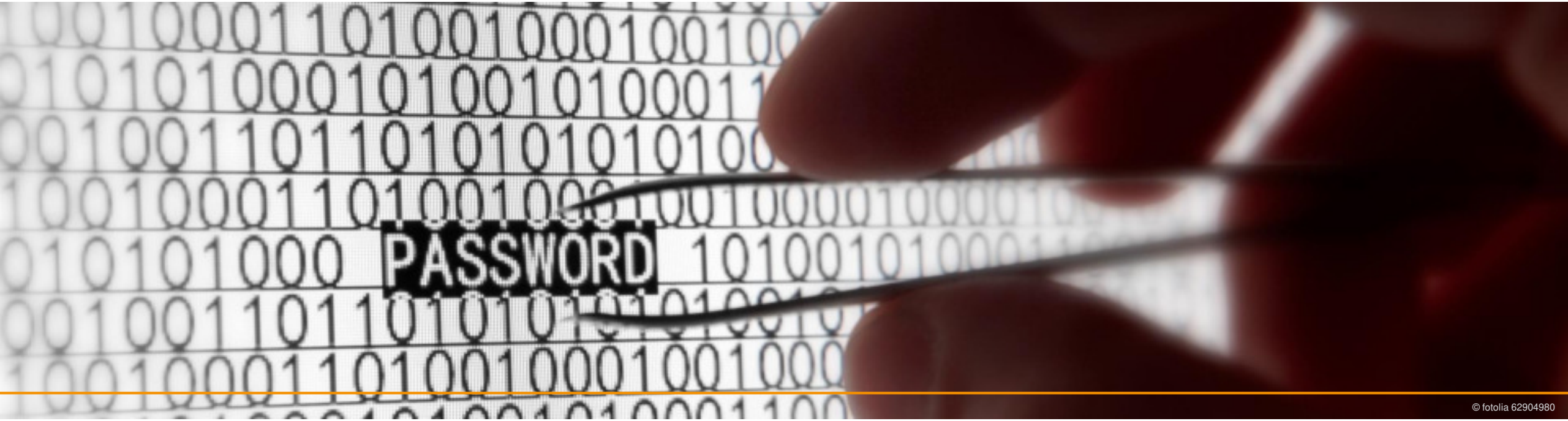


Web Application Firewall Bypassing

SEC Consult

Bypassing a WAF – Why?

- Number of deployed Web Application Firewalls (WAFs) is increasing
- WAFs make a penetration test more difficult
- Attempting to bypass a WAF is an important aspect of a penetration test

Main Goal

- Understand the limits of WAFs

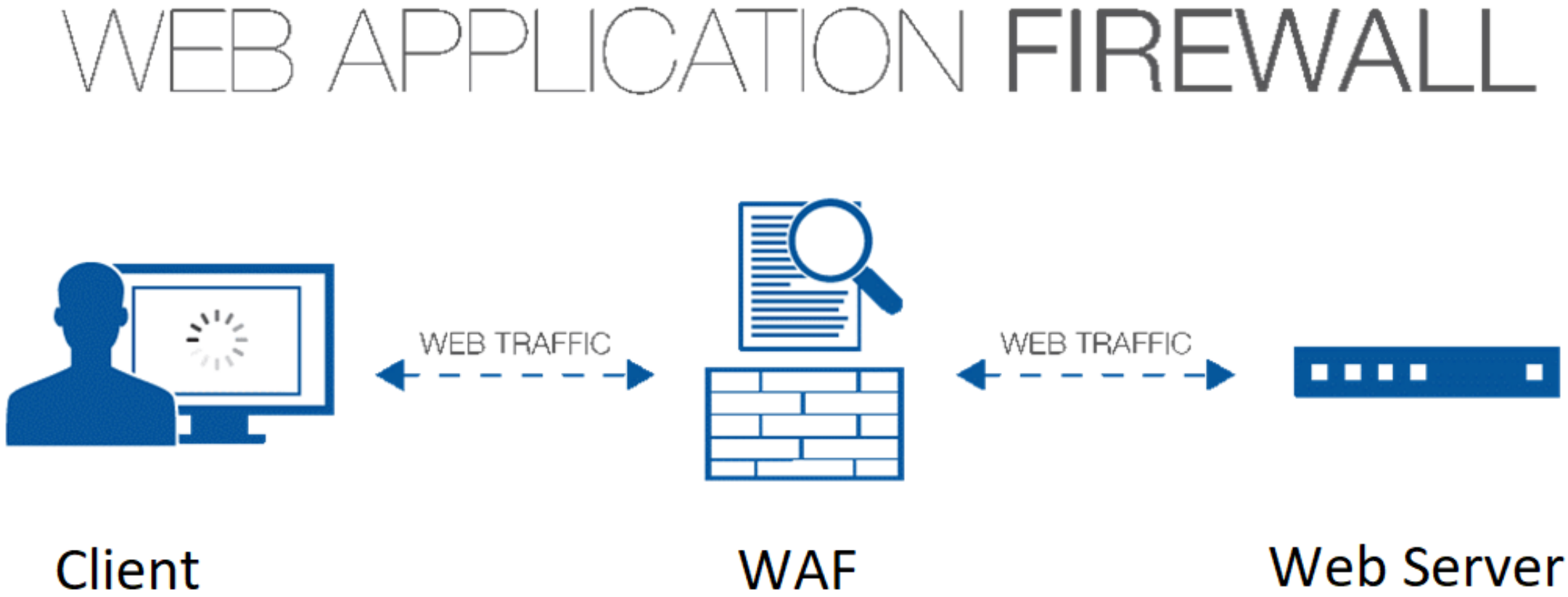
- Provide a practical approach to bypass WAFs for security experts in order to ensure accurate assessment results

