An Alternative Approach for Real-Life SQLi Detection

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Whoami

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- 10+ years experience in the area of web application security/WAF
- IT interests: Web and OS security, crypto, theoretical computer science, ...

AIRLOCK

Content

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- SQLi Not Yet Boring
- Real-Life SQLi Detection
- Classical Approach to Filter SQLi
- Libinjection
  - Recap
  - Weaknesses
  - Combined with Classical Approach
- New Approach Detect False Positives
- Prototype Demo

SQLi Not Yet Boring

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SQLi – Same Old Story

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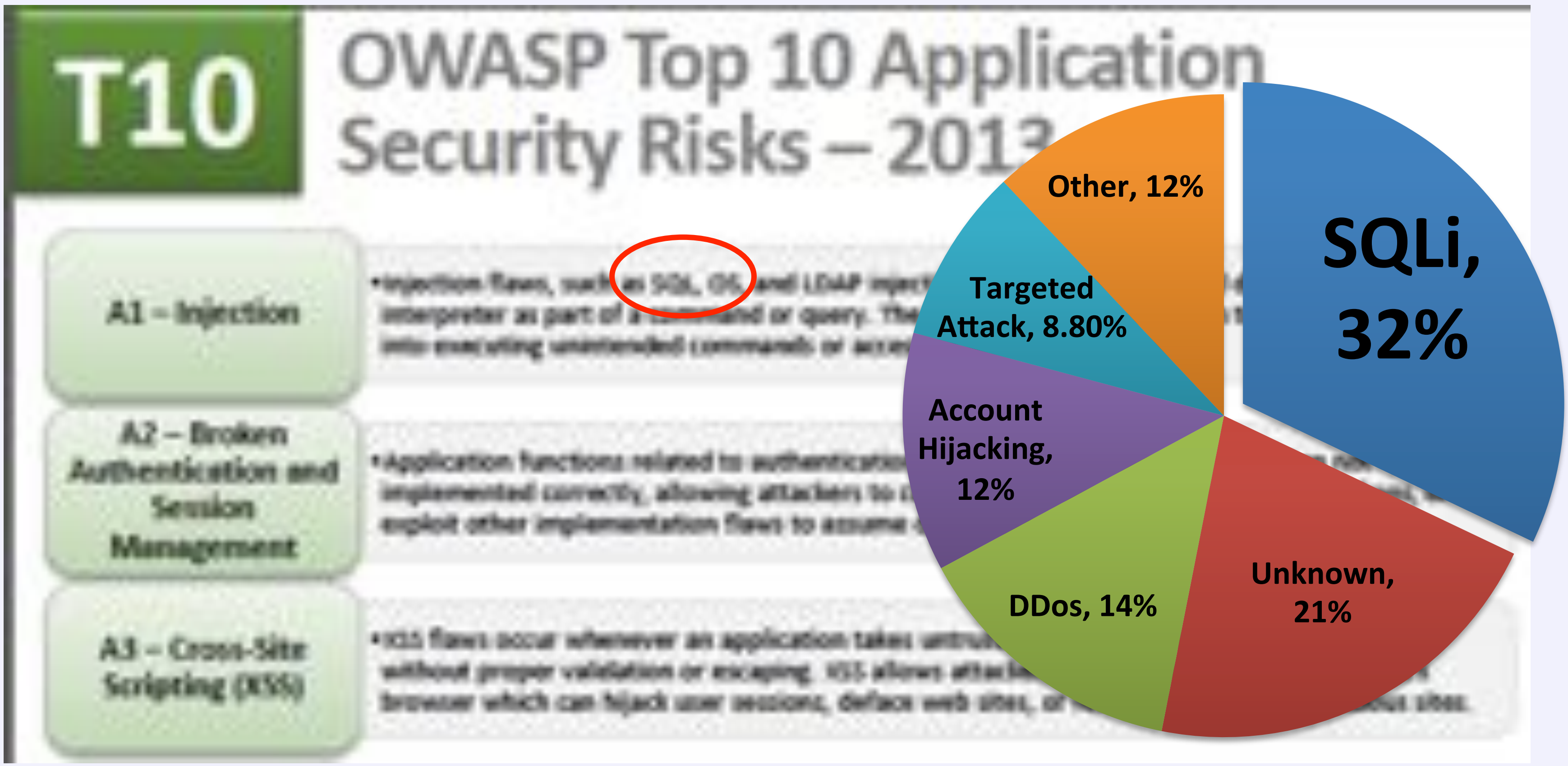
known since 15 years, remains a significant thread



Mai 2013
[hackmageddon.com]

Real-Life SQLi Detection

Is SQLi Blocking Hard?

