Web security: web basics

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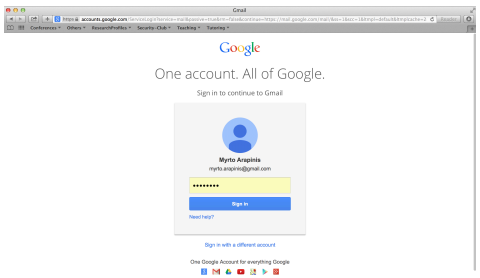
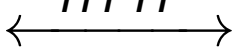
Web applications

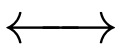


Client
(HTML, JavaScript)



Google

Server
(PHP)



Database
(SQL)

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=ffffffffc3a035be45525d5f4f58455e445a4
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>
...
```

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

OWASP TOP 10 Web security flaws (2013)

A1 – Injection	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.
A2 – Broken Authentication and Session Management	Application functions related to authentication and session management are often not implemented correctly, allowing attackers to compromise passwords, keys, or session tokens, or to exploit other implementation flaws to assume other users' identities.
A3 – Cross-Site Scripting (XSS)	XSS flaws occur whenever an application takes untrusted data and sends it to a web browser without proper validation or escaping. XSS allows attackers to execute scripts in the victim's browser which can hijack user sessions, deface web sites, or redirect the user to malicious sites.
A4 – Insecure Direct Object References	A direct object reference occurs when a developer exposes a reference to an internal implementation object, such as a file, directory, or database key. Without an access control check or other protection, attackers can manipulate these references to access unauthorized data.
A5 – Security Misconfiguration	Good security requires having a secure configuration defined and deployed for the application, frameworks, application server, web server, database server, and platform. Secure settings should be defined, implemented, and maintained, as defaults are often insecure. Additionally, software should be kept up to date.
A6 – Sensitive Data Exposure	Many web applications do not properly protect sensitive data, such as credit cards, tax IDs, and authentication credentials. Attackers may steal or modify such weakly protected data to conduct credit card fraud, identity theft, or other crimes. Sensitive data deserves extra protection such as encryption at rest or in transit, as well as special precautions when exchanged with the browser.
A7 – Missing Function Level Access Control	Most web applications verify function level access rights before making that functionality visible in the UI. However, applications need to perform the same access control checks on the server when each function is accessed. If requests are not verified, attackers will be able to forge requests in order to access functionality without proper authorization.
A8 - Cross-Site Request Forgery (CSRF)	A CSRF attack forces a logged-on victim's browser to send a forged HTTP request, including the victim's session cookie and any other automatically included authentication information, to a vulnerable web application. This allows the attacker to force the victim's browser to generate requests the vulnerable application thinks are legitimate requests from the victim.
A9 - Using Components with Known Vulnerabilities	Components, such as libraries, frameworks, and other software modules, almost always run with full privileges. If a vulnerable component is exploited, such an attack can facilitate serious data loss or server takeover. Applications using components with known vulnerabilities may undermine application defenses and enable a range of possible attacks and impacts.
A10 – Unvalidated Redirects and Forwards	Web applications frequently redirect and forward users to other pages and websites, and use untrusted data to determine the destination pages. Without proper validation, attackers can redirect victims to phishing or malware sites, or use forwards to access unauthorized pages.

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
  if ($_GET['domain']) {
    <?  echo system("whois".$_GET['domain']); ?>
  }
?>
```

Command injection: a simple example cont'd

- 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.c
                                                rm -r /;
```

- Resulting in the following PHP

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

Defense: input escaping

```
<?  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

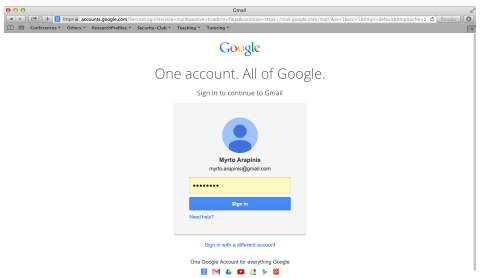
GET INPUT	Command executed
`www.google.com`	`whois 'www.google.com'`
`www.google.com; rm -rf/;`	`whois 'www.google.com rm -rf/;'`

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



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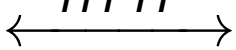

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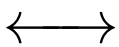
(PHP)



Database
(SQL)

Databases

username	password
alice	01234
bob	56789
charlie	43210

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:

username	password
alice	01234
bob	56789
charlie	43210

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:

username	password
alice	01234
bob	56789
charlie	43210

user_accounts

$\longrightarrow$

username	password
alice	01234
bob	56789
charlie	43210
eve	98765

user_accounts

```
INSERT INTO user_accounts VALUES ('eve', 98765)
```

Other SQL commands

- `DROP TABLE table`: deletes entire specified table
- Semicolons separate commands:
  Example:

```
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.

```
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

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