Introduction to Web Application Firewalls

Overview

- Replaces old fashioned Firewalls and IDS/IPS
- Understands HTTP traffic better than traditional firewalls
- Protects a web application by adding a security layer
- Checks for malicious traffic and blocks it

Overview



https://www.e2enetworks.com/help/glossary/waf-web-application-firewall/

Functionality

- Pre-processor:

  Decide whether a request will be processed further

- Normalization:

  Standardize user input

- Validate Input:

  Check user input against rules

Normalization Functions

- Simplifies the writing of rules

- No Knowledge about different forms of input needed

Function Name	Description
compressWhitespace	converts whitespace chars to spaces
hexDecode	decodes a hex-encoded string
lowercase	converts characters to lowercase
urlDecode	decodes a URL-encoded string

Input Validation

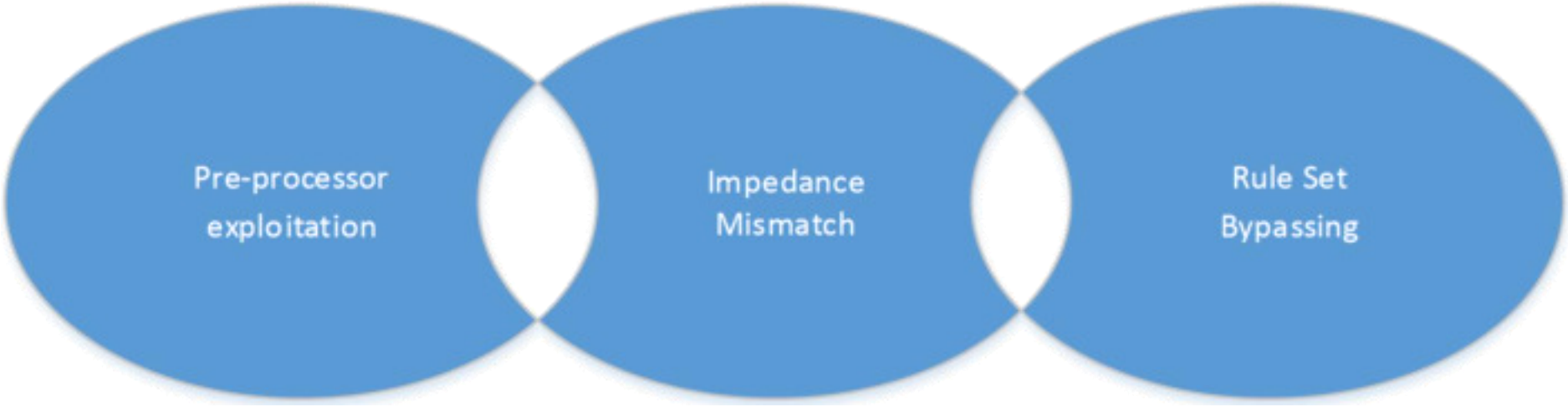
- Security Models define how to enforce rules
- Rules consist of regular expressions
- Three Security Models:
  - Positive Security Model
  - Negative Security Model
  - Hybrid Security Model

