Implementation and Management of Systems Security

158.738

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INTERNET SECURITY

How the Internet Works I

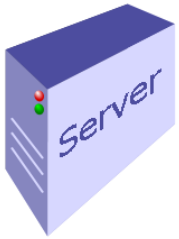
The client request contains the name and address (the URL) of the things the client is looking for

HTTP Request

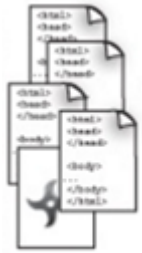
Web Browser

HTTP Response

The server's response contains the actual document that the client requested (or an error code if the request can't be processed)

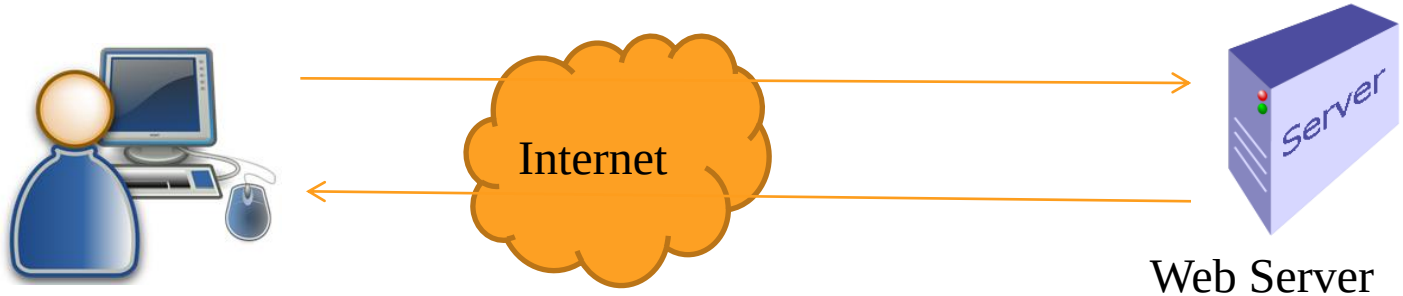


The server usually has lots of contents: documents, images, videos etc.,



Web Server

How the Internet Works II



User with web browser

Web technologies
(HTML/CSS/JavaScript)

Web Server

Server side programming (PhP…)

SQL instruction

DBMS

databases

Dynamic Content

- Content (web page) is generated “on-the-fly” and changes regularly
- Content contains “server-side” code, allows the server to generate unique content when the page is loaded
- PHP, ASP, JSP or other language is used to pull content from a database
- Example: upcoming events on a homepage pulling from a calendar and changing each day

