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Web Application Firewall Profiling and Evasion

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Introduction

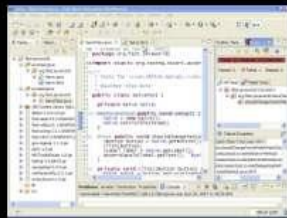
Michael Ritter

- Study media informatics
- University for Applied Sciences Mittelhessen
- Part-time working student at Deloitte
- About to start my BA thesis



Student

Computer Science Student



What My Friends Think I Do



What My Mom Thinks I Do



What Society Thinks I Do



What My Teacher Thinks I Do



What I Think I Do



What I Actually Do

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Basics

WEB APPLICATION FIREWALLS



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Web Application Firewalls (WAFs)

- WAFs are used to detect and block attacks against vulnerable web applications
- WAFs can offer protection against a large-scale of vulnerabilities
- Often used as second line of defense
- WAFs are a crucial topic to secure a companies web enviroment

Vendors

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modsecurity
Open Source Web Application Firewall

CITRIX®
NetScaler



 **IMPERVA**®
Protecting the Data That Drives Business®



AQTRONIX

 Barracuda



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Web Application Firewalls (WAFs)

- How do they work?
 - Using a set of rules to distinguish between normal requests and malicious requests
 - Sometimes they use a learning mode to add rules automatically through learning about user behaviour
- Operation Modes:
 - Negative Model (Blacklist based)
 - Positive Model (Whitelist based)
 - Mixed/Hybrid Model (Blacklist & whitelist model)
- Example (Blacklist based):
 - Do not allow in any page any user input like `<script>*</script>`

Implementation of a WAF

- 3 ways to implement a WAF
 - Reverse proxy
 - Inline
 - Connected to a Switch (SPAN->Port Mirroring)

Problems with the implementation

- Using the right rule set
 - Rule sets have an impact on the function of the Web Application behind the WAF
 - Problems
 - Blocking normal requests (false positives)
 - Rule set needs to be adjusted
- Rule set with exceptions 😊
 - Can result in (false negatives)
 - Attacker circumvents the WAF
 - Application exploitation





Identification Methods

HOW TO IDENTIFY A WAF



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WAF Identification methods

- Cookies

- Some WAF products add their own cookie in the HTTP communication.

```
User-Agent: Mozilla/5.0 (X11; Linux i686; rv:14.0) Gecko/20100101 Firefox/14.0.1
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
Proxy-Connection: keep-alive
Referer:
http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&sqi=2&ved=OCDIQFjAA&url=ht
%2F&ei=KfnxUK&ykqoqqDAWSqoCIAw&usg=AFQjCNE4PePCcYi508GYcXBKkLgvJmalEw&sig2=1429XFcnhg772XkAu
k
Cookie: ASPSESSIONIDAQQBTAAC=HHBGEFPDOQJGAFFJKHEIJDKI; ns_af=t7Kzloy9zMoGnxVbWJpyDnsnxQkA0;
ns_af._poupex.com.br_%2F_wat=QVNQUOVTVU01PTk1EQVFRQ1RBQwvLkKumQdSgMoDZdEb75a/VaoEgR1YA&
```

Citrix Netscaler

WAF Identification methods

- Header alternation (also Citrix Netscaler)
 - Some WAF products change the original response header to confuse the attacker

→ Citrix Netscaler

```
def isnetscaler(self):  
    """  
    First checks if a cookie associated with Netscaler is present,  
    if not it will try to find if a "Cneonction" or "nnCoection" is returned  
    for any of the attacks sent  
    """  
    # NSC_ and citrix_ns_id come from David S. Langlands <dsl 'at' surfstar.com>  
    if self.matchcookie('^ns_af=|citrix_ns_id|NSC_'):  
        return True  
    if self.matchheader(('Cneonction', 'close'), attack=True):  
        return True  
    if self.matchheader(('nnCoection', 'close'), attack=True):  
        return True  
    return False
```

wafw00f.py (Automated Detection Tool)

