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gFuzz: An instrumented Web application fuzzing environment

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Objectives

- Present a working tool (prototype-PoC) to test the security of a given web application. The tool tests for (SQL) injection attacks:
  - From the attacker's perspective
  - Intended to be included in QA process & security audits. Bringing precise information about potential security flaws. Not limited to security experts
  - Has high(er) accuracy than plain fuzzing and automated static analysis by themselves
  - Technique:
    - Fuzzing
    - Instrumentation

DISCLAIMER

This talk does not intend to present a fuzzer!
There are plenty of them out there and
you surely already have your favorite one.

Agenda

- (quick!) Web application security overview
- SQL-injection attacks inside-out
- Fuzzing and gFuzz
- Detecting *A*n**O** ɯAliEs with gFuzz
- Reporting
- Demo
- Future work

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Why Web Applications?

- Common entry point for back-end system and database access
- Widely used
- Easy to develop
  - Scripting languages
  - Inexperienced programmers are not security-aware
- Difficult to (fuzz + validate) errors with low false positive rate

Web application (in)security

Top Vulnerabilities (From OWASP Top 10 - 2007)

- XSS
- **Injection Vulns (particularly SQL)**
- Malicious File execution
- Insecure Direct Object Reference
- CSRF
- Information Leakage and Error handling
- Broken auth. , session management

Consequences (SQL-injection)

- Data theft
- Data unavailability
- Data alteration
- Money losses
- And much more

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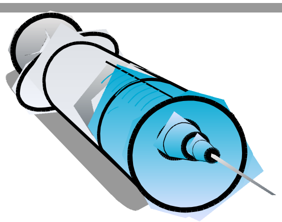
SQL injection facts

- It is an injection attack



  - It happens when (malicious) input sent by an attacker reaches the back-end DBMS engine
  - The attacker can execute queries which were “supposedly” not allowed.

- Are widely known inside the security community

  - Yet, developers still fail in avoiding them

The SQL injection problem: Basic idea

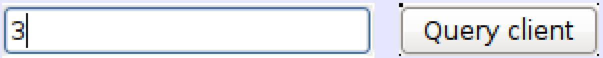
User-supplied data

```
<?php

$client_id = $_POST[“id”];

$client = mysql_query(“SELECT * FROM clients WHERE id = ” . $client_id);
```

Direct usage to query database

Supplying data

SERVER



$_POST[“id”] ← 3

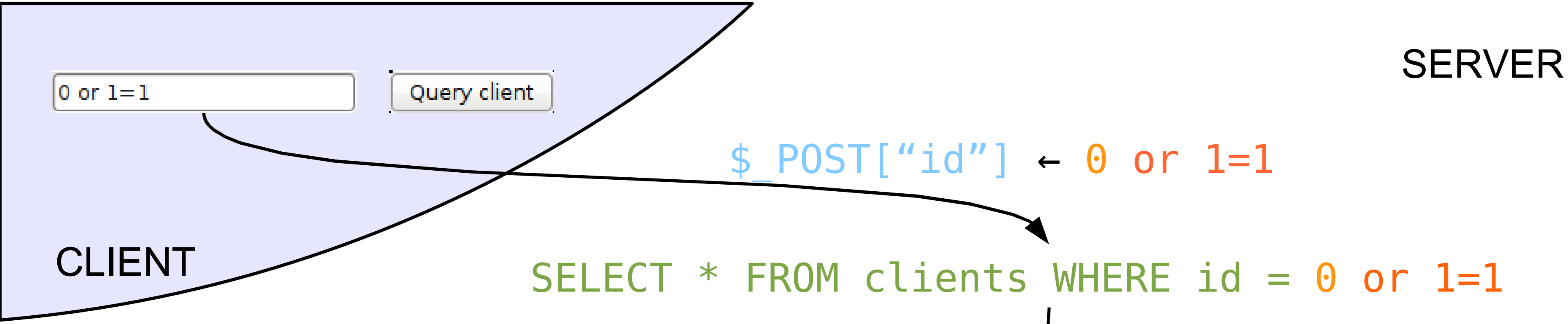
CLIENT

SELECT * FROM clients WHERE id = 3

client.id	*client.name*
3	John Doe

```
<?php

$client_id = $_POST[“id”];
$client = mysql_query(“SELECT * FROM clients WHERE id = ” . $client_id);
```

Supplying [offensive] data



```
$_POST["id"] ← 0 or 1=1
```

```
SELECT * FROM clients WHERE id = 0 or 1=1
```

client.id	client.name
1	George W
3	John Doe
4	Martin Green
5	Joshua B
76	Ellen Grant
8	Mark Twain

```
<?php

$client_id = $_POST["id"];
$client = mysql_query("SELECT * FROM clients WHERE id = " . $client_id);
```

Countermeasure technologies

- Web Application firewalls (& IDS - IPS)
- Static code analysis tools
- Dynamic code analysis tools
- Scanners
- Code audits