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- Easy: block everything
- Even blocking any request containing SQL terms/ symbols/... is difficult because of several obfuscation techniques
  e.g. Roberto Salgado:
  https://media.blackhat.com/us-13/US-13-Salgado-SQLi-Optimization-and-Obfuscation-Techniques-Slides.pdf
- Good classical blacklist rules tend to be very complex

Unsolvable Decision Problem

- Can‘t decide correctly in all cases without additional information
- Strict rules => extensive exception handling
- Block this...?

```
SELECT * FROM users WHERE
name = '%USER%' and password = '%INJECT%';
```

%INJECT% (MySQL):

'='	‘ &’	‘ << ‘	‘ >> ‘
‘ | ‘	‘ ^ ‘	‘ like ‘*	‘ % ‘1
‘ * ‘1	' / ‘1		

Unsolvable Decision Problem

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...even worse without quotes:

```
SELECT * FROM users WHERE
name = '%USER%' and PIN = %INJECT%;
```

%INJECT%: x,y = <any number> z = <any string>

x or y	x||y	x<y	x=0
'z' or y	'z'=0	0<=>0	x<>x
x < y	x<=y	x != y	PIN

Classical Approach to Filter SQLi

Our Classical Approach

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- Moderate complex Regex

- Categorize attack types, consider DBMS
  - Eliminating conditions (Comment symbols, ...)
  - Extending query results (UNION SELECT, string concat, ...)
  - Start of new Commands (; UPDATE...)
  - Change expression evaluation (tautologies, ...)
  - ...

Extending query result with UNION SELECT

Injection:

```
SELECT id,name FROM users WHERE name = 'tom' and
password = hash('') UNION SELECT id, name from
users WHERE (username = 'Administrator');
```

Obvious trivial filter:

```
select
```

Reduce false positives by adding conditions:

```
[\s'")]union[\s]+(all[\s]+)?select(--|[#'"\s])
```

Libinjection Recap

Libinjection Recap

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C++/python library for SQLi detection through lexical analysis

https://github.com/client9/libinjection

BSD open source license

Author: Nick Galbreath

2012@Black Hat USA

Contexts

1. As-is

```
SELECT * FROM users WHERE id = %INJECT%
```

2. Inside a single quoted string

```
SELECT * FROM users WHERE name = '%INJECT%'
```

3. Inside a double quoted string

```
SELECT * from users WHERE name = "%INJECT%"
```

Tokens

k	keyword		(	open brace
&	logic operator		)	close brace
1	number		B	group/order by
o	regular operator		n	none/name
U	union		f	function
s	string (quoted)		;	semicolon
v	at (@)		c	comment

```
' UNION SELECT * FROM pass WHERE user = 'admin'
```

as-is context: s n s

```
'' UNION SELECT * FROM pass WHERE user = 'admin''
```

single-quote context: s U k o k n k n o s

```
"' UNION SELECT * FROM pass WHERE user = 'admin'"
```

double-quote context: s

Parser Features

- Folding numbers: 234.3e3 => 1
- Folding strings: “test a b c” => s
- Convert simple arithm. expressions: 7+5 => 1
- Remove comment: SELECT /* bla*/ id FROM test
- Merging: “IS”, “NOT” => “IS NOT” (single op)
- Function must be followed by a parenthesis
- ...

Fingerprints

- Fingerprints of length up to 5 to detect SQLi
  &1o1U, &1osU, &1ovU, &f()o, &f(1), &f(s) ….
- Compare only the first 5 tokens of the parsed strings seems to be enough
  - If yes, we're lucky => fast
- Fingerprints generated (learned) from a large list (> 47000) of SQLi (src: pentest tools, cheat sheets, forums,...)

Libinjection Weaknesses

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- Bypass 5 token restriction with padding
- "as-is" context (MySQL):
  `…WHERE id = 1^1^1^1^1# AND…`
  token representation: 1o1o1
- Quoted context (Oracle):
  `…WHERE name = 'a'||'d'||'m'||'i'||'n'--' AND…`
  token representation: s&s&s
- Mixed (MySQL):
  `…WHERE id = 1 ^ 'N' || 2# AND…`
  `…WHERE id = (select @a or ( @a ))# AND…`

- False Positives and Lexical Analysis

1; from will create the case 7

vs.

99; UPDATE user SET type = 22

Parser may see the same:

<number>; <keyword> <name> <keyword> <name> <operator> <number>

Libinjection

+

Classical Approach

libinjection + regex

- Tokenize the full input string

- Pattern matching
  - Evasion by padding no longer possible
  - Fingerprint learning vs. human brain power

- More expensive?

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- Major benefit: Much simpler patterns
  - Dozens of variants to separate terms (space, tab variants, CR, LF, null byte, ...)
  - Long disjunction chains
    select|insert|update|delete|... => keyword
- Example Pattern:

  Classical Regex:

```
;.*(execute|exec|insert|update|select|delete|drop|waitfor|create|alter|begin)(--|[#'(\h\v])
```

  Token Regex:

```
;.*k[cs(]
```

- Slightly better detection rate but way more FP

New Approach to Detect False Positives Based on Lexical Analysis

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- Which token combinations are not common in SQL?

... <NAME> <NAME> ...

... <NUMBER> <NAME> ...

... <OPERATOR> <OPERATOR> ...

...

Why not having two consecutive names in the token representation of SQLi?

