Web security: web basics

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Web applications

[Diagram showing Web applications with client, server, and database connected by HTTP]
URLs

Protocol://host/FilePath?argt1=value1&argt2=value2

- **Protocol**: protocol to access the resource (http, https, ftp, ...)
- **host**: name or IP address of the computer the resource is on
- **FilePath**: path to the resource on the host
- **Resources can be static** (file.html) **or dynamic** (do.php)
- **URLs for dynamic content** usually include arguments to pass to the process (argt1, argt2)
HTTP requests

GET request

GET HTTP/1.1
Host: www.inf.ed.ac.uk
User-Agent: Mozilla/5.0
(X11; Ubuntu; Linux x86_64; rv:29.0)
Gecko/20100101 Firefox/29.0
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
HTTP responses

HTTP/1.1 200 OK
Server: Apache
Cache-control: private
Set-Cookie: JSESSIONID=B7E2479EC28064DF84DF4E3DBEE9C7DF;
            Path=/
Content-Type: text/html;charset=UTF-8
Date: Wed, 18 Mar 2015 22:36:30 GMT
Connection: keep-alive
Set-Cookie: NSC_xxx.fe.bd.vl-xd=fffffffffc3a035be45525d5f4f58455e445a4
            Content-Encoding: gzip
Content-Length: 4162

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN" "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml"
     xml:lang="en" lang="en">
  <head>
    <title> Informatics home | School of Informatics </title>
    ...
</html>
Web security: security goals
Security goals

Web applications should provide the same security guarantees as those required for standalone applications

1. visiting evil.com should not infect my computer with malware, or read and write files
   **Defenses:** Javascript sandboxed, avoid bugs in browser code, privilege separation, *etc*

2. visiting evil.com should not compromise my sessions with gmail.com
   **Defenses:** same-origin policy – each website is isolated from all other websites

3. sensitive data stored on gmail.com should be protected
Threat model

Web attacker
- controls evil.com
- has valid SSL/TLS certificates for evil.com
- victim user visits evil.com

Network attacker
- controls the whole network: can intercept, craft, send messages

A Web attacker is weaker than a Network attacker
<table>
<thead>
<tr>
<th>OWASP TOP 10 Web security flaws (2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1 – Injection</strong></td>
</tr>
<tr>
<td><strong>A2 – Broken Authentication and Session Management</strong></td>
</tr>
<tr>
<td><strong>A3 – Cross-Site Scripting (XSS)</strong></td>
</tr>
<tr>
<td><strong>A4 – Insecure Direct Object References</strong></td>
</tr>
<tr>
<td><strong>A5 – Security Misconfiguration</strong></td>
</tr>
<tr>
<td><strong>A6 – Sensitive Data Exposure</strong></td>
</tr>
<tr>
<td><strong>A7 – Missing Function Level Access Control</strong></td>
</tr>
<tr>
<td><strong>A8 - Cross-Site Request Forgery (CSRF)</strong></td>
</tr>
<tr>
<td><strong>A9 - Using Components with Known Vulnerabilities</strong></td>
</tr>
<tr>
<td><strong>A10 – Unvalidated Redirects and Forwards</strong></td>
</tr>
</tbody>
</table>
Injection attacks
Injection attack

OWASP definition

Injection flaws, such as SQL, OS, and LDAP injection occur when untrusted data is sent to an interpreter as part of a command or query. The attacker’s hostile data can trick the interpreter into executing unintended commands or accessing data without proper authorization.

We are going to look at:

▶ command injection attacks
▶ SQL injection attacks
Command injection: a simple example

- Service that prints the result back from the linux program whois

- Invoked via URL like (a form or Javascript constructs this URL):

  http://www.example.com/content.php?domain=example.php

- Possible implementation of content.php

  ```php
  <?php
  if ($_GET['domain']) {
    echo system("whois".$_GET['domain']);
  }
  ?>
  ```
This script is subject to a command injection attack! We could invoke it with the argument:

```
www.example.com; rm -rf /;
http://www.example.com/content.php?domain=www.google.com;
rm -r /;
```

Resulting in the following PHP:

```
<? echo system("whois www.google.com; rm -rf/;"); ?>
```
Defense: input escaping

```php
<? echo system("whois" . escapeshellarg($_GET['domain'])); ?>
```

`escapeshellarg()` adds single quotes around a string and quotes/escapes any existing single quotes allowing you to pass a string directly to a shell function and having it be treated as a single safe argument.