Security Models

Positive Security Model (Whitelist)	Negative Security Model (Blacklist)
Deny all but known good	Allow all but known bad
Prevents Zero-day Exploits	Shipped with WAF
More secure than blacklist	Fast adoption
Comprehensive understanding of application is needed	Little knowledge needed
Creating rules is a time-consuming process	Protect several applications
	Tends to false positives
	Resource-consuming

Bypassing Methods and Techniques

Overview



Pre-processor Exploitation:

Make WAF skip input validation

Impedance Mismatch:

WAF interprets input differently than back end

Rule Set Bypassing:

Use Payloads that are not detected by the WAF

Pre-processor Exploitation

Skipping Parameter Verification

- PHP removes whitespaces from parameter names or transforms them into underscores

```
http://www.website.com/products.php?%20productid=select 1,2,3
```

- ASP removes % character that is not followed by two hexadecimal digits

```
http://www.website.com/products.aspx?%productid=select 1,2,3
```

- A WAF which does not reject unknown parameters may be bypassed

Malformed HTTP Methods

- Misconfigured web servers may accept malformed HTTP methods

- A WAF that only inspects GET and POST requests may be bypassed

Overloading the WAF

- A WAF may be configured to skip input validation if performance load is heavy
- Often applies to embedded WAFs
- Great deal of malicious requests can be sent with the chance that the WAF will overload and let some requests through

Impedance Mismatch

HTTP Parameter Pollution

- Sending a number of parameters with the same name

- Technologies interpret this request

http://www.website.com/products/?**productid=1**&**productid=2**

differently:

Back end	Behavior	Processed
ASP.NET	Concatenate with comma	productid=1,2
JSP	First Occurrence	productid=1
PHP	Last Occurrence	productid=2

HTTP Parameter Pollution

- The following payload

```
productid=select 1,2,3 from table
```

- can be divided:

```
?productid=select 1&productid=2,3 from table
```

- WAF sees two individual parameters and analyzes both values independently

- ASP.NET back end concatenates both values

Double URL Encoding

- WAF normalizes URL encoded characters into ASCII text
- The WAF may be configured to decode characters only once
- Double URL Encoding a payload may result in a bypass

’s’ -> %73 -> %25%37%33

- The following payload contains a double URL encoded character

1 union %25%37%33elect 1,2,3

Rule Set Bypassing

Bypass Rule Set

- Two methods:
  - Brute force by enumerating different payloads
  - Reverse-engineer the WAFs rule set

Approach for Penetration Testers

Overview

- Similar to the phases of a penetration test

- Divided into six phases, whereas Phase 0 may not always be possible

Phase 0 – Disable WAF

Objective: **find security flaws in the application more easily**

- Allows a more focused approach when the WAF is enabled again
- More accurate results for the customer
- May not be realizable in some penetration tests

Phase 1 - Reconnaissance

Objective: **gather information to get an overview of the target**

- Basis for the subsequent phases

- Gather information about:
  - web server
  - programming language
  - WAF & Security Model
  - Internal IP Addresses

Objective: **make the WAF skip input validation**

- Identify which parts of a HTTP request are inspected by the WAF to develop an exploit:
  1. Send individual requests that differ in the location of a payload
  2. Observe which requests are blocked
  3. Attempt to develop an exploit

Phase 3 – Finding an Impedance Mismatch

Objective: **make the WAF interpret a request differently than the back end and therefore not blocking it**

- Knowledge about back end technologies is needed

Phase 5 – Finding Other Vulnerabilities

Objective: **find other vulnerabilities that can not be detected by the WAF**

- Broken authentication mechanism
- Privilege escalation vulnerabilities
- etc.