Internet Vulnerabilities

- Web Browsers
- Mulvertising
- Drive-by Downloads
- Cookies

Browser Vulnerabilities

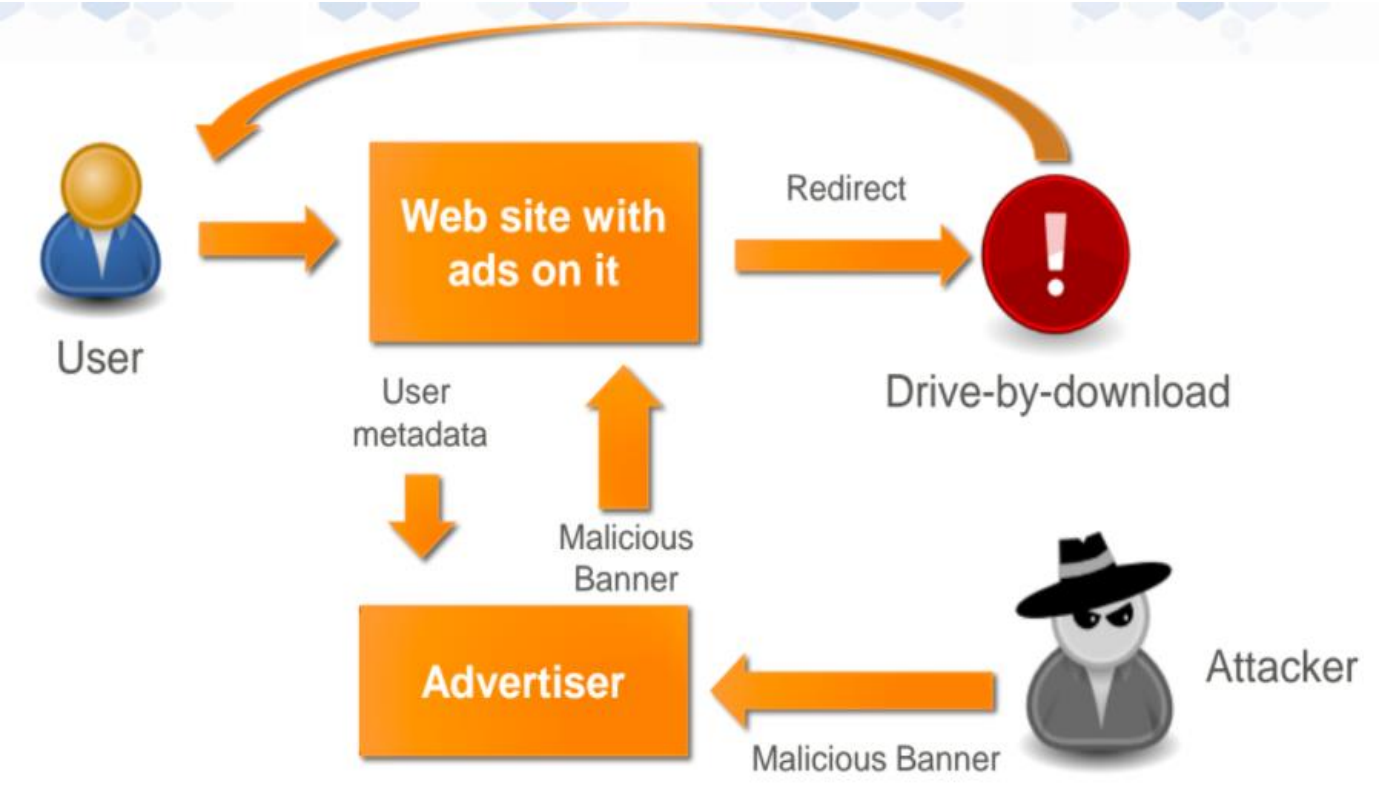
- Scripting Code
  - "automatically" download a script or a set of instructions to add more user interactive experience
  - JavaScript embedded on HTML documents
  - Defense: limit capabilities (e.g., sandboxing, same origin)

Browser Vulnerabilities

Name	Description	Location	Browser support	Examples
Extension	Written in JavaScript and has wider access to privileges	Part of web browser	Only works with a specific browser	Download selective links on webpage, display specific fonts
Add-ons	Adds functionality to browser itself	Part of web browser	Only works with a specific browser	Dictionary and language packs
Plug-ins	Links to external program	Outside of web browser	Compatible with many different browsers	Audio, video, PDF file display

Mulvertising

- Infect a mainstream website through third-party advertising networks



Source: http://www.radiusnetworks.co.nz/malvertising/

Drive-by Downloads

- Infect the website directly just from viev the website
  - Attackers implant malicious code in the web server
- Websites with popular content
  - Games: 60% of websites contain executable content, one-third contain at least one malicious executable
  - Celebrities, adult content, everything except news
- Many infectious sites exist only for a short time, behave non-deterministically, change often

Cookies

- HTML does not have a mechanism to track users if they have previously visited certain websites.
- The web server stores user-specific information through a cookie
- A cookie can contain a variety of information
  - User's preferences when visiting a website
  - Personally identifiable information (name, email address, work address, etc.,)