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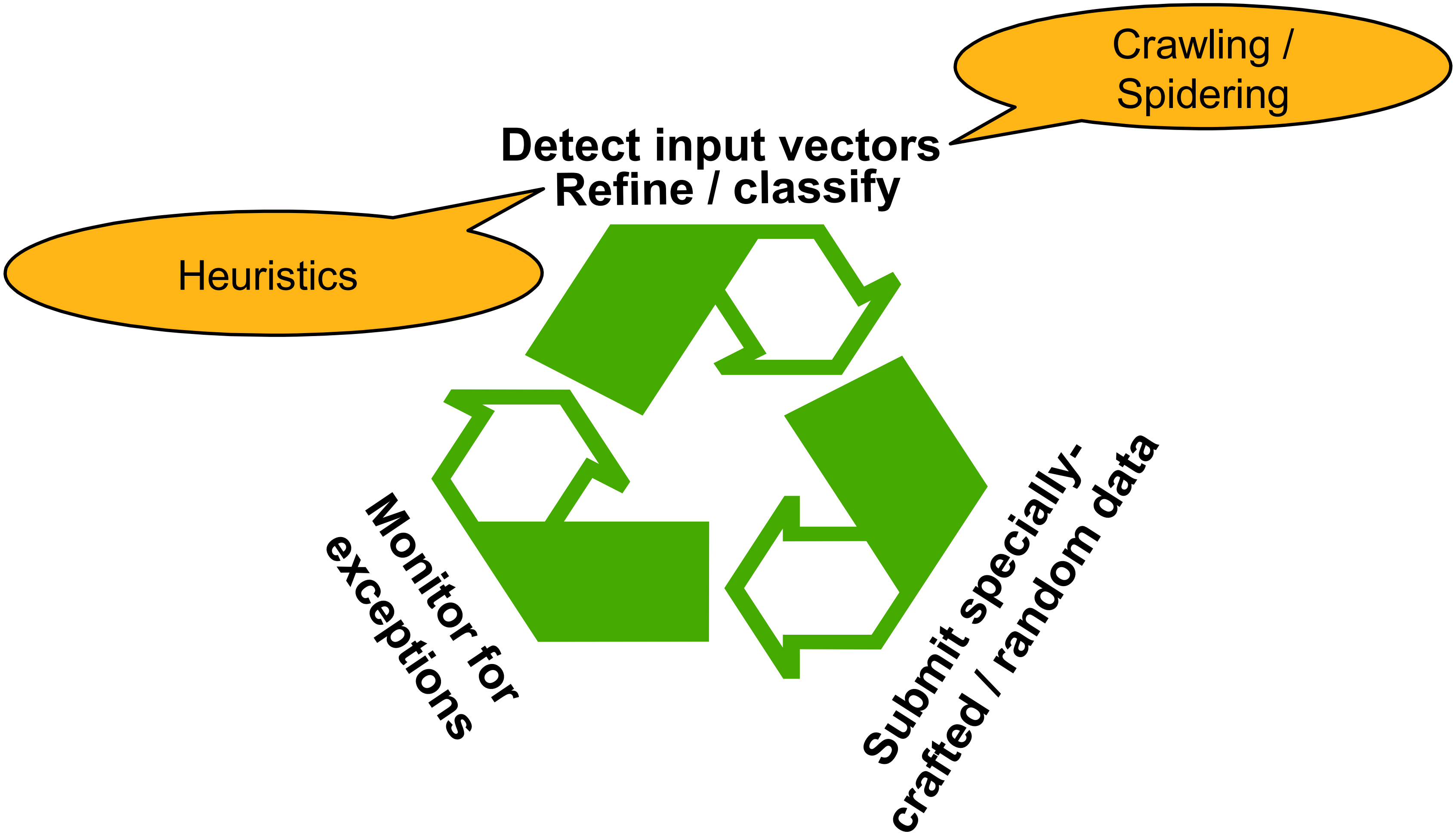
Fuzzing (general)



Web Application fuzzing

- Exception monitoring is not trivial
  - Which are “REAL exceptions”?
- Classification is not trivial
  - Difficult to distinguish between real vulns and false positives (or negatives)

- Validation and discovery heuristics are commonly used
  - Error message detection
  - Sent text reflected
  - Timing, and other
- Relating Fuzz vectors with exceptions and vulns is difficult

gFuzz's approach

Fuzzing

+

Character-grained taint analysis (aka. Core GRASP)

+

Grammar-based analysis

A LOT of information!

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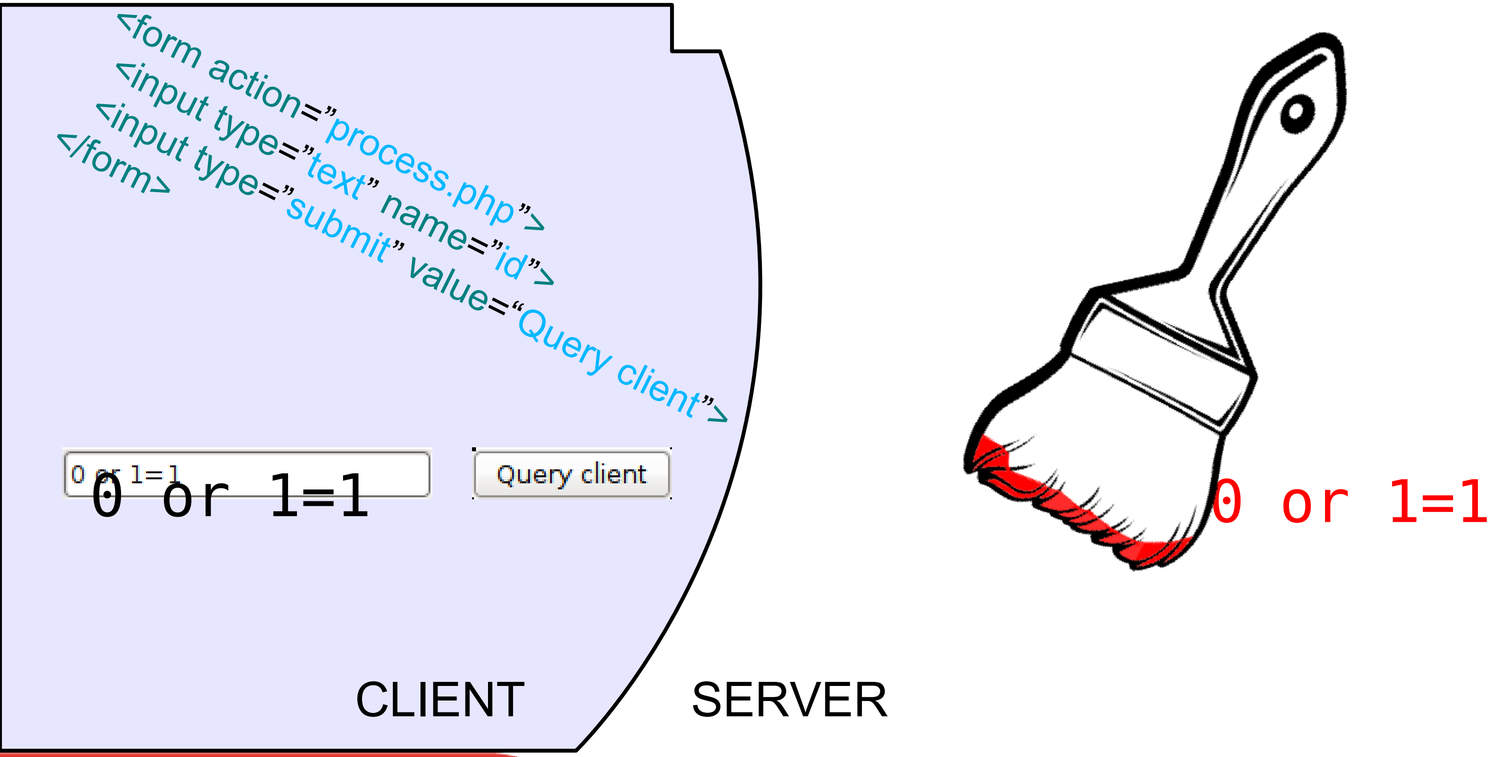
Character-grained taint analysis

