Web Security

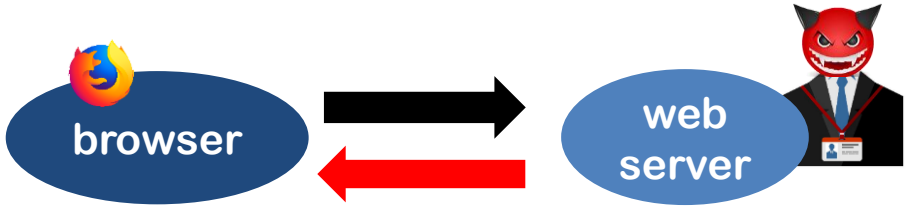
Server-side security risks

(esp. injection attacks)

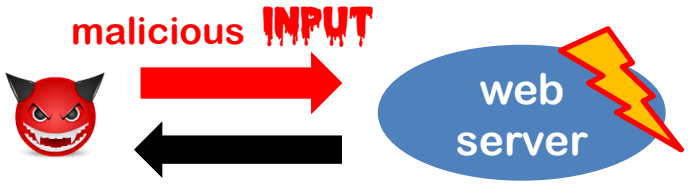
Attacker models

1. Man-in-the-Middle attacker

2. Spoofed/fake website



3. Attacks on web servers (this week)



4. Attacks on browsers & users (next weeks)

Security concerns with static web pages

Security worries for *static HTML*

Recall the first stage of the evolution of the web: static HTML

Security risk:

- Accidentally exposing parts of the file system on the internet

  `http://www.cs.ru.nl/~erikpoll/websec/exam/exam2024.pdf`
- Such files can even be indexed by search engines

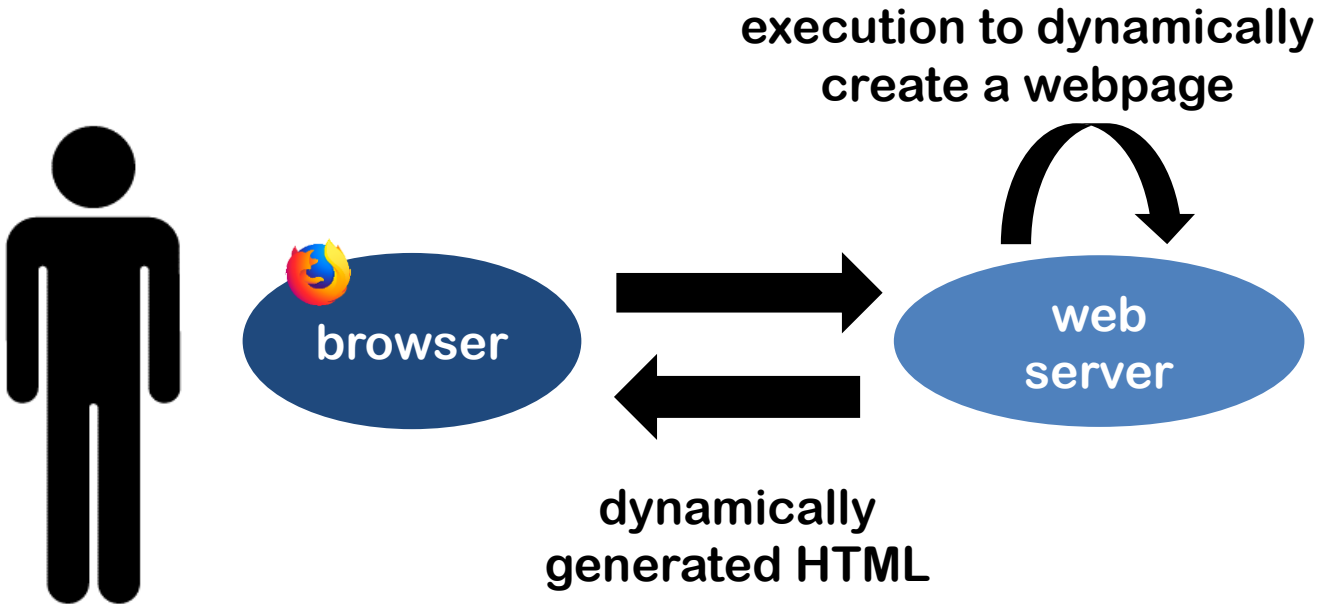
Countermeasures

- The OS (Operating System) imposes access control on the web server
- `.htaccess` file can be used to configure which files are exposed to the internet by the web server.
- Access restrictions for automated web crawlers, as used by search engines, can be specified in `robots.txt` files,
  - but it is up to the client to respect these - or not…