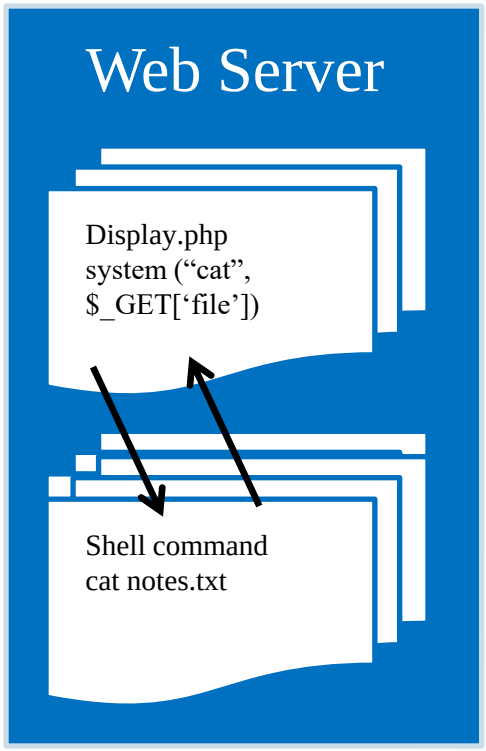
Web Attack Techniques

- Command Injection
- SQL Injection
- Cross-site Scripting (XSS)

Command Injection

display.php?file=notes.txt

Web page



Display.php <? echo system("cat", $_GET['file']); ?>

Command Injection

- Which one of the following URIs is an attack URI?

a. http://www.example.net/display.php?get=rm

b. http://www.example.net/display.php?file=rm –rf /;

c. http://www.example.net/display.php?file=notes.txt; rm -rf /;

d. http://www.example.net/display.php?file=

Command Injection

- Which one of the following URIs is an attack URI?

a. http://www.example.net/display.php?get=rm

b. http://www.example.net/display.php?file=rm –rf /;

c. http://www.example.net/display.php?file=notes.txt; rm -rf /;

d. http://www.example.net/display.php?file=

SQL Injection

- SQL: A query language for database
  - E.g., SELECT, INSERT, UPDATE, DELETE etc.,
- More info
  - E.g., http://en.wikipedia.org/wiki/SQL
- One of the most exploited vulnerabilities on the web. Cause of massive data theft
  - 24% of all data stolen in 2010
  - 89% of all data stolen in 2009
- Like command injection, caused when attacker controlled data interpreted as a (SQL) command

SQL Injection

- Consider a web page that logs in a user by seeing if a user exists with the given username and password.

```
$result = pg_query("SELECT * from users WHERE
                                    uid = '".$_GET['user']."' AND
                                    pwd = '".$_GET['pwd']."';“
                        );
if (pg_query_num($result) > 0) {
        echo "Success";
        user_control_panel_redirect();
```

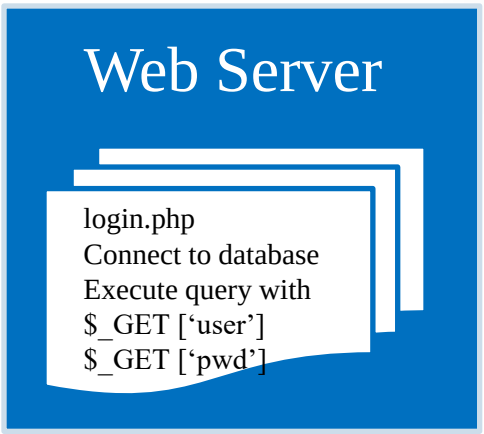
- It sees if results exist and if so logs the user in and redirects them to their user control panel.

SQL Injection

Web Browser

login.php?user=pikachu&pwd=1234

Success and redirect to user control panel

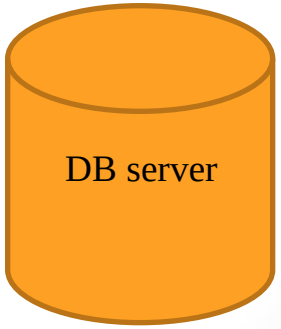


SELECT * from users WHERE
Uid='pikachu' AND pwd='1234';

