -1,
"Source", columnSrc, "text", COL_SRC, NULL);
        columnDst = gtk_cell_renderer_text_new();
        gtk_tree_view_insert_column_with_attributes(GTK_TREE_VIEW(listviewAlerts), -1,
"Destination", columnDst, "text", COL_DST, NULL);
        columnAlert = gtk_cell_renderer_text_new();
        gtk_tree_view_insert_column_with_attributes(GTK_TREE_VIEW(listviewAlerts), -1,
"Alert", columnAlert, "text", COL_ALERT, NULL);
        storeAlerts = gtk_list_store_new(4, G_TYPE_BOOLEAN, G_TYPE_STRING, G_TYPE_STRING,
G_TYPE_STRING);
        gtk_tree_view_set_model(GTK_TREE_VIEW(listviewAlerts),
GTK_TREE_MODEL(storeAlerts));
        gtk_widget_show(listviewAlerts);
        gtk_container_add(GTK_CONTAINER(scrolledwindowAlerts), listviewAlerts);
        gtk_tree_view_set_rules_hint(GTK_TREE_VIEW(listviewAlerts), TRUE);

        hboxControls = gtk_hbox_new(FALSE, 0);
        gtk_widget_show(hboxControls);
        gtk_box_pack_start(GTK_BOX(vboxSnort), hboxControls, FALSE, TRUE, 0);
        gtk_container_set_border_width(GTK_CONTAINER(hboxControls), 5);

        hbuttonboxAck = gtk_hbutton_box_new();
        gtk_widget_show(hbuttonboxAck);
        gtk_box_pack_start(GTK_BOX(hboxControls), hbuttonboxAck, FALSE, FALSE, 0);
```

```
        buttonAck = gtk_button_new();
        gtk_widget_show(buttonAck);
        gtk_container_add(GTK_CONTAINER(hbuttonboxAck), buttonAck);
        GTK_WIDGET_SET_FLAGS(buttonAck, GTK_CAN_DEFAULT);

        alignmentAck = gtk_alignment_new(0.5, 0.5, 0, 0);
        gtk_widget_show(alignmentAck);
        gtk_container_add(GTK_CONTAINER(buttonAck), alignmentAck);

        hboxAck = gtk_hbox_new(FALSE, 2);
        gtk_widget_show(hboxAck);
        gtk_container_add(GTK_CONTAINER(alignmentAck), hboxAck);

hboxAck = gtk_hbox_new(FALSE, 2);
        gtk_widget_show(hboxAck);
        gtk_container_add(GTK_CONTAINER(alignmentAck), hboxAck);

        imageAck = gtk_image_new_from_stock("gtk-apply", GTK_ICON_SIZE_BUTTON);
        gtk_widget_show(imageAck);
        gtk_box_pack_start(GTK_BOX(hboxAck), imageAck, FALSE, FALSE, 0);

        labelAck = gtk_label_new_with_mnemonic("Acknowledge");
        gtk_widget_show(labelAck);
        gtk_box_pack_start(GTK_BOX(hboxAck), labelAck, FALSE, FALSE, 0);

        g_signal_connect((gpointer) columnAck, "toggled",
G_CALLBACK(on_columnAck_toggled), NULL);
        g_signal_connect((gpointer) buttonAck, "clicked",
G_CALLBACK(on_buttonAck_clicked), NULL);

        g_object_set_data(G_OBJECT(windowSnort), "windowSnort", windowSnort);

        g_object_set_data_full(G_OBJECT(windowSnort), "vboxSnort",
gtk_widget_ref(vboxSnort),            (GDestroyNotify) gtk_widget_unref);
        g_object_set_data_full(G_OBJECT(windowSnort), "scrolledwindowAlerts",
gtk_widget_ref(scrolledwindowAlerts), (GDestroyNotify) gtk_widget_unref);
        g_object_set_data_full(G_OBJECT(windowSnort), "listviewAlerts",
gtk_widget_ref(listviewAlerts),       (GDestroyNotify) gtk_widget_unref);
        g_object_set_data_full(G_OBJECT(windowSnort), "hboxControls",
gtk_widget_ref(hboxControls),         (GDestroyNotify) gtk_widget_unref);
        g_object_set_data_full(G_OBJECT(windowSnort), "hbuttonboxAck",
gtk_widget_ref(hbuttonboxAck),        (GDestroyNotify) gtk_widget_unref);
        g_object_set_data_full(G_OBJECT(windowSnort), "buttonAck",
gtk_widget_ref(buttonAck),            (GDestroyNotify) gtk_widget_unref);
        g_object_set_data_full(G_OBJECT(windowSnort), "alignmentAck",
gtk_widget_ref(alignmentAck),         (GDestroyNotify) gtk_widget_unref);
        g_object_set_data_full(G_OBJECT(windowSnort), "hboxAck",
gtk_widget_ref(hboxAck),              (GDestroyNotify) gtk_widget_unref);
        g_object_set_data_full(G_OBJECT(windowSnort), "imageAck",
gtk_widget_ref(imageAck),             (GDestroyNotify) gtk_widget_unref);
        g_object_set_data_full(G_OBJECT(windowSnort), "labelAck",
gtk_widget_ref(labelAck),             (GDestroyNotify) gtk_widget_unref);

        gtk_window_add_accel_group(GTK_WINDOW(windowSnort), accel_group);
```

```
        return windowSnort;
}
```

In this code we can see each of the GTKWidgets are instantiated. Following this the appropriate GTK+ functions are called to set the properties of the widgets. Finally, the widgets are displayed.

We also take some of the widgets from the code and make them global. This way all the functions in our program (regardless of thread) can access them. This allows our alerts widget to be updated from a separate thread.

```
GtkWidget *windowSnort;             // The main window.
GtkListStore          *storeAlerts; // Global list store for alerts.
GtkTreeIter           iter;         // Iterator
GtkWidget *text;                    // Global textbox.
```

Function Layout

To use our interface, we first need to set up our plugin and register it with the Snort engine to accept events. The process of setting up an output plugin is much the same as for the other types of plugins. The plugin's *setup* function must be appended to the src/plugbase.c file. The output plugin's setup function is entered into the InitPlugins() function in the same way as our detection plugin.

The modified InitPlugins() function, with our setup function AlertGTKSetup(), is shown here:

```
void InitPlugIns()
{
    if(!pv.quiet_flag)
    {
        LogMessage("Initializing Plug-ins!\n");
    }
    SetupPatternMatch();
    SetupTCPFlagCheck();
    SetupIcmpTypeCheck();
    SetupIcmpCodeCheck();
    SetupTtlCheck();
    SetupIpIdCheck();
    SetupTcpAckCheck();
    SetupTcpSeqCheck();
    SetupDsizeCheck();
    SetupIpOptionCheck();
    SetupRpcCheck();
    SetupIcmpIdCheck();
    SetupIcmpSeqCheck();
    SetupSession();
    SetupIpTosCheck();
    SetupFragBits();
    SetupFragOffset();
    SetupTcpWinCheck();
    SetupIpProto();
```

```
    SetupIpSameCheck();
    SetupClientServer();
    SetupByteTest();
    SetupByteJump();
    SetupIsDataAt();
    SetupPcre();
    SetupFlowBits();
    SetupAsn1();
    AlertGTKSetup();
#ifdef ENABLE_RESPONSE
    SetupReact();
    SetupRespond();
#endif
}
```

When Snort starts up, it calls this function, which in turn calls the setup functions for each of the Snort plugins.

AlertGTKSetup()

When the AlertGTKSetup() function is called, it registers the appropriate keyword to be found in the snort.conf file. It does this using the RegisterOutputPlugin() function. The keyword that is associated is passed as the first argument to this function. We use the keyword *alert_gtk*. The third argument to this function is used to provide the callback function to call when the keyword is found. We associate the AlertGTKInit() function with our keyword.