Security concerns with dynamically created web pages

Recall: dynamically created web pages

Most web pages you see are dynamically created



CGI (Common Gateway Interface)

Old-fashioned way to have dynamically generated web pages

Given an HTTP request to a cgi executable

`http://bla.com/cgi-bin/my_script?yr=2014&str=a%20name`

the web server executes the program `my_script`

passing parameters as input, and

returning the (HTML) output to client.

For the URL above, the web server would execute

```
cgi-bin/my_script 2014 "a name"
```

The executable `my_script` can be in *any* programming language

Example: CGI perl script

```
#!/usr/bin/perl
print "Content-type: text/html\n\n";

print <<HTML;
  <html>
  <head> <title>My first perl CGI script </title>
  </head>
  <body> <p>Hello World</p>
  </body>
  </html>
HTML
exit;
```

Languages & frameworks for the web

CGI is simple but very clumsy

Therefore people made:

- dedicated programming languages for web applications

  PHP, Ruby on Rails, Adobe ColdFusion, …
- web frameworks offering a lot of standard software components

  Drupal (PHP), Spring (Java),
  React, Angular, AngularJS (JavaScript),
  ASP.NET (Microsoft CLR/.NET), …

Example PHP code

```
<html> <title>A simple PHP script </title>
  <body>
    The number you choose was
       <?php echo $x = $_GET['number']; ?>
    This number squared plus 1 is
       <?php  $y = $x*$x; $y++; echo $y; ?>
    Btw, I know that your IP address is
      <?php echo  $_SERVER['REMOTE_ADDR'];  ?>
     <script> alert('Hello World!'); </script>
 </body>
</html>
```

This looks just like an HTML page, with pieces of PHP code in it.

PHP code is executed *server-side*; browser only sees the resulting HTML

JavaScript code in the HTML is executed *client-side*.

Security worries with dynamically created web pages

Command injection (in a CGI script)

A CGI bash script might contain

```
cat thefile | mail clientaddress
```

to email a file to a user-supplied email address.

How would you attack this?

```
erik@cs.ru.nl ; rm -fr /
```

What happens then ?

```
cat thefile | mail erik@cs.ru.nl ; rm -fr /
```

OS command injection

Any server-side code that uses client input to interact with the underlying OS might be used to inject commands to the OS.

This is possibly in any programming language.

Dangerous things to look out for

- C/C++ `system(), execvp(), ShellExecute(), ..`
- Java `Runtime.exec(), ...`
- Perl `system, exec, open, `, /e, ...`
- Python `exec, eval, input, execfile, ...`

How would you prevent this or mitigate the potential impact?

1. input sanitisation: check for malicious inputs
   - easier said than done…
2. the server should run with minimal rights
   - eg. you don't want to run it as super-user/admin

How would you attack this?

Suppose a website contains a link

`http:/somesite.com/get-files.php?file=exam2023.pdf`

`exam2023.pdf` looks like a filename…

You can try any other filename, e.g. `exam2024.pdf`

Or even any other path name, e.g. `../../../etc/passwd`

Known as path traversal or directory traversal attack

Directory traversal aka path traversal

Consider PHP code below,

which uses PHP string concatenation operator .

```
$base_dir = "/usr/local/clientdata/";
echo file_get_contents($base_dir .
                                    $_GET['username']);
            // concatenates base_dir and username
```

This can be attacked in the same way.