- A modified version of CORE GRASP
  - Which is a modified PHP interpreter
    - Character-grained security information
    - 30% run-time penalty (current implementation)
    - Apache 2.0 license

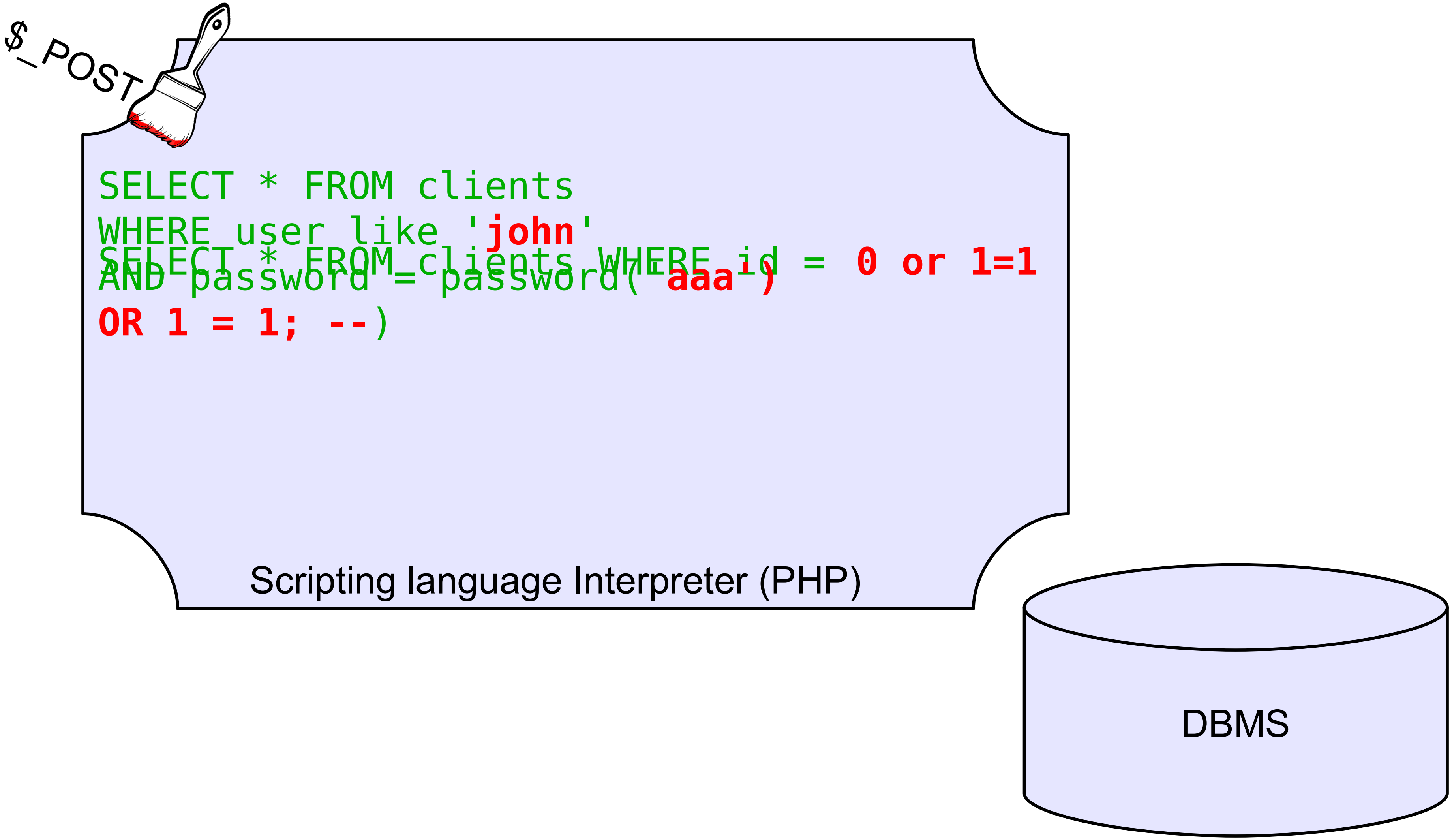
Character-grained taint analysis

- Run-time instrumentation
- It “paints” attacker-controlled characters as tainted and propagates taint information during execution.



```
<form action=”process.php”>
<input type=”text” name=”id”>
<input type=”submit” value=“Query client”>
</form>
```

Character-grained taint analysis (cont)



```
SELECT * FROM clients
WHERE user like 'john'
AND password = password('aaa')
OR 1 = 1; --)
```

```
SELECT * FROM clients WHERE id = 0 or 1=1
```

Character-grained taint analysis & gFuzz

- Data is marked from untrusted sources (e.g., GET, POST)

- Taint marks are propagated between string operations during execution

- GRASP sends information about executed queries to gFuzz (from inside the interpreter!)