```
void AlertGTKSetup(void)
{
    RegisterOutputPlugin("alert_gtk", NT_OUTPUT_ALERT, AlertGTKInit);

    DEBUG_WRAP(DebugMessage(DEBUG_INIT,"Output plugin: AlertGTK is setup...\n"););
}
```

A debug statement is also inserted into this function to make testing easier.

AlertGTKInit

Once the *alert_gtk* keyword is found in the snort.conf file, the AlertGTKInit() function is called, and any arguments that follow the keyword are passed in as the *u_char *args* parameter. In our case no arguments are needed; therefore, the args parameter is ignored. In most cases the args parameter would be passed to a parsing function as seen in the other plugins.

Our AlertGTKInit() function begins by declaring a new pthread. It then uses a debug message to announce that the initialisation is occurring. Our alert function (AlertGTK) is added to our list of output functions. When a new event is created Snort runs through this list and passes the event to each function.

Our pthread is then created. The startinterface() function is used in the new thread in order to create the GTK+ interface. Here is the code listing for the AlertGTKInit() function:

```
void AlertGTKInit(u_char *args)
{
        pthread_t thread;
        pthread_attr_t attr;

        DEBUG_WRAP(DebugMessage(DEBUG_INIT, "Output: AlertGTK Initialized\n"););

        pv.alert_plugin_active = 1;

        /* Set the preprocessor function into the function list */
        DEBUG_WRAP(DebugMessage(DEBUG_INIT,"Linking AlertGTK functions to call
lists...\n"););
        AddFuncToOutputList(AlertGTK, NT_OUTPUT_ALERT, NULL);

        /* Initialize the threads */
        pthread_attr_init(&attr);
        pthread_attr_setdetachstate(&attr, PTHREAD_CREATE_JOINABLE);

        if(pthread_create(&thread,&attr,&startinterface,NULL)) {
                DEBUG_WRAP(DebugMessage(DEBUG_INIT,"An error has occured while creating a
pthread.\n"););
                exit(EXIT_FAILURE);
        }
}
```

At this stage, the startinterface() function starts up in a new thread.

```
void startinterface(void)
{
        GtkWidget *windowSnort;

        gtk_set_locale();
        gtk_init(NULL, NULL);

        windowSnort = create_windowSnort();
        g_signal_connect (G_OBJECT (windowSnort), "delete_event", G_CALLBACK (destroy),
NULL);

        gtk_widget_show(windowSnort);
        gtk_main();

        pthread_exit(EXIT_SUCCESS);
}
```

This function is the main body of our newly created thread. It first instantiates the windowSnort widget, calling the create_windowSnort() function containing the code that was cut and pasted from our newly created form from Glade.

It then connects the signal that occurs when the window is closed, using the appropriate destroy function, *destroy()*. The gtk_widget_show() function is used to display the window on the screen before finally the gtk_main() function is called. The gtk_main() function sits and blocks until it receives events from the user or a signal is caught.

When a input event occurs, the gtk_main() function passes execution to the appropriate handler function. Once the handler has finished, execution resumes in this function and it continues to block.

AlertGTK

The AlertGTK() function is registered by the AlertGTKInit() function to be called by Snort when an alert is added to the queue. This function call occurs in the originating thread, rather than in the newly created GTK+ pthread.

An event struct is passed to this function and is parsed and passed to the insertAlert() function. This function contains the code necessary to add the alert to the GTK+ widgets on the window.

```
void AlertGTK(Packet *p, char *msg, void *arg, Event *event)
{
           char src[17],dst[17];

        snprintf(src,16,"%s",inet_ntoa(p->iph->ip_src));
        snprintf(dst,16,"%s",inet_ntoa(p->iph->ip_dst));
        insertAlert(src, dst, msg);
}
```

This insertAlert() function simply uses the gtk_list_store_append() function and the gtk_list_store_set() function to add a new element to the global storeAlerts widget. This widget is redrawn in the gtk_main() loop, displaying the alert to the user.

```
gboolean insertAlert(char *dst, char *src, char *alert)
{
        gtk_list_store_append(storeAlerts, &iter);
        gtk_list_store_set(storeAlerts, &iter, COL_ACK, FALSE, COL_SRC, dst, COL_DST, src,
COL_ALERT, alert, -1);

        return TRUE;
}
```

Exiting

When a user exits the main window, the delete_event is thrown, and the handler destroy() is called, due to the signal association which occurred earlier in the startinterface() function. Because our alerts are only stored in volatile memory (and the Snort alert file or database if needed) accidentally closing the window might prove to be a bad thing for our user. Because of this our destroy() function prompts the user to confirm the quit action before closing anything down.

The destroy() function begins by creating a new dialog box. This dialog box contains the message "Are you sure you want to quit?" and the GTK_BUTTONS_YES_NO **Yes** and **No** buttons. When the dialog box returns the selection, the function tests it. If the user selects the **No** button the function simply returns to the calling function in order to resume the gtk_main() loop. However, if the **Yes** button is clicked, the function begins the (evil) process of closing down Snort. This function is shown in the following example:

```
static void destroy( GtkWidget *widget, gpointer  data )
{
        GtkWidget *dialog;
        GtkWidget *msgbox = gtk_window_new (GTK_WINDOW_TOPLEVEL);;
        gint choice;

        dialog = gtk_message_dialog_new (msgbox,
                                GTK_DIALOG_DESTROY_WITH_PARENT,
                                GTK_MESSAGE_QUESTION,
                                GTK_BUTTONS_YES_NO,
                                "Are you sure you want to quit?"
                                );
        choice = gtk_dialog_run (GTK_DIALOG (dialog));
        if(choice == GTK_RESPONSE_YES) {
                gtk_widget_destroy (dialog);
                gtk_main_quit ();
                gtk_thread = pthread_self();
                atexit(exitgracefully);         // lies
                kill(getpid(),SIGINT);
                exit(EXIT_SUCCESS);
        }
        gtk_widget_hide (dialog);
        return;
}
```

Because the destroy() function is called in the second thread, exit()'ing this thread will leave the Snort thread running and unaware that anything has been changed. Because of this we need to either modify the Snort source or perform an evil thread closing dance. Because we are implementing this as a Snort plugin rather than a patch to Snort we use the latter method.

Our function retrieves the number of the current thread and stores it in the global gtk_thread variable:

```
pthread_t gtk_thread;               // Used by ugly exit hack.
```

It then uses the atexit() function to associate a callback function that will be called when the program is exit()ing. The associated callback function is the exitgracefully() function.

Because Snort normally expects a user to press **Ctrl + C** to exit, a signal handler is set up to catch the SIGINT signal using the signal() function. In this handler function, Snort cleans up after itself to shutdown safely. Because we want Snort to exit quickly but safely we use the kill() function to send a SIGINT to our own process. This causes Snort to branch execution to its signal handler and clean up appropriately after itself.

After this happens Snort tries to exit cleanly; however we have associated an atexit() handler. Execution is then passed to this handler.