DoS by directory traversal

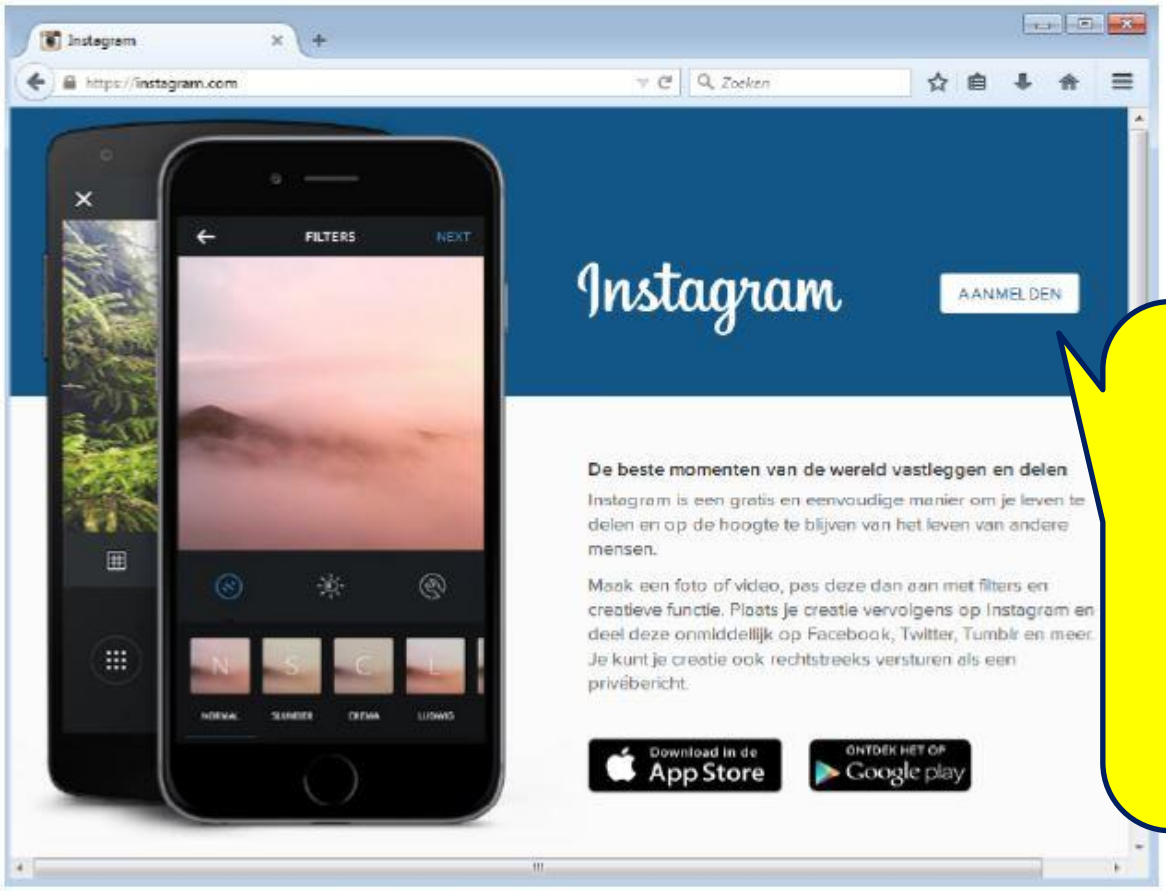
Directory traversals can also cause Denial-of-Service, if you access

- a file or directory that does not exists
  - This may crash a web application, though it's unlikely
- device files, ie pseudo-files that provide interfaces to devices
  - `/var/spool/printer`

    This printer queue cannot be opened for reading, only for writing. Opening it for reading may cause web application to hang.
  - `/dev/urandom`