Phase 6 – After the Pentest

Objective: **report vulnerabilities to customer**

- Advise customer to fix the **root cause** of a vulnerability
- For the time being, the vulnerability should be **virtually patched** by adding specific rules to the WAF
- Explain that the WAF can help to mitigate a vulnerability, but is **not a water-proof solution**

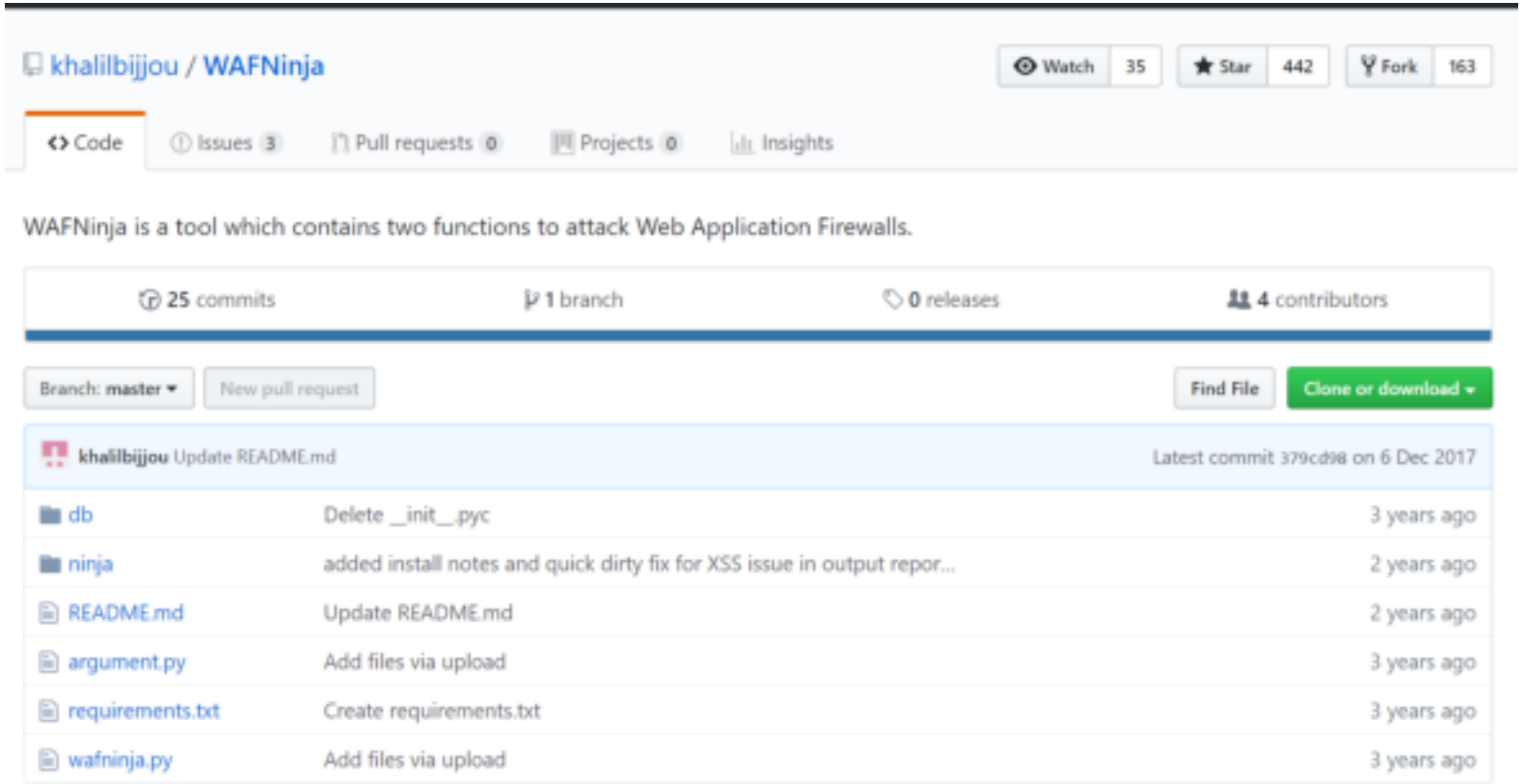
WAFNinja

Overview

- CLI Tool written in Python
- Automates parts of the approach
- Used by security experts world-wide ☺
- Supports
  - GET and POST parameter
  - Usage of cookies
  - Usage of an intercepting proxy

Overview

- Published on GitHub ☺



- https://github.com/khalilbijjou/WAFNinja

Fuzzing

- Sends different symbols and keywords
- Analyzes the response
- Results are displayed in a clear and concise way
- Fuzzing strings can be
  - shared within a team
  - extended with the insert-fuzz function

Demo

Never forget!

Always fix the **root cause** of your vulnerabilities