```
void exitgracefully()
{
        pthread_kill(gtk_thread,SIGKILL); // EVIL  HACK
}
```

Finally, inside our exitgracefully() function, the stored thread number is retrieved and a SIGKILL (9) signal is sent to our thread, causing it to forcefully exit. Although not great, this is

safe at this stage because we have cleaned up appropriately after ourselves. This leaves the Snort process terminated entirely.

Setting Up

Now that our plugin is complete, all that is left is to compile and run Snort to test it. In order for the GTK+ library to be included with Snort, we need to set environment variables used by the ./configure utility.

The small script in the next example can be used to work out the appropriate libraries needed, set the environment variables, and run the ./configure utility:

```
#!/bin/sh
export LDFLAGS="`pkg-config --cflags --libs gtk+-2.0` -pthread"
export CFLAGS=`pkg-config --cflags gtk+-2.0`-ggdb
./configure
```

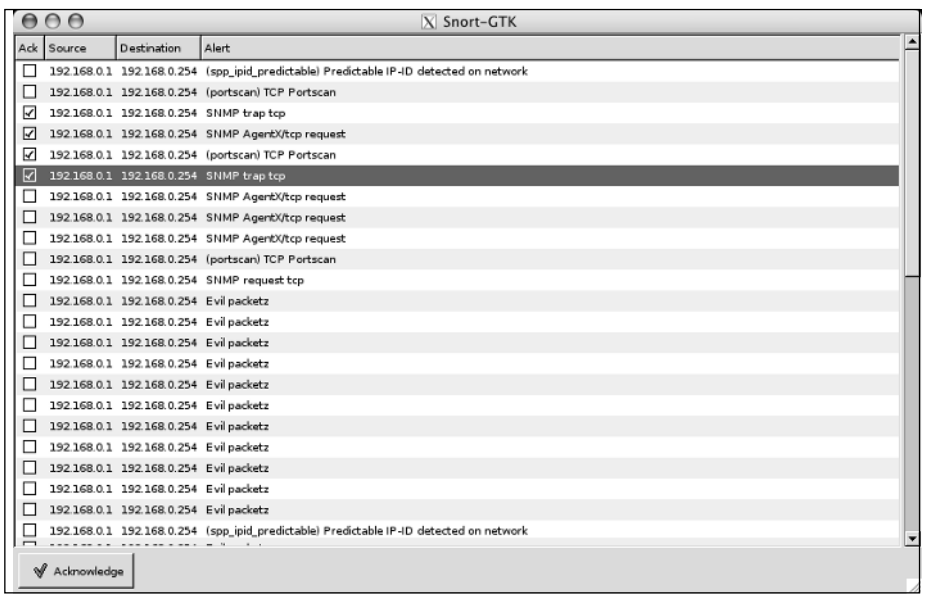
Once this script has finished running, all that is left is to compile Snort as normal using the **make** command, followed by **make install**.

Once Snort is built correctly, the appropriate initialization keyword must be added to the snort.conf file. No options are required for our plugin, so simply using the keywords shown in the following example will be sufficient to initiate the plugin:

```
output alert_gtk
```

We can now start Snort in the usual method and (assuming X11 and GTK+ are set up correctly on the target system) our shiny new interface will appear. Figure 9.2 shows our interface running with some generated alerts.

Figure 9.2 The Finished Interface



Miscellaneous

The snort.conf syntax supports the *ruletype* keyword. This keyword allows the user to group sets of output plugins together and provide a name and classification for the group. This classification can be used in Snort rules in the *type* field (see Chapter 8). The syntax of the ruletype keyword is similar to that of C and is as follows:

```
ruletype type_name
{
     type <type>
        output <output plugin>
        …
}
```

In the case of our output plugin in the previous example, we might define a *ruletype* that goes straight to the GUI and also logs to a database. To accomplish this we could use the following:

```
ruletype guidb_alert
{
   type alert
   output gtk_alert
   output database: log, mysql, user=myuser password=mypass dbname=snort host=sqlserver
}
```

Final Touches

Although the Snort API provides an easy way to jump right in and start building your own custom Snort plugins for your every need, you have to be careful! A lot of the code you write in a Snort plugin is going to be directly accessible remotely. This means that any mistakes you make while coding these plugins can increase the chances of a remote compromise of your Snort IDS sensor. Not to mention that a badly implemented preprocessor can easily bring Snort to a grinding halt. Don't let this scare you from writing your plugin, but it might be a useful exercise to have other people auditing the source of your plugins before implementing them on a production site.

Chapter 10

Modifying Snort

Solutions in this chapter:

- **Snort-AV**
- **Snort-Wireless**

In This Toolbox

In this chapter, you will learn how to modify the Snort source code to solve an otherwise difficult task. You will also become familiar with various open source projects that build on Snort to achieve their functionality, and the limitations of the Snort engine.

Introduction

There are many reasons why you would want to modify the Snort source. Perhaps you want to add new functionality to Snort, or you know that the Snort engine can provide an excellent building block as a base system in almost any kind of packet-sniffing utility. Whatever the reason, this chapter provides you with enough background knowledge to get you well on your way with your new project.

Currently, many projects use the Snort engine to get the job done. During the course of this chapter, we will look at two different variations to the source:

- **Snort-AV** An active verification modification for Snort.
- **Snort-Wireless** A wireless packet sniffer and IDS similar to the AirDefense product.

Snort-AV

The Snort-AV project is an open source implementation of the concept of *active verification* using the Snort engine. Before we look at the implementation, let's discuss the concept of active verification. To achieve its functionality, the Snort-AV project modifies the core Snort source functions and changes their behavior.

The Snort-AV package is available for a free download from www.cs.ucsb.edu/~wkr/projects/ids_alert_verification/.

Active Verification

The concept of active verification is relatively new to the IDS world. One of the biggest problems an IDS faces is the vast quantity of false positives it receives after being plugged in to an active network.

A *false positive* is the condition in which an IDS generates an event for a condition that never exists in reality.

In the case of a home network, false positives can be annoying; however, for a large corporate company, the time spent by analysts investigating and validating false positives can be devastating in terms of time and money.

Active verification is a concept that attempts to solve the problem of false positives in an automated way. It sets out to emulate as much of the IDS analyst's role in investigating the alert as possible, before actually generating an alert.

To do so, an extra step is taken after the IDS processes a packet and discovers a match for a particular signature. At this stage, typically, the IDS would generate an alert; however, with active

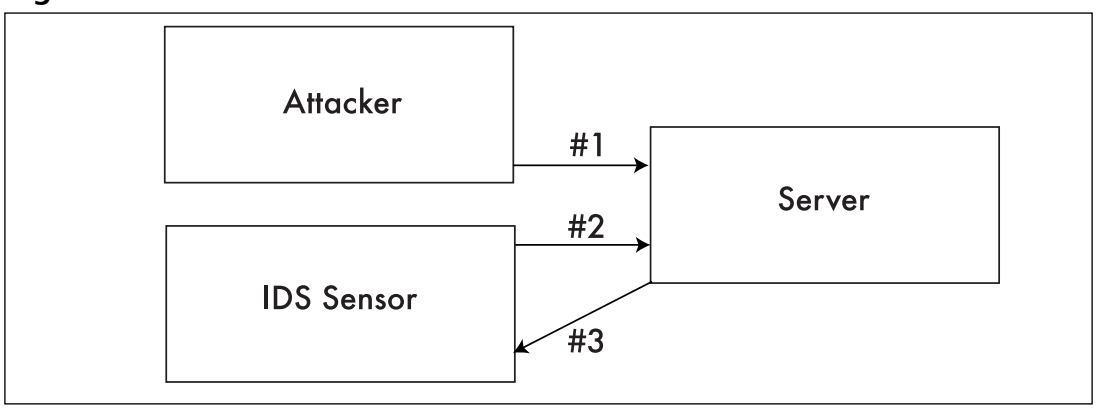
verification, the IDS will follow up the alert with a vulnerability scan of the particular service on which the alert was generated. This scan is performed using signatures that correlate with the actual IDS signature. This way, if the scan determines that the service being attacked is not vulnerable to the particular attack, an alert is not generated.

NOTE

The active verification strategy does not help reduce false negatives, where a real attack happens but is not picked up by the IDS.

Figure 10.1 shows the order in which this process happens.

Figure 10.1 Active Verification



1. The IDS sensor detects the attacker sending malicious packets to the server.
2. The IDS sensor sends a similar attack to verify the existence of the vulnerability.
3. The sensor responds to the attack, the content of which is used to determine if the original attack was successful.

This method can save a company time and resources investigating each alert by hand. However, in many cases, performing a vulnerability scan of a service can be risky, and there is a risk of crashing the service. For this reason, this method is often not implemented on major corporate networks.

Snort-AV- Implementation Summary

The Snort-AV project implements active verification using the Snort source as a base. To verify Snort alerts when they occur, NASL (Nessus Attack Scripting Language) scripts, which are discussed in Chapter 1, "The Inner Workings of NASL (Nessus Attack Scripting Language)," are used to perform follow-up scans for the targeted vulnerability.

To correlate the Snort rules with the NASL plugins, the CVE ID (Common Vulnerabilities and Exposures) associated with the vulnerability targeted by both the NASL plugin and the Snort rule is used.

At the time of writing, the Snort-AV patch is implemented as a .diff file. The file contains a list of additions and removals from the Snort source tree, which are indicated by a "+" or "-" character starting each line. The Snort-AV patch is available for only the `snort-2.1.3` source tree.

To install Snort-AV, simply download the .diff .gz file from the Web site and the snort-2.1.3 source tree from www.snort.org.

Once the tree has been extracted, the command `zcat snort-av-2.1.3-0.9.6.diff.gz | patch -p1` can be used in the Snort directory to apply the patch.

Master Craftsman

Creating Patches with diff

Once you have patched a source tree, you can use the GNU *diff* utility to create a patch that can be reapplied to the fresh source tree.

To create a diff patch for a source tree, you need to have two directories. One directory must contain the original source, and the other must contain the modified source.

Once this is done, the following UNIX command can be used to create the diff patch:

```
diff -uNr <original source> <modified source> > <diff file>
```

The "–u" flag is used to output the diff file in unified format. The "-N" flag means that diff will take into account new or removed files. The "-r" flag causes diff to recursively spider the source tree for changes.

Snort-AV Initialization

We will now run through the changes that Snort-AV makes to the Snort source to initialize itself during Snort's startup process. Each change is grouped according to the file in which it is contained.

Snort.h

The first changes we will look at occur in the snort.h file. Two new attributes are appended to the PV struct, which is used to store arguments and settings. These attributes are used to store the location of the alert verification scripts and the status of alert verification (enabled/disabled).

```
int alert_verification;
char *verify_script_dir;
```

The PacketCount struct is also modified to keep track of the number of verified, unverifiable, and unverified alerts. These values are appended to the struct in the form of the following variables:

```
/* Alert verification stats */
    u_long verified;
    u_long unverifiable;
    u_long unverified;
```

Snort.c

The snort.c file contains several changes after the diff patch is applied. This file (as seen in Chapter 7, "The Inner Workings of Snort") contains a large body of the Snort initialization code.

The first change to the file is performed on the ShowUsage() function. This is merely a cosmetic change to present the new command-line options to the user.

The following example shows the newly added command-line options:

```
FPUTS_UNIX ("         -a <mode>  Enable alert verification (mode = mark|suppress)\n");
FPUTS_UNIX ("                     mark    : Tag alerts with verification status\n");
FPUTS_UNIX ("                     suppress: Suppress unverified alerts\n");
FPUTS_UNIX ("         -H <num>   Number of verification threads\n");
FPUTS_UNIX ("         -K <secs>  Set alert verification cache timeout to <secs>\n");
FPUTS_UNIX ("         -x <dir>   Specify directory containing verification scripts\n");
```

For these command-line options to take effect, the ParseCmdLine() function is also modified. The appropriate argument values are added to the valid_options string.

The following example shows the new valid_options string with the Snort active verification related options appended.

```
valid_options = "?a:A:bB:c:CdDefF:g:h:H:i:Ik:K:l:L:m:n:NoOpP:qr:R:sS:t:Tu:UvVwx:Xyz";
```

This string is used to indicate to the getopts() function called by Snort, which options should be provided on the command line when it is executed. The ":" character is used to indicate that the flag requires an additional parameter to be passed along with it on the command line. For example, the "a:" part of the string is used to indicate that the –a flag can be used and should be followed by the "mode" parameter.

In addition, in the ParseCmdLine() function, handlers are created to set the appropriate variables in the PV struct to indicate alert verification settings.