    The random number generator that provides infinite stream of random numbers

Real life example



Page in Dutch, based on IP address or language settings of browser/OS

https://instagram.com

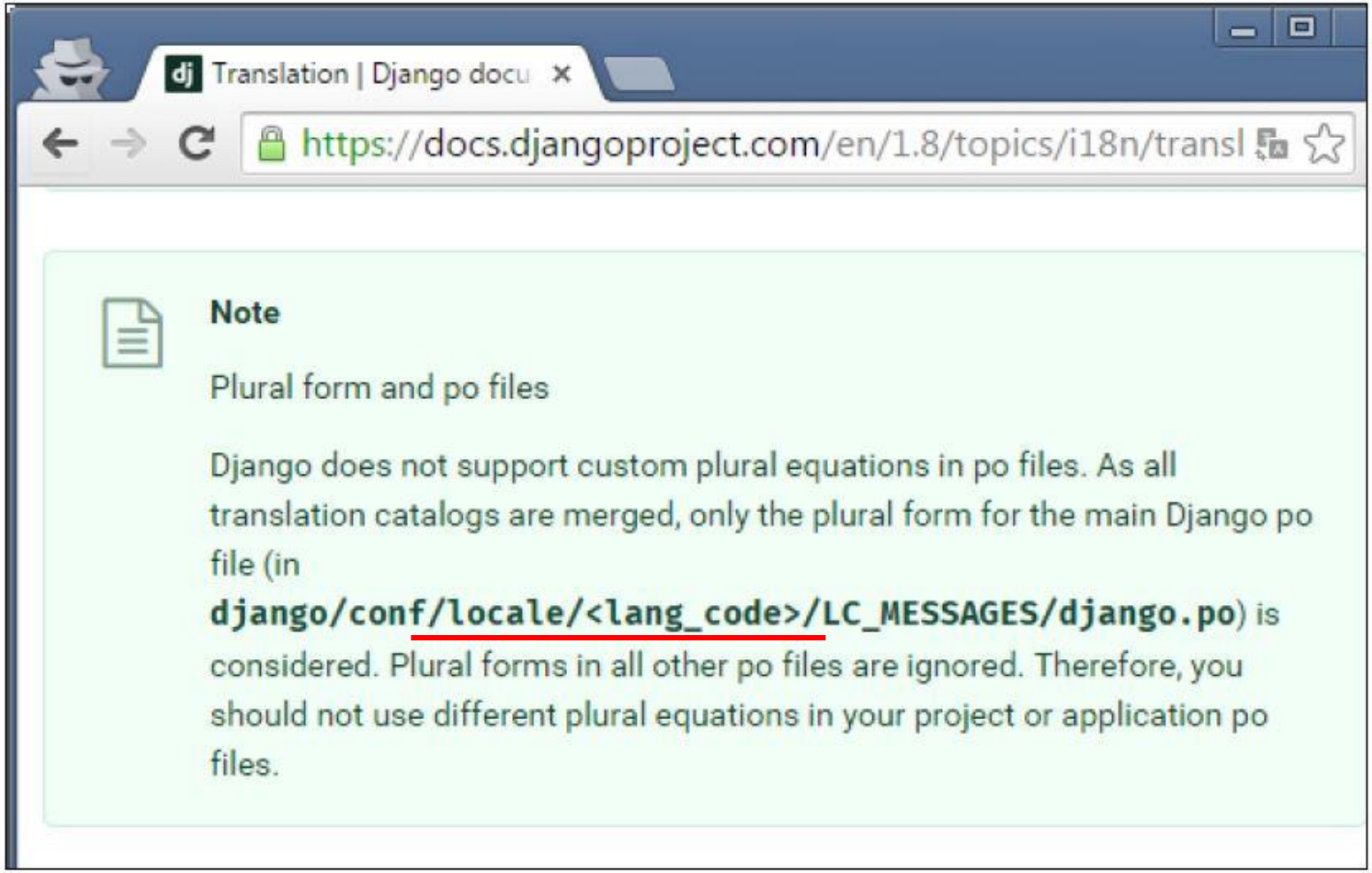
Thanks to Arne Swinnen. See his blog at http://www.arneswinnen.net.

https://instagram.com/?hl=en


Instagram
https://instagram.com/?hl=./en
Instagram
LOG IN
Capture and Share the World's Moments
Download on the App Store
GET IT ON Google play
No error message: ./en gives same result as en
https://instagram.com/?hl=./en