QUERY

Results:
25 | pikachu | 1234 | student

RESULT



SQL Injection

- Q: Which one of the following queries will log you in as admin?
- Hints: The SQL language supports comments via '--‘ characters

a. http://www.example.net/login.php?user=admin&pwd='

b. http://www.example.net/login.php?user=admin--&pwd=foo

c. http://www.example.net/login.php?user=admin'--&pwd=f

SQL Injection

- Q: Which one of the following queries will log you in as admin?
- Hints: The SQL language supports comments via '--‘ characters

a. http://www.example.net/login.php?user=admin&pwd='

b. http://www.example.net/login.php?user=admin--&pwd=foo

c. http://www.example.net/login.php?user=admin'--&pwd=f

```
pg_query("SELECT * from users WHERE
uid = 'admin'--' AND pwd = 'f';");

pg_query("SELECT * from users WHERE
uid = 'admin';");
```

SQL Injection

- Q: Under the same premise as before, which URI can delete the users table in the database?

  a. www.example.net/login.php?user=;DROP TABLE users;--

  b. www.example.net/login.php?user=admin'; DROP TABLE users;--' AND pwd='f';

  c. www.example.net/login.php?user=admin; DROP TABLE users; -- AND pwd=f

  d. It is not possible. (None of the above)

SQL Injection

- Q: Under the same premise as before, which URI can delete the users table in the database?

a. www.example.net/login.php?user=;DROP TABLE users;--

b. www.example.net/login.php?user=admin’; DROP TABLE users;--’ AND pwd=‘f’;

c. www.example.net/login.php?user=admin; DROP TABLE users; -- AND pwd=f

d. It is not possible. (None of the above)

```
pg_query("SELECT * from users WHERE
            uid = 'admin'; DROP TABLE users;--' AND
            pwd = 'f';");

pg_query("SELECT * from users WHERE uid = 'admin';
DROP TABLE users;");
```

Input Validation

- Whitelisting: Only allow known-good values

```
<?
if(!preg_match("/^[a-z0-9A-Z.]*$/", $_GET['file'])) {
    echo “The file should be alphanumeric.";
    return;
}
echo system("cat ".$_GET['file']);
?>
```

GETINPUT	PASSES?
notes.txt	Yes
notes.txt; rm -rf /;	No
security notes.txt	No

Input Escaping

```
<?
        echo system("cat ".escapeshellarg($_GET['file']));
?>
```

- *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 :--http://www.php.net/manual/en/function.escapeshellarg.php

GETINPUT	Command Executed
notes.txt	cat 'notes.txt'
notes.txt; rm –rf /;	cat 'notes.txt rm –rf /;'
mary o'donnel	cat 'mary o'\''donnel'

SQL Injection

- Given that our web application employs the input validation mechanism for usernames, which of the following URIs would still allow you to login as admin?

```
pg_query("SELECT * from users WHERE
uid = '".$_GET['user']."' AND
pwd = '".$_GET['pwd']."';");
```

a. http://www.example.net/login.php?user=admin&pwd=admin

b. http://www.example.net/login.php?user=admin&pwd=‘ OR 1=1;--’;

c. http://www.example.net/login.php?user=admin'--&pwd=f

d. http://www.example.net/login.php?user=admin&pwd='--

SQL Injection

- Given that our web application employs the input valida
which of th
to login as a

```
pg_query("SELECT
uid = '".$_GET['user']."' AND
pwd = '".$_GET['pwd']."';");
```

pg_query("SELECT * from users WHERE uid = 'admin' AND pwd = '' OR 1 = 1;--';");

1=1 is true everywhere. This returns all the rows in the table, and thus number of results is greater than zero.

a. http://www.example.net/login.php?user=admin&pwd=admin

b. http://www.example.net/login.php?user=admin&pwd=‘ OR 1=1;--’;

c. http://www.example.net/login.php?user=admin'--&pwd=f

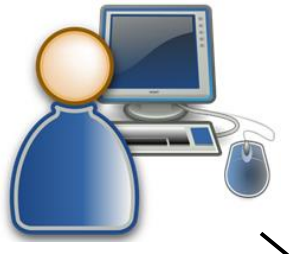
d. http://www.example.net/login.php?user=admin&pwd='--