WAF Identification methods

- Inside the response
 - Some WAF identify themselves inside the response

dotDefender

```
HTTP/1.1 200 OK
Cache-Control: no-cache
Content-Type: text/html
Vary: Accept-Encoding
Server: Microsoft-IIS/7.5
X-Powered-By: ASP.NET
Date: Thu, 05 Dec 2013 03:40:14 GMT
Content-Length: 2616

<!DOCTYPE HTML PUBLIC "-//W3C//DTD XHTML 1.0 Frameset//EN"
"http://www.w3.org/TR/xhtml1/DTD/xhtml1-frameset.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
<title>dotDefender Blocked Your Request</title>
.....
```

04-Dec-13

dotDefender Blocked Your Request

Please contact the site administrator, and provide the following
Reference ID:

C5D7-93D0-04A0-5959



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WAF Identification methods

- Response Codes

- Some WAF products reply with specific response codes

WebKnight

Request

```
GET /?PageID=99<script>alert(1);</script>HTTP/1.1
Host: www.aqtronix.com
User-Agent: Mozilla/5.0 (Windows NT 6.1; WOW64; rv:25.0) Gecko/20100101
Firefox/25.0
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
```

Response

```
HTTP/1.1 999 No Hacking
Server: WWW Server/1.1
Date: Thu, 05 Dec 2013 03:14:23 GMT
Content-Type: text/html; charset=windows-1252
Content-Length: 1160
Pragma: no-cache
Cache-control: no-cache
Expires: Thu, 05 Dec 2013 03:14:23 GMT
```



The Sony Case



WAF Identification methods

- Further known methods
 - Drop Action - Sending a FIN/RST packet (technically could also be an IDS/IPS)
 - Pre Built-In Rules - Each WAF has different negative security signatures
 - Side-Channel Attacks (Timing behavior)

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Profiling WAFs

WAF DETECTION TOOLS



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WAF detection tools

- `imperva-detect.py` (Specialised on imperva)
- runs a baseline test + 5 additional tests
- Very quick results

```
Test 0 - Good User Agent...
Test 1 - Web Leech User Agent...
Test 2 - E-mail Collector Robot User Agent Blocking...
Test 3 - BlueCoat Proxy Manipulation Blocking...
Test 4 - Web Worm Blocking...
Test 5 - XSS Blocking...

--- Tests Finished on [https://www.example.com] -- 4 out of 5 tests indicate Imperva
application firewall present ---
```

WAF detection tools

- More vendor based detection tools:
 - Paradox WAF detection
 - F5 Cookie Decoder Burp extension
 - FatCat SQL Injector

http://wafbypass.me/w/index.php/Bypass_Tools

Nmap script (http-waf-detect)

- script can detect numerous IDS, IPS, and WAF products
- Works with:
ModSecurity, Barracuda WAF, PHPIDS, dotDefender,
Imperva Web Firewall, Blue Coat SG 400

Example Usage

```
nmap -p80 --script http-waf-detect <host>
```

Script Output

```
PORT      STATE SERVICE  
80/tcp    open  http  
|_http-waf-detect: IDS/IPS/WAF detected
```



Wafw00f.py

- Problem
 - Smart WAFs will hide their identity from cookie values as well as http responses e.g. they give 200 OK responses
- Solution
 - – Additional test need to be performed
 - like imperva-detect.py
 - Built-in feature of wafw00f.py



Bypass the security system

WAF BYPASSING METHODS

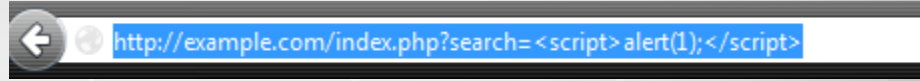
BYPASSING METHODS

- Five bypassing methods
 - Brute forcing
 - Running a set of payloads
 - Tools like sqlmap use this approach
 - often fails
 - Automated tools
 - Reg-ex Reversing
 - WAF's rely upon matching the attack payloads with the signatures in their databases
 - Payload matches the reg-ex the WAF triggers alarm

BYPASSING METHODS

History of payloads

Example:



`<script>alert(1);</script>`
(normal payload)

==

`</script><scRiPt>aLeRt(1);</script>`
(HTML mix with upper/lowercase)