```
case 'a': /* enable alert verification */
                if (!strcasecmp(optarg, "mark"))
                    pv.alert_verification = VERIFICATION_MODE_MARK;
                else if (!strcasecmp(optarg, "suppress"))
                    pv.alert_verification = VERIFICATION_MODE_SUPPRESS;
                else
                    FatalError("Unrecognized alert verification mode, supported modes
                        are 'mark' or 'suppress'\n");
                break;

case 'H':
                if (!optarg)
                  FatalError("Verification thread pool size needs a numeric
                      argument.\n");
                numVerificationThreads = strtoul(optarg, NULL, 10);
                break;
```

```
case 'K': /* verification cache timeout */
                  vcacheTimeout = strtoul(optarg, NULL, 10);
                  break;


case 'x': /* specify verification script directory */
                  if ((pv.verify_script_dir = strdup(optarg)) == NULL)
                    FatalError("Unable to assign verification script directory\n");

                  if (access(pv.verify_script_dir, 2) != 0)
                    FatalError("Unable to access verification script directory (%s)\n",
                      pv.verify_script_dir);

                  break;
```

Finally, a call to the InitializeAlertVerification() function is added to the SnortMain() function to initialize the alert verification system during Snort startup. An equivalent call to the HaltAlertVerification() function is added to the CleanExit() function to shut down the alert verification system when Snort is terminated.

Parser.c

The parser.c file is modified to set up the structures associated with each rule so that they hold information pertaining to active verification.

The code in the following example is added to the ParseRuleOptions() function.

```
else if (!strcasecmp(option_name, "verify"))
             {
               ONE_CHECK(one_verify, opts[0]);
               if (num_opts != 2)
                 FatalError("\n%s(%d) => Malformed verify keyword\n",
                   file_name, file_line);

               if (!strcasecmp(opts[1], "true")) {
                 otn_tmp->sigInfo.doVerify = 1;
               } else if (!strcasecmp(opts[1], "false")) {
                 otn_tmp->sigInfo.doVerify = 0;
               } else {
                 FatalError("\n%s(%d) => verify keyword requires true/false argument\n",
                   file_name, file_line);
               }
             }
```

The preceding code is used to check for the *verify* keyword in a rule followed by a true or false value reflecting whether to verify the rule. If the value is set to true, the Siginfo data in the OptTreeNode struct is modified to set the doVerify attribute to 1 appropriately; otherwise, the attribute is set to 0.

NOTE

The ONE_CHECK macro is used inside the parser.c file to make sure that the option specified in a rule is provided only once. It does this using a temporary variable that is passed to the ONE_CHECK macro. The macro increments this, and tests to make sure the count has not gone above 1.

```
#define ONE_CHECK(_onevar,xxx)                                          \
       (_onevar)++;                                                      \
       if ((_onevar) > 1)                                                \
       {                                                                 \
            FatalError("%s(%d) => Only one '%s' option per rule\n",\
                            file_name, file_line, xxx);                  \
       }
```

Signature.h

The signature.h file has only a single change made to it. In this file, an entry is added to the SigInfo structure, which holds information about a given signature, to test if the signature should be verified. The modified structure is shown here:

```
typedef struct _SigInfo
{
    u_int32_t generator;
    u_int32_t id;
    u_int32_t rev;
    u_int32_t class_id;
    ClassType *classType;
    u_int32_t priority;
    u_int32_t doVerify;
    char *message;
    ReferenceNode *refs;
} SigInfo;
```

Detect.c

The detect.c file holds a large portion of the Snort-AV patches' functionality. The following headers are included by this file:

```
#include <nessus/libnessus.h>
#include <nessus/nessus-devel.h>
#include <nessus/nasl.h>
```

These headers are added in order to use the libnasl functionality to perform the verification.

As we saw earlier, during the initialization of Snort the InitializeAlertVerification() function is called. This function is defined here in detect.c.

The function begins by testing the alert_verification attribute of the PV struct to determine what mode the user has selected.

```
void
InitializeAlertVerification(void)
{
  int i;
  char *mode = NULL;

  if (pv.alert_verification == VERIFICATION_MODE_NONE)
    return;

  verify = 1;

  switch (pv.alert_verification) {
    case VERIFICATION_MODE_MARK:
      mode = "mark";
      break;

    case VERIFICATION_MODE_SUPPRESS:
      mode = "suppression";
      break;

    default:
      FatalError("Unknown verification mode '%d'\n", pv.alert_verification);
  }

  LogMessage("Initializing alert verification v" VERIFICATION_VERSION
    " [%s mode, %d verification threads]\n", mode, numVerificationThreads);

  /* Check for verification script directory */
  if (!pv.verify_script_dir && (pv.verify_script_dir = (char *)
      VarGetNonFatal(VSCRIPT_DIR)) == NULL)
    FatalError("Must specify a verification script directory with '-x <dir>' or by
      setting " VSCRIPT_DIR "\n");

  /* Initialize statistics */
  if (pthread_mutex_init(&vstats.lock, NULL))
    FatalError("Unable to initialize verification statistics lock\n");

  /* Initialize verification cache buckets */
  for (i = 0; i < VCACHE_SIZE; i++) {
    vcache[i].head = NULL;
    pthread_mutex_init(&vcache[i].lock, NULL);
  }

  /* Initialize unverified alert queue */
  if ((unverifiedAlerts = CreateAlertQueue()) == NULL)
    FatalError("Unable to initialize unverified alert queue\n");

  /* Initialize verified alert queue */
  if ((verifiedAlerts = CreateAlertQueue()) == NULL)
    FatalError("Unable to initialize verified alert queue\n");

  /* Initialize queued alerts condition */
  if (pthread_mutex_init(&queuedAlertsLock, NULL))
```

```
    FatalError("Unable to initialize queued alerts condition\n");

  if (pthread_cond_init(&queuedAlerts, NULL))
    FatalError("Unable to initialize queued alerts condition\n");

  /* Initialize verification threads */
  if ((verificationThreads = malloc(sizeof(*verificationThreads) * numVerificationThreads))
      == NULL)
    FatalError("Unable to allocate verification thread array\n");

  for (i = 0; i < numVerificationThreads; i++) {
    if (pthread_create(&verificationThreads[i], NULL, VerifyAlerts, NULL))
      FatalError("Unable to create verification thread %d\n", i);
  }
}
```

This function uses the CreateAlertQueue() function to create a set of AlertQueue structures to hold each of the events that need to be verified, and a list of verified alerts. The AlertQueue structure contains an AlertNode pointer to the start of a linked list of AlertNodes. The two structures used to create this alert queue are shown in the following example, and are both defined in the src/detect.h file.

```
typedef struct _AlertQueue

{
  AlertNode *head;
  pthread_mutex_t lock;
} AlertQueue;

typedef struct _AlertNode
{
  struct _AlertNode *next;
  Packet *pkt;
  char *msg;
  ListHead *head;
  Event event;
  OptTreeNode *otn;
} AlertNode;
```

The Snort-AV project uses an array of pthreads to perform multiple verifications at the same time. The number of threads used is passed to Snort via the "-H" option. This value is stored in the numVerificationThreads variable. The code in the following example is used by the InitializeAlertVerification() function to allocate space for each of the threads and initialize them.