Cross Site Scripting

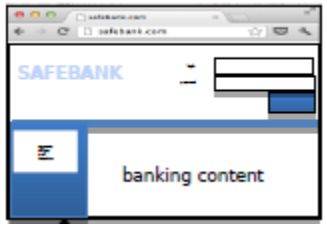
- Vulnerability in web application that enables attackers to inject malicious scripts into web pages viewed by other users.
- Types
  - Type 2: The attack vector is stored at the server
  - Type 1: Reflected: The vulnerability is in the server-side
  - Type 0: DOM based: The vulnerability is in the client side only

XSS: Type2: setting the scene

Consider a form on a website that allows a user to chat with a customer service associate



Associate

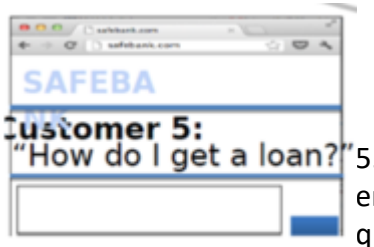


User

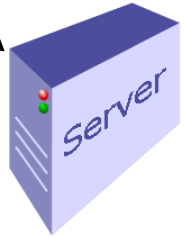
3. Associate requests the questions page

1. User asks a question via HTTP POST (message:"how do I get a loan?")

4. Server retrieves all questions from the DB



5. Server returns HTML embedded with the question



2. Server stores the question in database

PHP code: <? echo "<div class='question'>$question</div>";?>
HTML code: <div class="question'>How do I get a loan?"

Cross Site Scripting

- Look at the following code fragments. Which one of these could possibly be a command that could be used to perform a XSS injection?

  a. '; system('rm –rf /');

  b. rm –rf /

  c. DROP TABLE QUESTIONS;

  d. <script>doEvil()</script>

Cross Site Scripting

- Look at the following code fragments. Which one of these could possibly be a command that could be used to perform a XSS injection?

  a. '; system('rm –rf /');

  b. rm –rf /

  c. DROP TABLE QUESTIONS;

  d. <script>doEvil()</script>

```
<html><body>
...
<div class='question'>
<script>doEvil()</script>
</div>
...
</body></html>
```

XSS: Type2: attack (1)

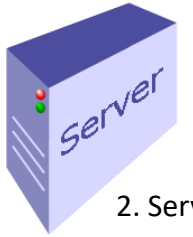
Consider a form on a website that allows a user to chat with a customer service associate

Associate

1. Attacker asks malicious question via HTTP POST
(message: <script>doEvil()</script>)

3. victim requests the questions page

4. Server retrieves all questions from the DB



2. Server stores the question in database

XSS: Type2: attack (2)

Consider a form on a website that allows a user to chat with a customer service associate

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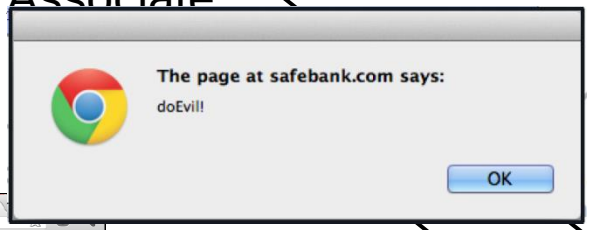
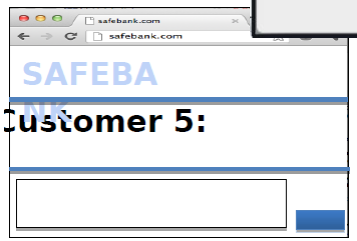
1. Attacker asks malicious question via HTTP POST
(message: <script>doEvil()</script>)

3. victim requests the questions page





4. Server retrieves all questions from the DB

5. Server returns HTML embedded with malicious question

2. Server stores the question in database

PHP code: <? echo “<div class=‘question’>$question</div>”;?>
HTML code: <script>doEvil()</script>

END