Detect keywords:

UPDATE TEST SET A = 1 WHERE ID = 1

Consider strings:

SELECT "foo bla" FROM t

Remove comments:

SELECT id /* this is comment */ FROM t

Detect False Positives

Single quote context example:

Dancin'	like	a	robot	on	fire
↓	↓	↓	↓	↓	↓
string	operator	name	name	keyword	name
		↓	↓		

Two consecutive names => FP

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Exception example for: <name> <name>

Column and table alias without AS keyword

SELECT id i, name FROM mytable

SELECT id, name FROM mytable m

Pros New Approach

- No need to consider SQLi and FP in a single complex regex:

  1) **Simple regex** to detect SQLi

  Please click on facebook's 'like' button

  Blacklist rule: <quote><logical operator>

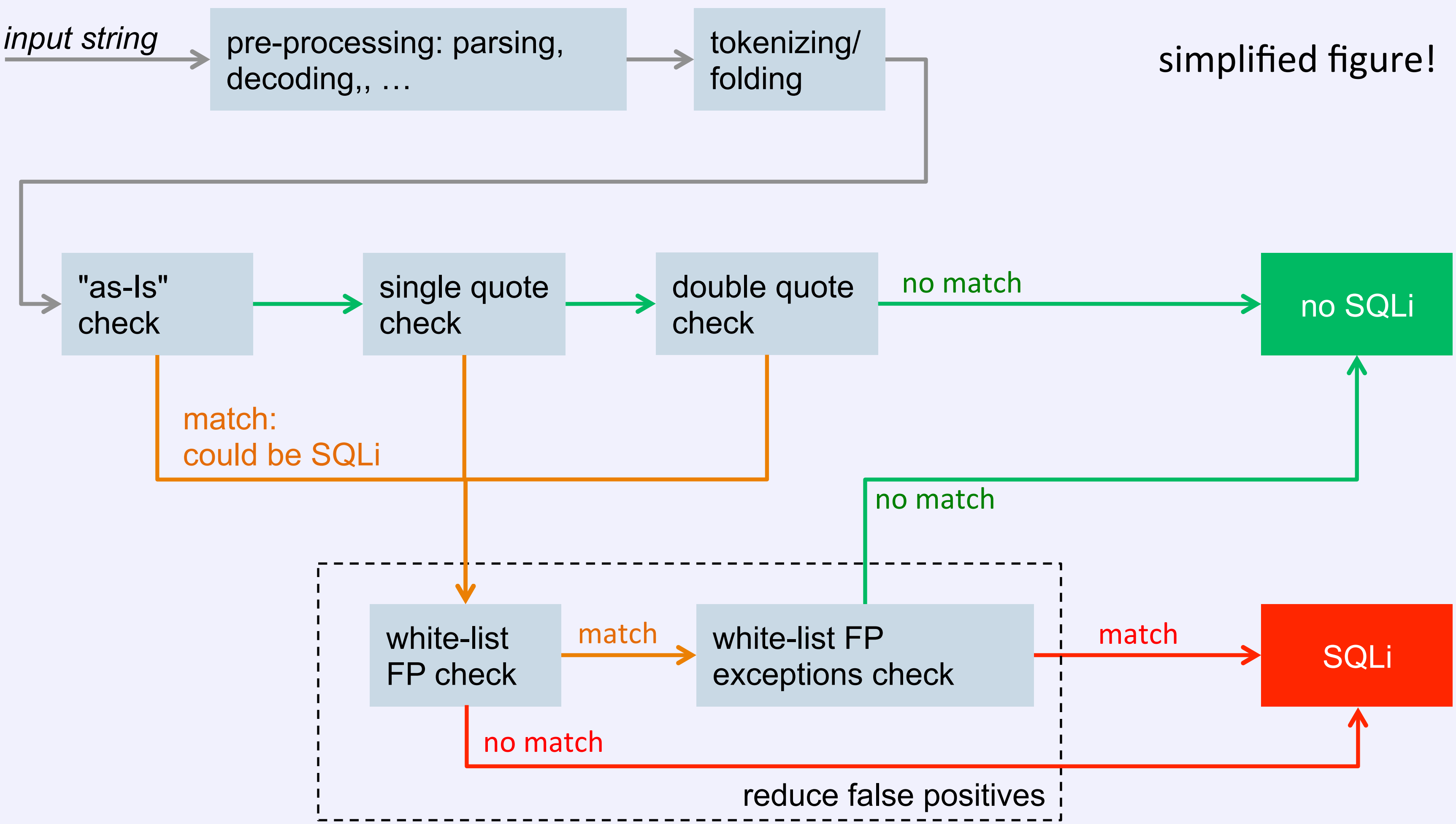
  2) **Simple regex** to whitelist false positive

  Please click on facebook's 'like' button

  Whitelist rule: <name> <name>

- Can whitelisting step be used to evade filter?

Overall Process



simplified figure!

Prototype Demo

Conclusions

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- Real-life SQLi detection without additional info is hard
- False positives are a pain
- Lexical analysis
  - Simplifies blacklist rules
  - False positives reduction by whitelisting
  - Worth for further research
- Can we use lexical analysis to prevent other code injection attacks?

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