gFuzz entry sent by GRASP

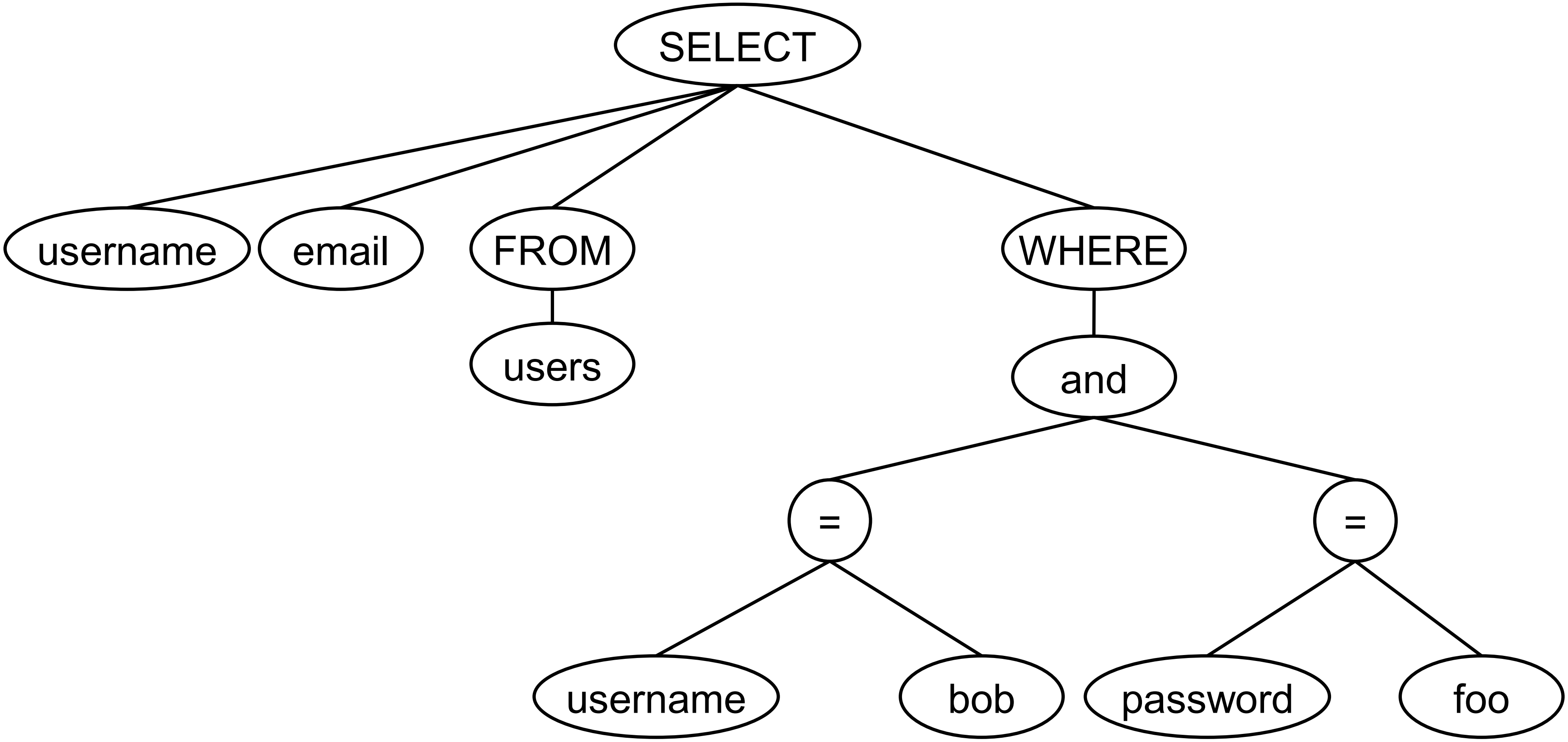
```
<GRASP_FUZZ_ENTRY>
  <GRASP_QUERY_ID>
    /location/of/the/executed/file/userlogin.php:40
  </GRASP_QUERY_ID>
  <GRASP_FUZZ_IS_ATTACK>0</GRASP_FUZZ_IS_ATTACK>
  <GRASP_FUZZ_QUERY>
   SELECT name,email FROM users WHERE username='bob' and password='foo'
  </GRASP_FUZZ_QUERY>
  <GRASP_FUZZ_QUERY_MARK>
   .............................................XXX................XXX.
  </GRASP_FUZZ_QUERY_MARK>
</GRASP_FUZZ_ENTRY>
```

gFuzz entry sent by GRASP

```
    <GRASP_FUZZ_ENTRY>
      <GRASP_QUERY_ID>
<GRASP_FUZZ_QUERY>
 SELECT name,email FROM users WHERE username='bob' and password='foo'
</GRASP_FUZZ_QUERY>
<GRASP_FUZZ_QUERY_MARK>
 .............................................XXX................XXX.
```

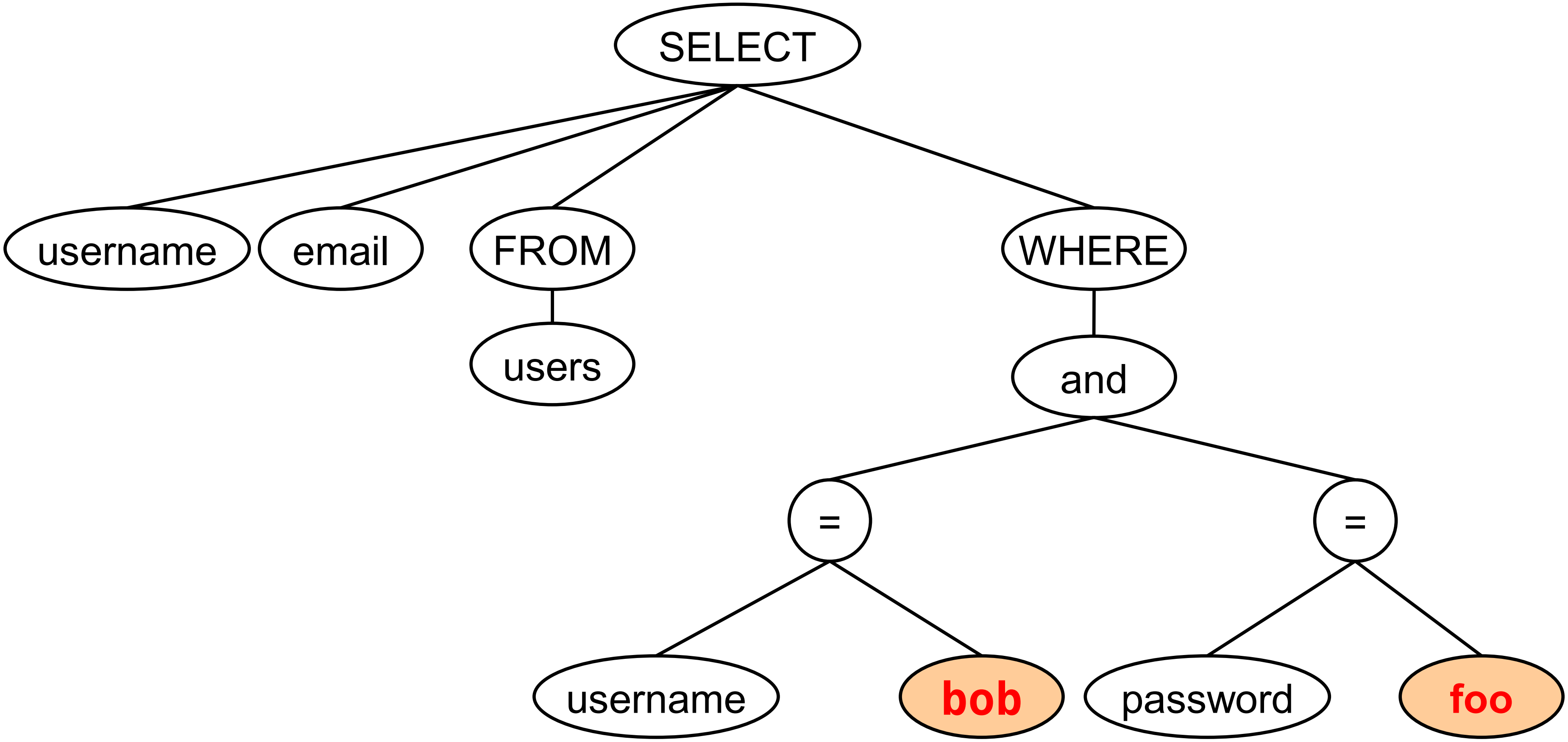
```
      <GRASP_FUZZ_QUERY_MARK>
       .............................................XXX................XXX.
      </GRASP_FUZZ_QUERY_MARK>
    </GRASP_FUZZ_ENTRY>
```

