Global Information Assurance Certification Paper

Copyright SANS Institute
Author Retains Full Rights

This paper is taken from the GIAC directory of certified professionals. Reposting is not permitted without express written permission.

Interested in learning more?
Check out the list of upcoming events offering "Web App Penetration Testing and Ethical Hacking (Security 542)"
at http://www.giac.org/registration/gwapt
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.
First of all one must define a new scanner check by the registerScannerCheck() method:

```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($str) {
    return preg_replace('/^(.*)$/i', "filter_function('\\\1')", $str);
}

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

**Figure 1. - Vulnerable preg_replace() usage**

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 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**

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

**Figure 3. - PhpPregArray initialization**
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:

![Code snippet showing method implementation]

**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:

![Code snippet showing parameter collection]

**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:

![Code snippet showing array parameter construction]

**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:

![Code snippet showing parameter removal]

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

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

**Figure 8. - Build the new array parameters and values**

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

```java
newRequest0 = self.helpers.addParameter(newRequest0, newParam0)
newRequest0 = self.helpers.addParameter(newRequest0, newParam1)
```

**Figure 9. - Create new HTTP request**

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

```java
if ("_REQUEST" in resp):
  url = self.helpers.analyzeRequest(attack).getUrl()
  if (url not in self.done):
    self.done.append(url)
  return [CustomScanIssue(attack.getHttpService(), url, [attack], 'Code injection',
                      '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:
Burp Suite (up) with fancy scanning mechanisms

Figure 12. - Reported issue

The request tab contains the detailed trigger information:

GET /p3.php?a=123&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:

Author Name, email@address
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:

```
#!/usr/bin/perl
use DBI;
use CGI;
use DBD:mysql;

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

my $cgi = CGI->new();
my $driver = "mysql";
my $database = "mysql";
my $dsn = "DBI:driver:database=$database";
my $userid = "gwaqt";
my $password = "goldpaper";
my $dbh = DBI->connect($dsn, $userid, $password) or die $DBI::errstr;

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

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

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.

```python
def getInsertionPoints(self, baseRequestResponse):
    path = self.helpers.analyzeRequest(baseRequestResponse).getUrl().getPath()
    parameters = self.helpers.analyseRequest(baseRequestResponse).getParameters()
```

**Figure 16. - Getting the URL and HTTP parameters**

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

```python
if '.' in path:
    ext = path.split('.')[1][-1]
else:
    ext = ''
if ext in ['pl', 'cgi']:
    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:

```python
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:

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

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

The getInsertionPointName method returns the scanned HTTP parameter name:

Author Name, email@address
The getBaseValue method returns the base value of the actual insertion point:

```python
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:

```python
def buildRequest(self, payload):
    return self_helpers.buildParameter(self, self_helpers.bytesToString(payload), self_helpers.buildParameter(self._dataParameter.getFullName(), self._dataParameter.getValue()))
```

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:

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

Figure 20. – getInsertionPointName

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:

```java
if (test in ['cgi', 'pl']) {
  return [InsertionPointDrupal(self, helpers, baseRequest, getInsertionPoints(), parameter) for parameter in parameters]
} else {
  return [InsertionPointDrupal(self, helpers, baseRequest, getInsertionPoints(), 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:

```java
if (definitionLocation == "array") {
  self.insertionPointPrefix = "x" + dataParameter.getPrefix() + self.helpers.urlEncode("[&select 1 from where '1=1']
  self.insertionPointSuffix = "x" + dataParameter.getParamName() + "[&select 1 from where '1=1']
}
```

**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 71\(^{st}\) 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:

```java
[...
```

**Figure 26.** - Reported issue
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:

```
146 class UTF8XSS([ScannerCheck]):
147     def _init_(self, callbacks):
148         self_helpers = callbacks.getHelpers()
149         self_payloads = [
150             # JavaScript alert()
151             # UTF8 encoded strings
152             # ...]
```

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.
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:

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

Figure 30. - Constructing the testing payload

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