```
if ((verificationThreads = malloc(sizeof(*verificationThreads) * numVerificationThreads))

    == NULL)
    FatalError("Unable to allocate verification thread array\n");

  for (i = 0; i < numVerificationThreads; i++) {
    if (pthread_create(&verificationThreads[i], NULL, VerifyAlerts, NULL))
      FatalError("Unable to create verification thread %d\n", i);
  }
```

The pthread_create() function is used to create a new thread and call the VerifyAlerts() function when the thread starts. This function uses the pthread_cond_wait() function to wait for the engine to generate an alert. This is used to wait for a signal sent by the pthread_cond_signal() function. The signal in this case is the "queuedAlerts" signal generated during event generation. This function operates as the "main loop" for the Snort-AV functionality.

Snort-AV Event Generation

Once Snort-AV has been set up and the appropriate data structs are populated for each of the rules, the next step is to perform the verification.

To catch Snort events and determine if they require verification, Snort-AV needs to be able to catch events after they have been generated. The GenerateSnortEvent() function is located in the src/event_wrapper.c file within the Snort source, and is used to add events to the event queue to be processed by the output plugins.

The code for this function begins by creating a new Event structure. It then populates this event using the SetEvent() function and passes it to the CallAlertFuncs() function for processing by the output plugins.

```
u_int32_t GenerateSnortEvent(Packet *p,
                             u_int32_t gen_id,
                             u_int32_t sig_id,
                             u_int32_t sig_rev,
                             u_int32_t classification,
                             u_int32_t priority,
                             char *msg)
{
    Event event;

    if(!msg)
    {
        return 0;
    }

    SetEvent(&event, gen_id, sig_id, sig_rev, classification, priority, 0);
    CallAlertFuncs(p, msg, NULL, &event);
```

Here, Snort-AV performs its interception of the event. The CallAlertFuncs() code stored in the src/detect.c file is renamed to the DoCallAlertFuncs() function. Snort-AV implements its own CallAlertFuncs() function to process the event. In this way, when an event is generated, it is passed directly to Snort-AV code to be processed.

The code for this function first checks to see if the active verification mode selected by the invoking user requires action. If the alert_verification attribute of the PV struct is set to VERIFICATION_MODE_NONE during initialization (the user selected to disable active verification.), the old (renamed) function is called to skip the process of verifying the event.

Otherwise, the doVerify attribute of the SigInfo struct is tested to determine if active verification is enabled for the signature that generated the alert. This value was set earlier in the ParseRuleOptions() function during the initialization of the Snort-AV functionality.

After determining that active verification is required for the alert specified, the QueueAlerts() function is used to add the event to the unverifiedAlerts queue to be processed by the initialized threads.

```
void
CallAlertFuncs(Packet *p, char *message, ListHead *head, Event *event)
{
  AlertNode *n;

  /* If no verification, safe to simply alert */
  if (pv.alert_verification == VERIFICATION_MODE_NONE) {
    DoCallAlertFuncs(p, message, head, event);
    return;
  }

  n = CreateAlertNode(p, message, head, event, otn_tmp);

  /* Check if verification turned off for this rule */
  if (otn_tmp->sigInfo.doVerify == 0) {
    n->event.verified = ALERT_UNVERIFIABLE;
    IncrementUnverifiable(&vstats);
    QueueAlerts(verifiedAlerts, n);
  } else {
    /* Queue up alert for verification */
    QueueAlerts(unverifiedAlerts, n);

    /* Signal verification thread */
    pthread_mutex_lock(&queuedAlertsLock);
    pthread_cond_signal(&queuedAlerts);
    pthread_mutex_unlock(&queuedAlertsLock);
  }

  /* Output any verified alerts */
  OutputVerifiedAlerts();
}
```

Once the event has been queued, the pthread_cond_signal() function is used to let the worker threads know an event has occurred. This takes us back to VerifyAlerts(), discussed at the end of the Initialization phase, which suddenly springs to life in the worker thread.

Back in the CallAlertFuncs() function, when an event was originally generated, the OutPutVerifiedAlerts() function is called. This function runs through the alerts in the verifiedAlerts queue and passes them to the DoCallAlertFuncs() function to be output by the enabled Snort output plugins.

```
static void
OutputVerifiedAlerts(void)
{
  AlertNode *n;
```

```
  while ((n = DequeueAlert(verifiedAlerts)) != NULL) {
    DoCallAlertFuncs(n->pkt, n->msg, n->head, &n->event);
    DestroyAlertNodes(n);
  }
}
```

Snort-AV Event Verification

Now that an event has been added to the unverifiedAlerts queue and the worker threads have been signaled to begin work, execution continues in the VerifyAlerts() function to perform the follow-up assessment of the target service with a scan. The code for this function is shown here:

```
static void *
VerifyAlerts(void *data)
{
  AlertNode *n;
  int vulnerable;

  while (1) {
    while ((n = DequeueAlert(unverifiedAlerts)) == NULL && verify) {
      pthread_mutex_lock(&queuedAlertsLock);
      pthread_cond_wait(&queuedAlerts, &queuedAlertsLock);
      pthread_mutex_unlock(&queuedAlertsLock);
    }

    if (!n && !verify)
      break;

    vulnerable = VerifyAlert(n);

    if (pv.alert_verification == VERIFICATION_MODE_MARK ||
      n->event.verified == ALERT_VERIFIED ||
      n->event.verified == ALERT_UNVERIFIABLE)
      QueueAlerts(verifiedAlerts, n);
    else
      DestroyAlertNodes(n);
  }

  return NULL;
}
```

To accomplish the task of verifying an alert, the VerifyAlerts() function pops an event (AlertNode) from the top of the unverifiedAlerts queue. This occurs using the DequeueAlert() function.

The event is then passed to the VerifyAlert() function to be tested. This function begins by using the GetDestination() function to extract the destination IP address and port from the event to determine where the scan should occur. It then runs through the rules SigInfo structs ReferenceNode list, which was created using the *reference* keyword in the rule, and continues

until a valid CVE ID is found. If the signature does not have an appropriate CVE ID, no correlation can be performed.

An entry is added to Snort-AV's VCache for the destination IP and port, with an unverified result. The CachePut() function is used for this. The VCache is used to store the status of each scan for a designated timeout period, which avoids running the same scan repeatedly, wasting time and CPU. If an entry for the provided IP address, port, and CVE ID exists in the VCache, the status of the previous scan is returned.

If the VCache does not contain an existing entry for the event, the ExecuteNASL() function is then called, passing in the CVE ID and destination host. This function is used to perform the actual scan.

The return value from the ExecuteNASL() function is evaluated, and the VCacheUpdate() function is called to update the status of the scan for future checks.

The ExecuteNASL() function uses the functionality of the libnasl library (shown in the section of this book titled "Nessus Tools") to perform a scan of the target.

This function fork()'s to create a new process before running the scan. The new process then exits as soon as the execute_nasl_script() function finishes.

The appropriate NASL plugin is selected by appending the CVE ID number to the selected script directory, using the snprintf() Libc function.

A check is then performed on the NASL plugin to make sure it exists and is accessible by the user ID in which Snort is running. Next, a call to the libnasl function execute_nasl_script() is used to run the script.

The return value of the ExecuteNASL() function is then used to determine if the alert was successful.