Grammatical analysis of SQL queries



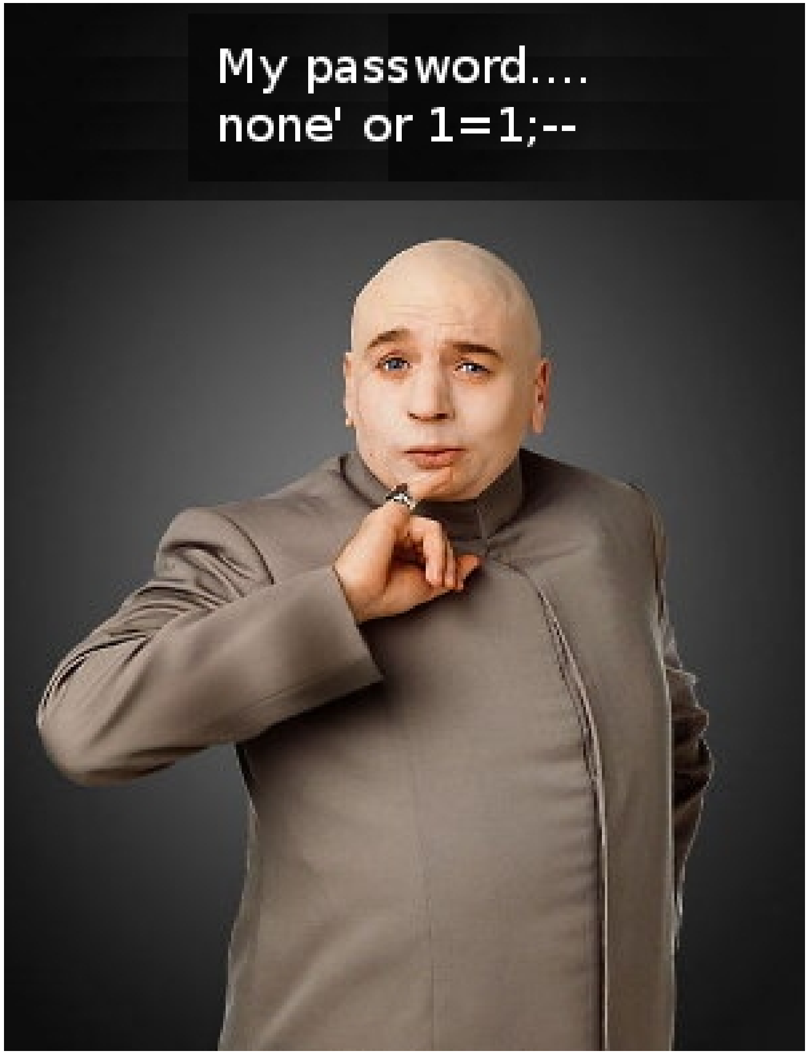
```
SELECT name,email FROM users
WHERE username='bob' and password='foo'
```

Grammatical analysis + taint marks

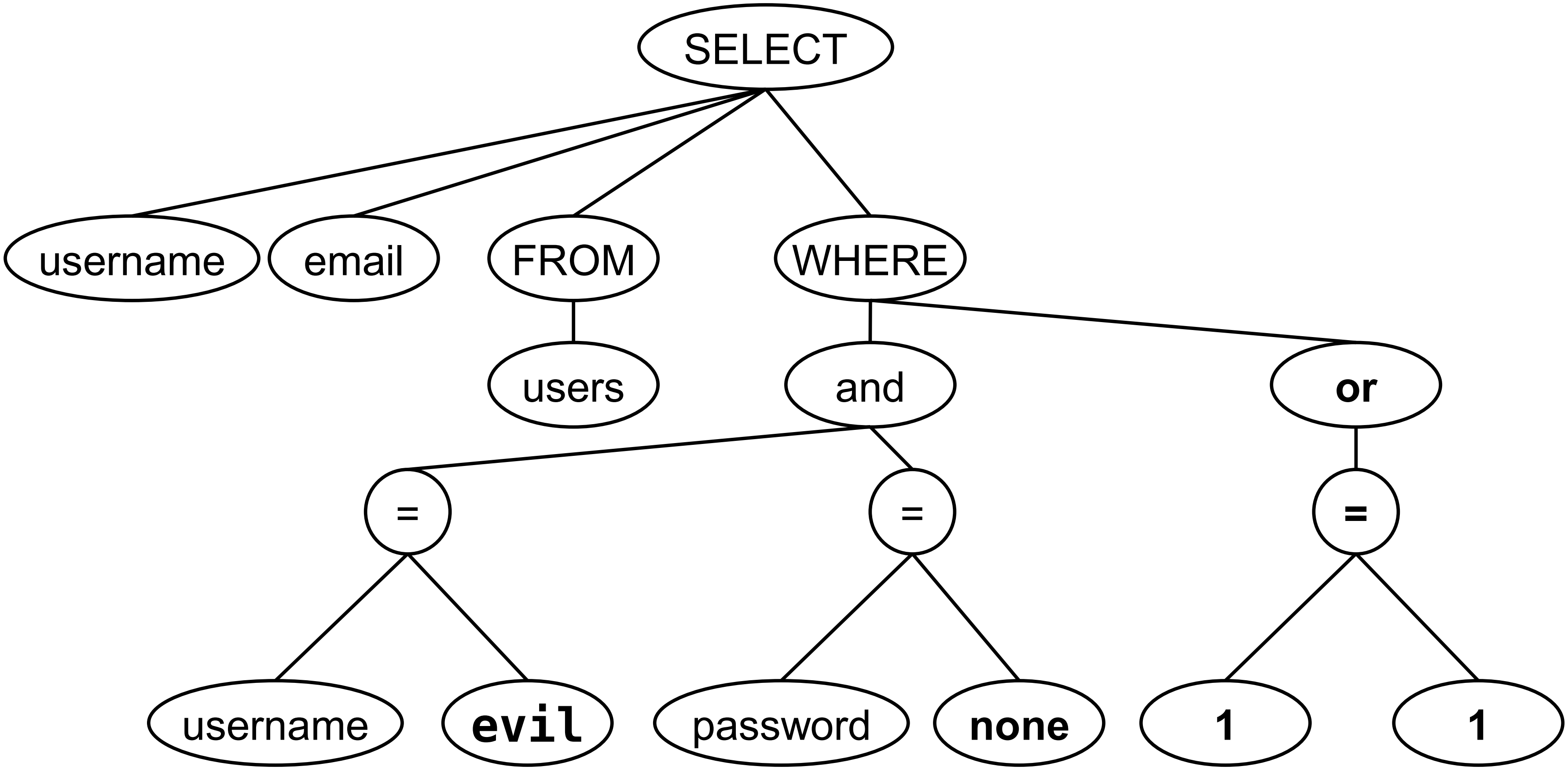


```
SELECT name,email FROM users
WHERE username='bob' and password='foo'
```

Evil inputs...