==

`<scr<script>ipt>alert(1)</scr<script>ipt>`

==

`%3C%73%63%72%69%70%74%3E%61%6C%65%72%74%28%31%29%3B%3C%2F%73%63%72%69%70%74%3E`
(HEX-VALUE)

==

`<script>alert(1);</script>`

(HTML with semicolons)



BYPASSING METHODS

- Vendors know about this issue
 - Preprocessing
 - Transformation of different encodings before the test runs

BYPASSING METHODS

- Brower Bugs
 - Alternative method in case everything fails
 - Using old browser bug to bypass the ruleset
- Google Dorks approach
- Using different language chars
 - e.g. ē instead of e
 - This one is a evasion technique used to circumvent the keyword „select“

IBM Web Application Firewall Bypass - Exploit Database
www.exploit-db.com/exploits/17438/
Jun 23, 2011 - The IBM Web Application Firewall can be evaded, allowing an attacker to exploit web vulnerabilities that the product intends to protect.

Fortinet FortiWeb Web Application Firewall Policy Bypass
www.exploit-db.com/exploits/18840/
May 7, 2012 - BINAR10 has found a policy bypass occurrence when large size data is sent in. POST (data) or GET request. 3) Technical Details. 3.1.

Web Application Firewall Bypass using HTTP Parameter ...
www.exploit-db.com/exploits/12912/
Jun 11, 2009 - Web Application Firewall Bypass using HTTP Parameter Pollution. EDB-ID: 12912, CVE: N/A, OSVDB-ID: N/A. Author: Lavakumar Kuppan ...

Web Application Firewall Bypass using HTTP Parameter ...
www.exploit-db.com/papers/12912/
Web Application Firewall Bypass using HTTP Parameter Pollution. 340.pdf. © Offensive Security 2009-2015.

Profense 2.2.20/2.4.2 Web Application Firewall Security ...
www.exploit-db.com/exploits/33002/
May 20, 2009 - An attacker can exploit these issues to bypass certain security restrictions and perform various web-application attacks. Versions "prior to" the ...

Beyond SQLi: Obfuscate and Bypass - Exploit Database
www.exploit-db.com/papers/17934/
Oct 6, 2011 - This papers will disclose advanced bypassing and obfuscation techniques about the techniques to bypass Web Application Firewall (WAF).

PDF "Http Parameter Contamination"
www.exploit-db.com/download_pdf/17534/
Jun 25, 2011 - Introduction to Http Parameter Contamination (HPC), Web Server Enumeration, Web Application Firewall (WAF) Bypass Proof Of Concept.

PDF CloudFlare vs Incapsula: Round 2 - Exploit Database
www.exploit-db.com/docs/29315.pdf
This test was designed to bypass security controls in place, in any possible way, ... known filter evasion techniques to bypass their web application firewall ...

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Questions I want to answer

BACHELOR THESIS APPROACH



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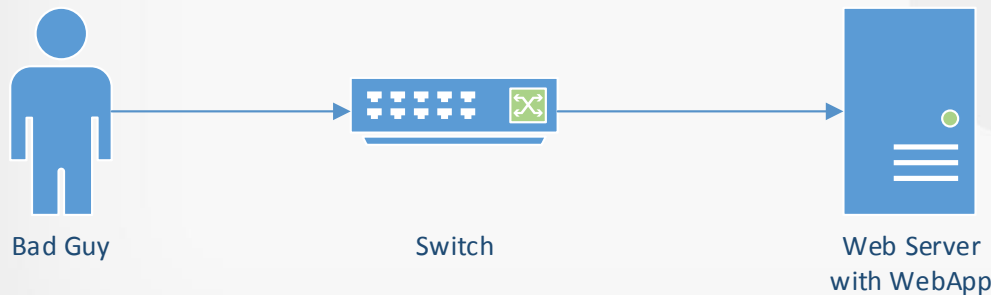
Why is this topic relevant?

- Identifying a WAF will
 - Improve productivity during a pentest
 - Known vulnerabilities in certain products
- How is it possible to evade the security of a WAF?
 - Are old methods still effective against modern WAFs?
 - Are there common weaknesses that can be used during a pentest?