```python
attack = callbacks.makeHttpRequest(basePair, newRequest)
resp = selfhelpers.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:

```python
if ">alert(1)<" in resp:
    url = self.helpers.analyzeRequest(attack).getURL()
    if (url not in self_done):
        self_done.append(url)
        return (CustomScanIssue(attack, httpService(), 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.
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 (Denoren, 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).
References


https://portswigger.net/burp/

https://support.portswigger.net/customer/en/portal/topics/719256-feature-requests/questions

# Upcoming Training

<table>
<thead>
<tr>
<th>Training Event</th>
<th>Location</th>
<th>Dates</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SANS Northern VA - Reston Spring 2020</td>
<td>Reston, VA</td>
<td>Mar 02, 2020 - Mar 07, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>Mentor Session @work- SEC542</td>
<td>Oklahoma City, OK</td>
<td>Mar 03, 2020 - Apr 02, 2020</td>
<td>Mentor</td>
</tr>
<tr>
<td>SANS San Francisco Spring 2020</td>
<td>San Francisco, CA</td>
<td>Mar 16, 2020 - Mar 27, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>Community SANS Cincinnati SEC542</td>
<td>Cincinnati, OH</td>
<td>Mar 30, 2020 - Apr 04, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>SANS 2020</td>
<td>Orlando, FL</td>
<td>Apr 03, 2020 - Apr 10, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS Riyadh April 2020</td>
<td>Riyadh, Kingdom Of Saudi Arabia</td>
<td>Apr 04, 2020 - Apr 16, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS London April 2020</td>
<td>London, United Kingdom</td>
<td>Apr 20, 2020 - Apr 25, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>Community SANS New York SEC542</td>
<td>New York, NY</td>
<td>Apr 20, 2020 - Apr 25, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>Pen Test Austin 2020 - SEC542: Web App Penetration Testing and Ethical Hacking</td>
<td>Austin, TX</td>
<td>Apr 27, 2020 - May 02, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>SANS Pen Test Austin 2020</td>
<td>Austin, TX</td>
<td>Apr 27, 2020 - May 02, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS Baltimore Spring 2020</td>
<td>Baltimore, MD</td>
<td>Apr 27, 2020 - May 02, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS Security West 2020</td>
<td>San Diego, CA</td>
<td>May 06, 2020 - May 13, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS Amsterdam May 2020</td>
<td>Amsterdam, Netherlands</td>
<td>May 11, 2020 - May 18, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>Rocky Mountain HackFest Summit &amp; Training 2020</td>
<td>Denver, CO</td>
<td>Jun 01, 2020 - Jun 08, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS Las Vegas Summer 2020</td>
<td>Las Vegas, NV</td>
<td>Jun 08, 2020 - Jun 13, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>Community SANS Seattle SEC542</td>
<td>Seattle, WA</td>
<td>Jun 15, 2020 - Jun 20, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>Community SANS Phoenix SEC542</td>
<td>Phoenix, AZ</td>
<td>Jun 22, 2020 - Jun 27, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>SANS Cyber Defence Canberra 2020</td>
<td>Canberra, Australia</td>
<td>Jun 29, 2020 - Jul 11, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>Cyber Defence Japan 2020</td>
<td>Tokyo, Japan</td>
<td>Jun 29, 2020 - Jul 11, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS Louisville 2020</td>
<td>Louisville, KY</td>
<td>Jul 06, 2020 - Jul 11, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS London July 2020</td>
<td>London, United Kingdom</td>
<td>Jul 13, 2020 - Jul 18, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS Pen Test Hackfest Europe Summit &amp; Training 2020</td>
<td>Berlin, Germany</td>
<td>Jul 19, 2020 - Jul 25, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS Rocky Mountain Summer 2020</td>
<td>Denver, CO</td>
<td>Jul 20, 2020 - Jul 25, 2020</td>
<td>Live Event</td>
</tr>
<tr>
<td>SANS Chicago 2020</td>
<td>Chicago, IL</td>
<td>Aug 17, 2020 - Aug 22, 2020</td>
<td>Live Event</td>
</tr>
</tbody>
</table>