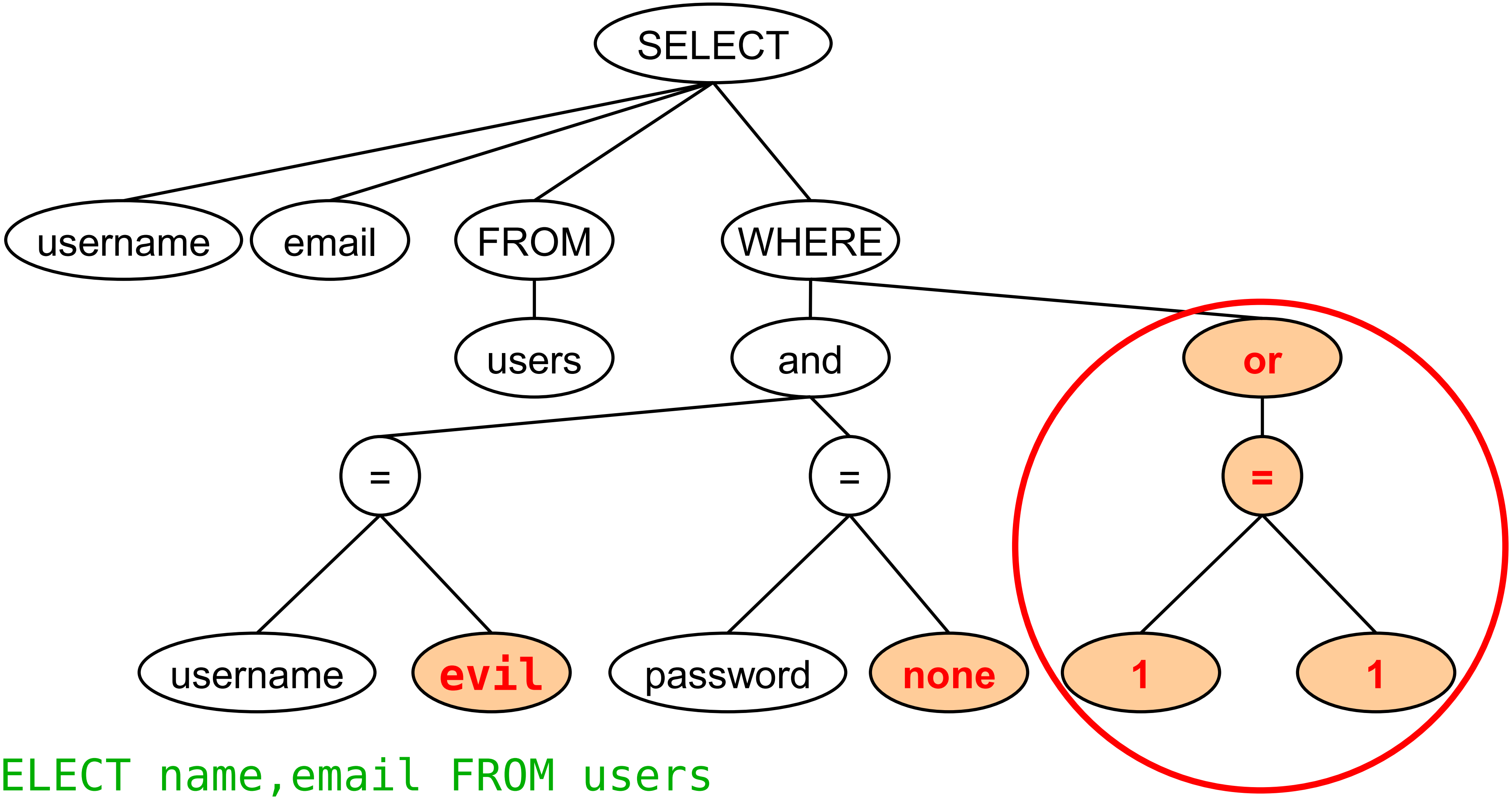


Grammatical analysis



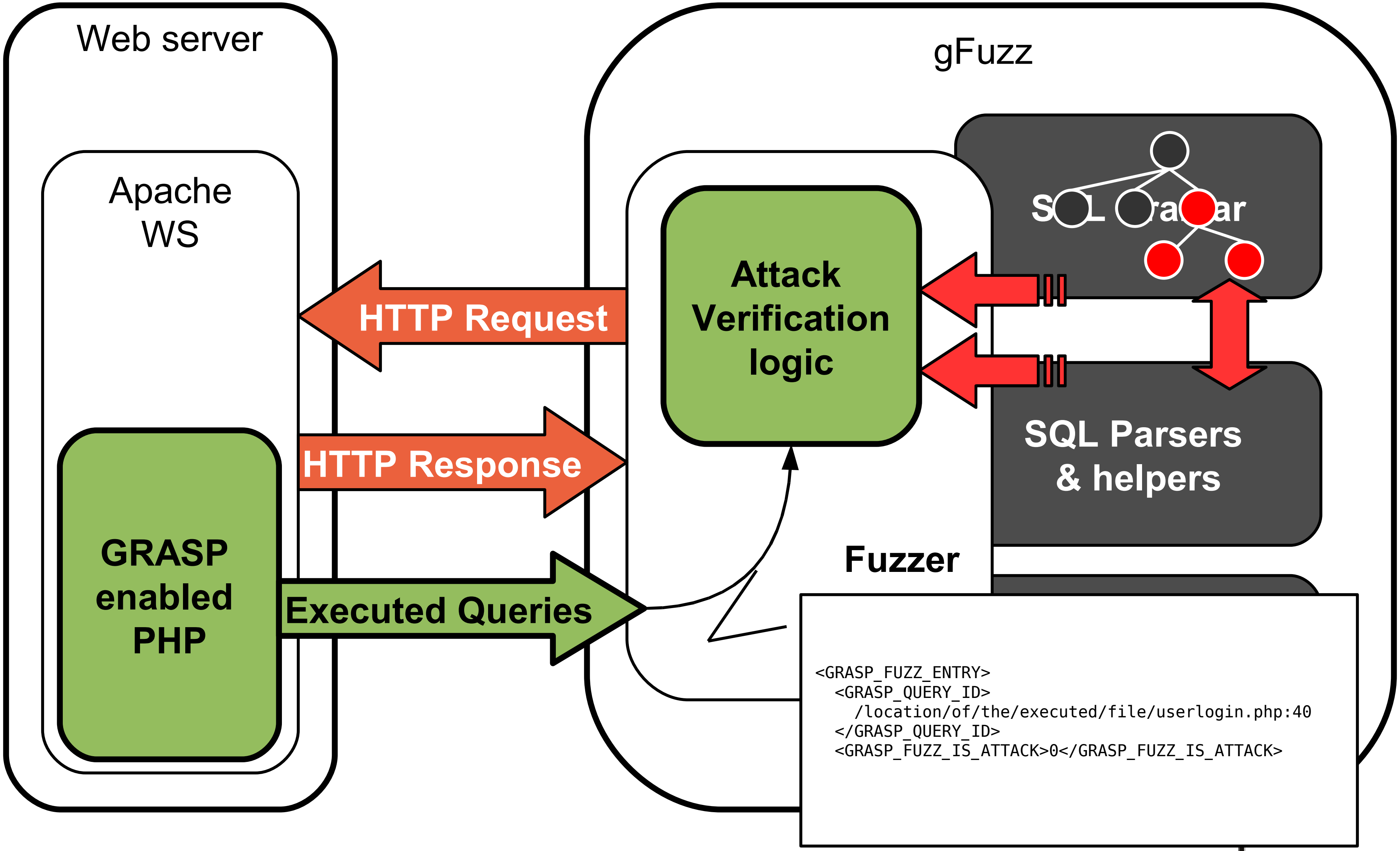
```
SELECT name,email FROM users
WHERE username=’evil’ and password=’none' or 1=1;--’
```