Approach for my thesis – Stage 1

Building a testing lab with 2 environments

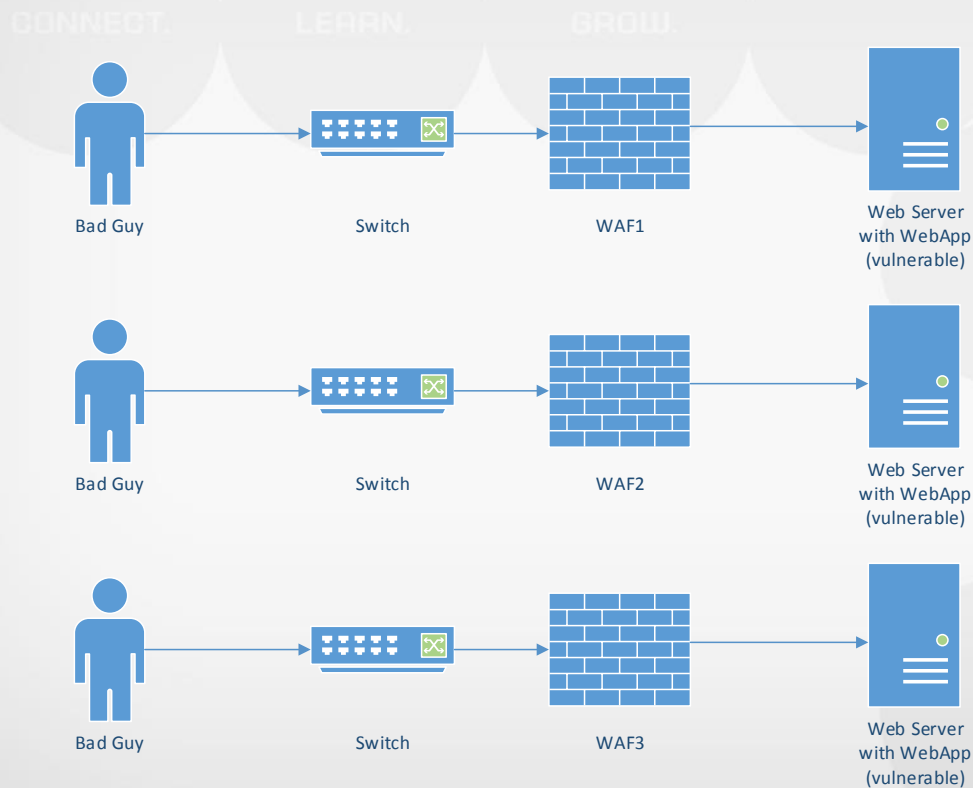
- WebApp without a WAF



Approach for my thesis – Stage 1

Building a testing lab with 2 environments

- WebApp with WAFs of several vendors



Approach for my thesis – Stage 2

- Profiling tests on WAF
 - Manual approach vs. Automated tools
 - Did vendors change patterns of their WAF?

Approach for my thesis – Stage 3

- Testing the vulnerabilities without a WAF
 - Documentation of existing vulnerabilities and payloads that I used



Approach for my thesis – Stage 4

- Creation of a payload sets based on the OWASP Top 10
 - SQLi
 - XSS
 - Directory Traversal
 - etc.

Approach for my thesis – Stage 5

- Testing the vulnerabilities with a WAF
 - Documentation of WAF responses
 - Payload passthrough statistics



Approach for my thesis – Stage 6

- Concept a methodology for pentesting web applications behind WAFs

Thesis output

- Thesis output
 - Pentest methodology for WebApps behind WAFs
 - Are automated tools always working?
 - How can you avoid that your WAF gets identified?
 - What can I do, to bypass a WAF
 - Up to date identification patterns for several WAFs
 - In case, I find new patterns I will support the wafw00f project

THANK YOU

... FOR YOUR ATTENTION

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Discussion/Exchange

- Further resources for evasion pattern?
- WAF vendors/products?
 - Do you have any suggestions?
 - Do you have experience with poor WAF solutions?
- Whitepapers that might be useful?
- More tools?
- Any ideas for further approaches?