<table>
<thead>
<tr>
<th>GET INPUT</th>
<th>Command executed</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>www.google.com</code></td>
<td><code>whois 'www.google.com'</code></td>
</tr>
<tr>
<td><code>www.google.com; rm -rf/;</code></td>
<td><code>whois 'www.google.com rm -rf/; '</code></td>
</tr>
</tbody>
</table>
Command injection recap

- Injection is generally caused when data and code share the same channel:
  - "whois" is the code and the filename the data
  - **But ’;;’** allows attacker to include new command

- **Defenses** include input validation, input escaping and use of a less powerful API
Web applications

Client
(HTML, JavaScript)

$\text{HTTP}$

Server
(PHP)

Database
(SQL)
Databases

<table>
<thead>
<tr>
<th>username</th>
<th>password</th>
</tr>
</thead>
<tbody>
<tr>
<td>alice</td>
<td>01234</td>
</tr>
<tr>
<td>bob</td>
<td>56789</td>
</tr>
<tr>
<td>charlie</td>
<td>43210</td>
</tr>
</tbody>
</table>

user_accounts

- Web server connects to DB server:
  - Web server sends **queries** or **commands** according to incoming HTTP requests
  - DB server returns associated values
  - DB server can **modify/update** records
- SQL: commonly used database query language
SQL SELECT

Retrieve a set of records from DB:

```
SELECT field FROM table WHERE condition -- SQL comment
```

returns the value(s) of the given field in the specified table, for all records where condition is true

Example:

<table>
<thead>
<tr>
<th>username</th>
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</tr>
</thead>
<tbody>
<tr>
<td>alice</td>
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<td>charlie</td>
<td>43210</td>
</tr>
</tbody>
</table>

user_accounts

```
SELECT password FROM user_accounts WHERE username='alice' returns the value 01234
```
SQL INSERT

Retrieve a set of records from DB:

```
INSERT INTO table VALUES record -- SQL comment
```

adds the value(s) a new record in the specified table
Example:

<table>
<thead>
<tr>
<th>username</th>
<th>password</th>
</tr>
</thead>
<tbody>
<tr>
<td>alice</td>
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user_accounts

→

<table>
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<td>56789</td>
</tr>
<tr>
<td>charlie</td>
<td>43210</td>
</tr>
<tr>
<td>eve</td>
<td>98765</td>
</tr>
</tbody>
</table>

user_accounts

```
INSERT INTO user_accounts VALUES ('eve', 98765)
```
Other SQL commands

- **DROP TABLE table**: deletes entire specified table

- Semicolons separate commands:
  
  **Example**:

  ```sql
  INSERT INTO user_accounts VALUES ('eve', 98765);
  SELECT password FROM user_accounts
  WHERE username='eve'
  
  returns 98765
  ```
SQL injection: a simple example

The web server logs in a user if the user exists with the given username and password.

```php
login.php:
$conn = pg_pconnect("dbname=user_accounts");
$result = pg_query(conn,
    "SELECT * from user_accounts
    WHERE username = " .$_GET[‘user’].""
    AND password = " .$_GET[‘pwd’]."";";
if(pg_query_num($result) > 0) {
    echo "Success";
    user_control_panel_redirect();
}
```

It sees if results exist and if so logs the user in and redirects them to their user control panel.
SQL injection: a simple example

Login as admin:
SQL injection: a simple example

Login as admin:
http://www.example.com/login.php?user=admin'--&pwd=f

pg_query(conn,
    "SELECT * from user_accounts
    WHERE username = 'admin' -- ' AND password = 'f';");
SQL injection: a simple example

Login as admin:
http://www.example.com/login.php?user=admin’--&pwd=f

```
pg_query(conn,
    "SELECT * from user_accounts
    WHERE username = 'admin' -- ' AND password = 'f';");
```

Drop user_accounts table:
SQL injection: a simple example

Login as admin:
http://www.example.com/login.php?user=admin’--&pwd=f

pg_query(conn,
    "SELECT * from user_accounts
    WHERE username = 'admin' -- ' AND password = 'f';");

Drop user_accounts table:
http://www.example.com/login.php?user=admin’;
DROP TABLE user_accounts --&pwd=f

pg_query(conn,
    "SELECT * from user_accounts;
    WHERE user = 'admin'; DROP TABLE user_accounts;
    -- ' AND password = 'f';");
Defense: prepared statements

- Creates a template of the SQL query, in which data values are substituted
- Ensures that the untrusted value is not interpreted as a command

```php
$result = pg_query_params(
    conn,
    SELECT * from user_accounts WHERE username = $1
        AND password = $2,
    array($_GET['user'], $_GET['pwd']));
```