Grammatical analysis + taint marks



```
SELECT name,email FROM users
WHERE username='evil' and password='none' or 1=1;--'
```

Altogether



```
<GRASP_FUZZ_ENTRY>
  <GRASP_QUERY_ID>
    /location/of/the/executed/file/userlogin.php:40
  </GRASP_QUERY_ID>
  <GRASP_FUZZ_IS_ATTACK>0</GRASP_FUZZ_IS_ATTACK>
```

Attack verification - witnesses

- The fuzzer sends “witness” requests
  - Not always possible
  - How to choose witness strings (heuristic):

```
SELECT *
FROM users
WHERE
  username = '12345'
AND
  password = '12345 '
```

✓

```
SELECT *
FROM users
WHERE
  username =  12345
AND
  password =  12345
```

✓

```
SELECT *
FROM users
WHERE
  username = 'someString'
AND
  password = 'someString'
```

✓

```
SELECT *
FROM users
WHERE
  username =  someString
AND
  password =  someString
```

✗

Attack verification - witnesses

- The fuzzer sends “witness” requests
  - Web application logic is set appart:

```
<?php

    if ( isset($_POST[“concerned”]) &&
         isset($_POST[“indifferent”]) && isset($_POST[“dontknow”]) )
    {
        echo “you cannot be concerned, indifferent and
              don't know about it at the same time!”;
    }

?>
```

This is related to fuzz logic. But must be taken into account for witnesses

Attack verification - witnesses

Conclusion:

It is not always possible to submit a **witness** query.

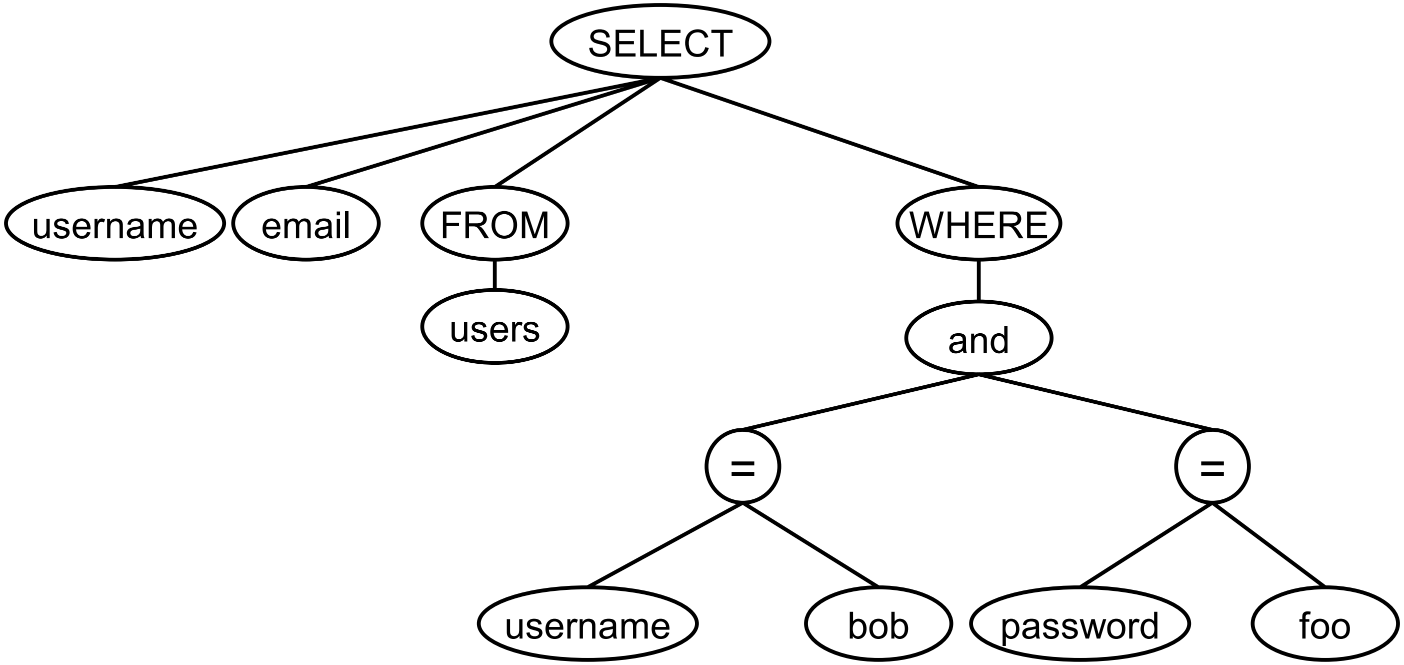
Classifying

For each query received

- If it had a witness, perform grammatical analysis to compare structural differences
- Otherwise, check if there's a terminal node with parent and brother fully controlled
- Report with instrumentation info