```
static int
ExecuteNASL(unsigned int addr, const char *id)

{
  pid_t pid;
  int status, len, ret, fd[2];
  char buf[PATH_MAX], *hostname;
  struct arglist *args, *hostinfo, *portinfo;
  ntp_caps caps;
  struct in_addr *in;

  if ((args = malloc(sizeof(*args))) == NULL)
    FatalError("ERROR: Unable to allocate NASL argument list\n");
  memset(args, 0, sizeof(*args));

  if ((hostinfo = malloc(sizeof(*hostinfo))) == NULL)
    FatalError("ERROR: Unable to allocate NASL host information list\n");
  memset(hostinfo, 0, sizeof(*hostinfo));

  if ((portinfo = malloc(sizeof(*portinfo))) == NULL)
    FatalError("ERROR: Unable to allocate NASL port information list\n");
  memset(portinfo, 0, sizeof(*portinfo));

  if ((in = malloc(sizeof(*in))) == NULL)
    FatalError("ERROR: Unable to allocate address struct\n");
  memset(in, 0, sizeof(*in));
```

```
  if (socketpair(AF_UNIX, SOCK_STREAM, 0, fd) < 0)
    FatalError("ERROR: Unable to allocate NASL socket pair\n");

  memset(&caps, 0, sizeof(caps));
  caps.ntp_version = 12;
  caps.ciphered = 0;
  caps.ntp_11 = 1;
  caps.scan_ids = 1;
  caps.pubkey_auth = 0;

  in->s_addr = addr;
  if ((hostname = inet_ntoa(*in)) == NULL)
    FatalError("ERROR: Unable to get hostname\n");

  len = strlen(hostname);

  arg_add_value(hostinfo, "FQDN", ARG_STRING, len, (void *) hostname);
  arg_add_value(hostinfo, "NAME", ARG_STRING, len, (void *) hostname);
  arg_add_value(hostinfo, "IP", ARG_PTR, sizeof(*in), (void *) in);
  arg_add_value(hostinfo, "PORTS", ARG_ARGLIST, -1, portinfo);

  arg_add_value(args, "HOSTNAME", ARG_ARGLIST, -1, hostinfo);
  arg_add_value(args, "SOCKET", ARG_INT, sizeof(fd[1]), (void *) fd[1]);
  arg_add_value(args, "NTP_CAPS", ARG_STRUCT, sizeof(caps), (void *) &caps);

  switch ((pid = fork())) {
    case 0:
      snprintf(buf, sizeof(buf), "%s/%s", pv.verify_script_dir, id);

#ifdef DEBUG_NASL
      fprintf(stderr, "DEBUG: executing %s\n", buf);
#endif

      if (access(buf, R_OK | F_OK)) {
#ifdef DEBUG_NASL
        fprintf(stderr, "ERROR: Unable to access %s, aborting...\n", buf);
#endif
        exit(1);
      }

#ifndef DEBUG_NASL
      fclose(stderr);
#endif

      execute_nasl_script(args, buf, 0);
      exit(0);

    case -1:
      fprintf(stderr, "ERROR: Unable to fork NASL process\n");
      exit(1);
  }

  close(fd[1]);
```

```
  ret = TARGET_INVULNERABLE;
  while ((len = recv(fd[0], buf, sizeof(buf), 0)) > 0) {
    buf[len] = 0;
    send(fd[0], "A", 2, 0);

    if (strstr(buf, "<|> HOLE <|>")) {
#ifdef DEBUG_NASL
      fprintf(stderr, "DEBUG: HOLE [%s]\n", buf);
#endif
      ret = TARGET_VULNERABLE;
    }
  }

  waitpid(pid, &status, 0);
  if (WIFEXITED(status) && WEXITSTATUS(status)) {
#ifdef DEBUG_NASL
    fprintf(stderr, "DEBUG: error executing NASL script\n", buf);
#endif
    ret = TARGET_UNDETERMINED;
  }

  free(args);
  free(hostinfo);
  free(portinfo);
  free(in);

  close(fd[0]);

  return ret;
}
```

Setting Up

The Snort-AV diff patch also makes changes to the configure script and various Makefiles among the source tree. This is done to make sure the user has the appropriate libraries required to build Snort-AV, and to ensure the libnasl library is linked with the final binary.

The Snort-AV authors have also included a bash shell script, create_nasl_links.sh, to assist in setting up Snort-AV. This script loops through each of the NASL plugins in a directory searching for the CVE ID. It then creates a series of symbolic links to each of the NASL plugins in another directory, all of which use their appropriate CVE ID as a name. This way, the Snort-AV source can look up the appropriate CVE ID simply by opening the file with the correct name.

Snort-Wireless

The Snort-Wireless project is a Snort modification targeted at providing Layer 2 wireless IDS functionality to Snort. It was written as an open source alternative to commercial products such as AirDefense (www.airdefense.net).

Snort-Wireless is available for download from www.snort-wireless.com as a diff patch or tar ball. A patched version of the Snort 2.3.3 (the latest Snort at the time of publication) is available.

Implementation

To achieve its functionality, the Snort-Wireless modification adds a selection of preprocessors and detection plugins. It also makes several changes to the Snort source to integrate the functionality cleanly, and to add decoders, as there is no clean modular way to add decoders at the time of writing (all decoders are contained in a single file: src/decodec).

Snort-Wireless implements a new style of rule in which source and destination MAC addresses can be specified, along with a new series of detection options specifically related to 802.11x wireless protocols.

The following example shows the syntax of the Snort-Wireless specific rule type:

```
<action> wifi <src mac> -> <dst mac> (<rule options>)
```

The official Snort-Wireless user's guide is available online at http://snort-wireless.org/docs/usersguide/ and shows examples of the new rule options.

To accommodate the new "Wi-Fi" protocol in the rule type, the wireless protocol code is inserted into the WhichProto() function. This code returns the appropriate #define to represent the Wi-Fi protocol type:

```
#ifdef WIRELESS
    if(!strcasecmp(proto_str, "wifi")){
#ifdef DEBUG
       fprintf(stderr, "WhichProto() returning: DLT_IEEE802_11\n");
#endif
       return DLT_IEEE802_11;
#warning "need to make a REAL protocol #define for wifi"
    }
#endif /* WIRELESS */
```

To perform detection on the captured packets, Snort must first populate the Packet struct via the decoders. Before the protocol is decoded, there needs to be space in the Packet struct for the data to be stored. This is added to the Packet struct in the decode.h file. The following code shows the fields added to the Packet structure:

```
WifiHdr *wifih;          /* wireless LAN header */
#ifdef WIRELESS
    PrismHdr *prismh;        /* PRISM header */
    WSTIdx wstidx;
#endif /* WIRELESS */

typedef struct _PrismHdr {

  u_int32_t msg_code;
  u_int32_t msg_len;
  char dev_name[16];
  prism_val host_time;
```

```
  prism_val mac_time;
  prism_val channel;
  prism_val rssi;
  prism_val sq;
  prism_val signal;
  prism_val noise;
  prism_val rate;
  prism_val is_tx;
  prism_val frame_len;

} PrismHdr;

/*
 *  Wireless Header (IEEE 802.11)
 */
typedef struct _WifiHdr
{
#ifdef WIRELESS
  union{
#endif /* WIRELESS */
  u_int16_t frame_control;
#ifdef WIRELESS
          struct {
                  u_int16_t version:2;
                  u_int16_t type:2;
                  u_int16_t stype:4;
                  u_int16_t to_ds:1;
                  u_int16_t from_ds:1;
                  u_int16_t more_frags:1;
                  u_int16_t retry:1;
                  u_int16_t pwr_mgmt:1;
                  u_int16_t more_data:1;
                  u_int16_t wep:1;
                  u_int16_t order:1;
          };
  };
#endif /* WIRELESS */
  u_int16_t duration_id;
  u_int8_t  addr1[6];
  u_int8_t  addr2[6];
  u_int8_t  addr3[6];
#ifdef WIRELESS
  union {
  u_int16_t seq_control;
          struct {
                  u_int16_t fragnum:4;
                  u_int16_t seqnum:12;
          };
  };
#endif /* WIRELESS */
  u_int8_t  addr4[6];
} WifiHdr;
```

To break down a prism header into its appropriate fields in the Packet struct, the DecodePrismHdr() decoder is added. Its definition is shown here:

```
#ifdef WIRELESS
void DecodePrismHdr(Packet *, struct pcap_pkthdr *, u_int8_t *);
#endif /* WIRELESS */
```

Preprocessors

Snort-Wireless implements most of its features using the modular plugin interface that Snort provides. Several preprocessors are included in the bundle to analyze wireless traffic in various ways.

Each of these preprocessors is included in its own file. A listing of the new files in the src/preprocessors directory is shown here:

```
spp_antistumbler.c
spp_antistumbler.h
spp_auth_flood.c
spp_auth_flood.h
spp_deauth_flood.c
spp_deauth_flood.h
spp_macspoof.c
spp_macspoof.h
spp_rogue_ap.c
spp_rogue_ap.h
```

Anti-Stumbler

The anti stumbler preprocessor is designed to detect wireless devices that are scanning for active access points (stumbling). To do so, it checks for probe request frames on the network that have NULL SSID fields.

Auth Flood

The auth flood preprocessor is used to detect a flood of auth frames, which could cause a denial-of-service attack against the access point or be used to generate key frames to crack WEP encryption. Values are passed to the preprocessor during its initialization to configure the threshold values on which to trigger.

De-Auth Flood

Much like the spp_auth_flood preprocessor, the de-auth flood preprocessor is used to detect a flood of de-auth frames. This preprocessor also accepts parameters dictating the threshold values to use when detecting this attack.

Mac-Spoof

The mac-spoof preprocessor is written in an attempt to detect MAC addresses that are being spoofed on the network to bypass MAC address filtering. It does so by checking the difference in sequence numbers in a connection.

Rogue-AP

The Rogue-AP preprocessor is used to detect unauthorized access points in the airspace around your network. A list of the SSID values and corresponding MAC addresses must be specified in the configuration for each of the authorized access points in your network. This way, any unspecified access points can be considered dangerous and alerted on.

Detection Plugins

To implement rules specific to the Wi-Fi protocol type, Snort-Wireless implements a variety of detection plugins, each contained in its own file. Each option provides a method of testing a different aspect of the packet.

The file wifi_datatypes.h is used to store data structure definitions for various aspects of a Wi-Fi frame.

```
sp_wifi_addr4.c
sp_wifi_addr4.h
sp_wifi_bssid.c
sp_wifi_bssid.h
sp_wifi_duration_id.c
sp_wifi_duration_id.h
sp_wifi_fragnum.c
sp_wifi_fragnum.h
sp_wifi_frame_control.c
sp_wifi_frame_control.h
sp_wifi_from_ds.c
sp_wifi_from_ds.h
sp_wifi_more_data.c
sp_wifi_more_data.h
sp_wifi_more_frags.c
sp_wifi_more_frags.h
sp_wifi_order.c
sp_wifi_order.h
sp_wifi_pwr_mgmt.c
sp_wifi_pwr_mgmt.h
sp_wifi_retry.c
sp_wifi_retry.h
sp_wifi_seqnum.c
sp_wifi_seqnum.h
sp_wifi_ssid.c
sp_wifi_ssid.h
sp_wifi_stype.c
sp_wifi_stype.h
sp_wifi_to_ds.c
sp_wifi_to_ds.h
sp_wifi_type.c
sp_wifi_type.h
sp_wifi_wep.c
sp_wifi_wep.h
wifi_datatypes.h
```

As you can see, each of the Wi-Fi detection options is stored in a file with the "sp_wifi" prefix.

We will now look at each of the new detection plugins added by Snort-Wireless. The format of a detection plugin is discussed in Chapter 9, "Plugins and Preprocessors." All these new detection plugins adhere to the format discussed.

Wifi Addr4

The Wifi Addr4 detection plugin is used to test an 802.11 frame's fourth address field, and associates the *addr4* keyword with this task. The "!" and {} characters can be used in conjunction with the MAC address, which is required for a match.

BSSID

This detection plugin is used to test the BSSID field in the 802.11 frame; again, the "!" and {} characters can be used. The *bssid* keyword is associated with this option.

Duration ID

This detection option is used to test the Duration ID field. It associates the *duration_id* keyword. The "!" and {} options can be used, along with a number on which to match.

Fragnum

This plugin associates the *fragnum* keyword with a check for the fragnum control field of the 802.11 frame. The plugin takes the "!" and {} options, and a number between 0 and 15 representing the Fragnum to test.

Frame Control

The frame control plugin is used to test the frame_control field of the 802.11 frame. The parameters for this option are "!", {}, and a number between 0 and 65535. This plugin uses the *frame_control* keyword.

From DS

The from_ds plugin tests the from_ds field of the 802.11 frame, and is used to associate the *from_ds* keyword with a check of this field. This plugin, like most of the Snort-Wireless detection plugins, accepts the operators "!" and {}. This plugin also accepts the values "ON," "OFF," "TRUE," and "FALSE" to determine what value to test for.

More Data

The more_data plugin is used to test the more_data field in the 802.11 frame, and uses the *more_data* keyword. This plugin takes the operators "!" and {}, and a value representing the state with which to test the more_data field. This field can also have the possible values "ON," "OFF," "TRUE," and "FALSE."