Query classification

- **Harmless**: Valid query and no terminal nodes are **fully** (brothers and parent) controlled by the attacker



Query classification

- **Warning**: The query is not grammar-compliant (and could not be analyzed):

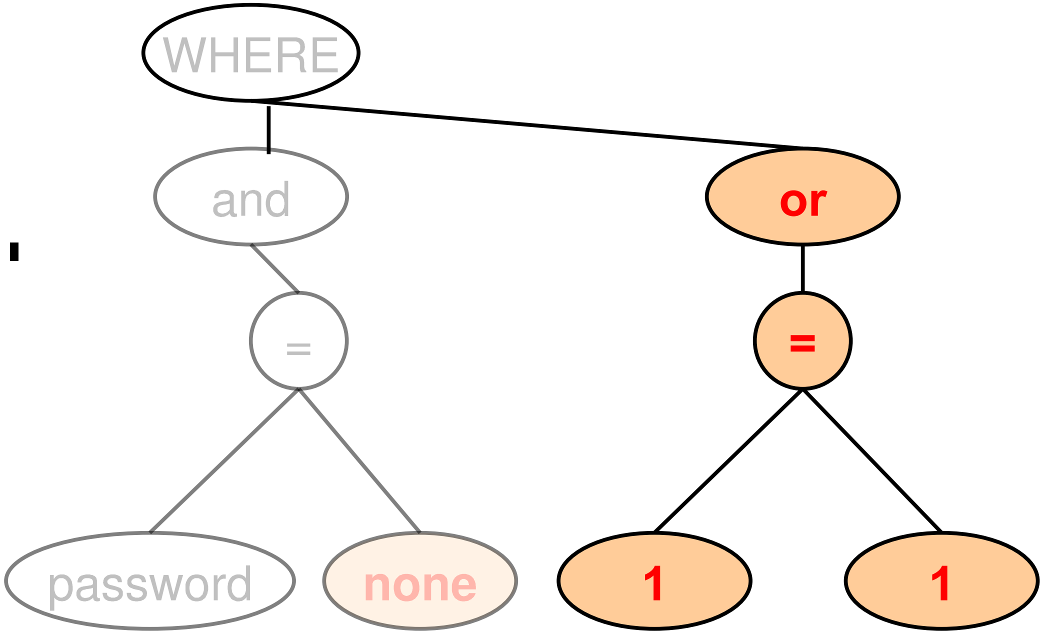
```
SELECT  name,email FROM users
WHERE   username='bob'
and     password='''
```

Could result in a successful attack or unexploitable error (this case IS exploitable)

Query classification

- **Successful Attack**: the attacker can control a terminal node, its brothers and its parent:

```
SELECT name,email
FROM users
WHERE username='bob'
and
  password='none'
or 1=1; --'
```



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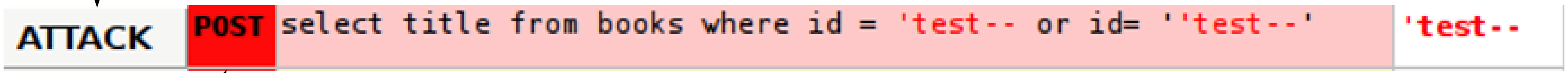
Reporting

Gfuzz analysis

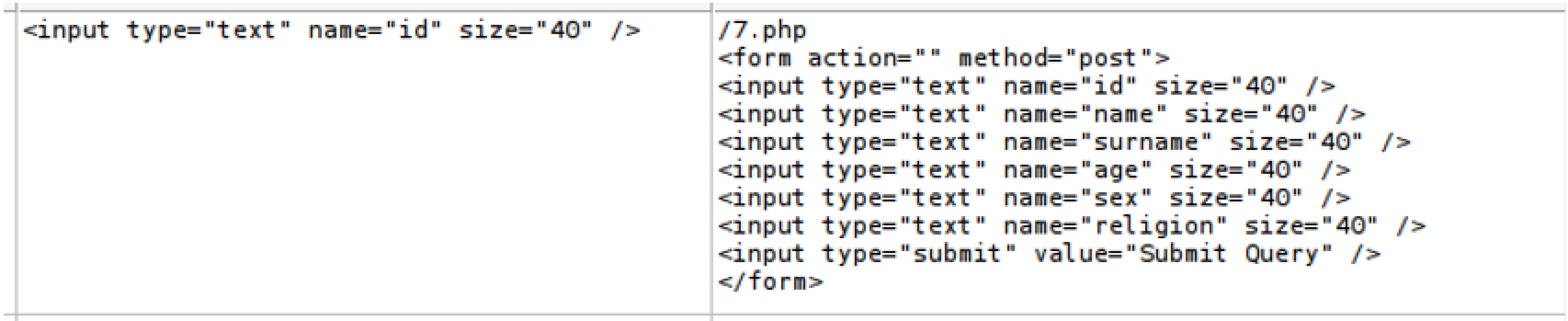


ATTACK	POST	select title from books where id = 'test-- or id= ''test--'	'test--

Executed query (controlled chars in red) with analysis info (background)

Fuzz string

Grasp analysis & fuzz method



`<input type="text" name="id" size="40" />`	/7.php
	`<form action="" method="post">`
	`<input type="text" name="id" size="40" />`
	`<input type="text" name="name" size="40" />`
	`<input type="text" name="surname" size="40" />`
	`<input type="text" name="age" size="40" />`
	`<input type="text" name="sex" size="40" />`
	`<input type="text" name="religion" size="40" />`
	`<input type="submit" value="Submit Query" />`
	`</form>`

Input / URL parameter

Target

Fuzz vector

Demo

About the prototype

- The fuzzing logic is very simple, can be significantly improved
- SQL “grammar” is standard ANSI SQL-92 and only for selects. Can be extended (e.g., INSERT, UPDATE, nested SELECTS, ...)
- In Python, BSD license
- Any volunteers wishing to help?

Future

- Improve SQL support / attack detection

- Improve fuzzing engine
  - Create an audit module for w3af framework! (http://w3af.sourceforge.net)

- Add XSS detection
  - Bounded to GRASP support for XSS! (Any volunteer to help?)

- Improve run time!

Thanks!

Useful data

Corelabs research site:

http://corelabs.coresecurity.com

CORE Grasp for PHP (original version):

http://grasp.coresecurity.com

contact:

egutesman@coresecurity.com

Acknowledgments

- Pictures from
  - http://www.sxc.hu
  - http://www.openclipart.org
  - http://www.flickr.com ©

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