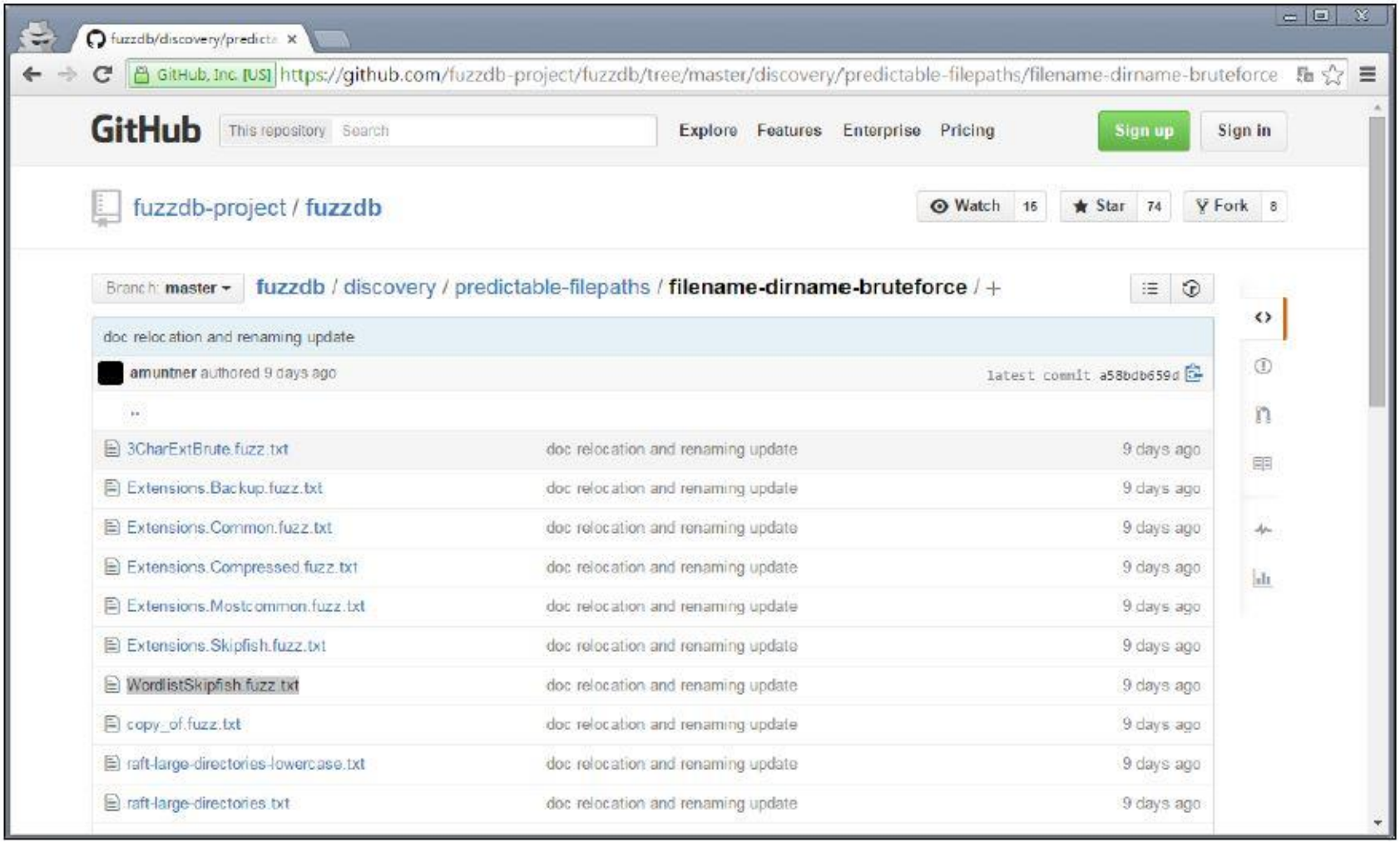
Strange input leads to the Dutch page. Why?

Looking up some documentation (for Django framework used by Instagram)




Instagram
https://instagram.com/?hl=../locale/en
Zoeken
Instagram
LOG IN
Capture and Share the World's Moments
Instagram is a free and simple way to share your life and
up with other people.
Take a picture or video, then customize it with filters and
creative tools. Post it on Instagram and share instantly on
Facebook, Twitter, Tumblr and more—or send it directly a
private message. Find people to follow based on things y
into, and be part of an inspirational community.
Download on the App Store
GET IT ON Google play
Webpage in English, so ../locale/en exists
https://instagram.com/?hl=../locale/en

Using fuzzdb to fuzz common file names



Success!

Fuzzdb finds 42 hits for `../<GUESS>/../locale/nl/`

Facebook's bug bounty program paid Arne 500$

Trying out

https://instagram.com/?hl=../dev/random%00
https://instagram.com/?hl=../dev/urandom%00

could have caused serious damage

The NULL trick

https://instagram.com/?hl=../../../../../../../../../../../../../../../../dev/random%00
https://instagram.com/?hl=../../../../../../../../../../../../../../../../dev/urandom%00

If the attacker's input ends up in the middle of a concatenation, this limits the scope of the attack.
For instance, by supplying malicious `<INPUT>` to

`/usr/local/web/conf/<INPUT>.html`

then attacker can only access files with `.html` extensions

But: with NULL character, URL-encoded as `%00`, at the end of `<INPUT>`, the web server may ignore the rest of the string

More recent example

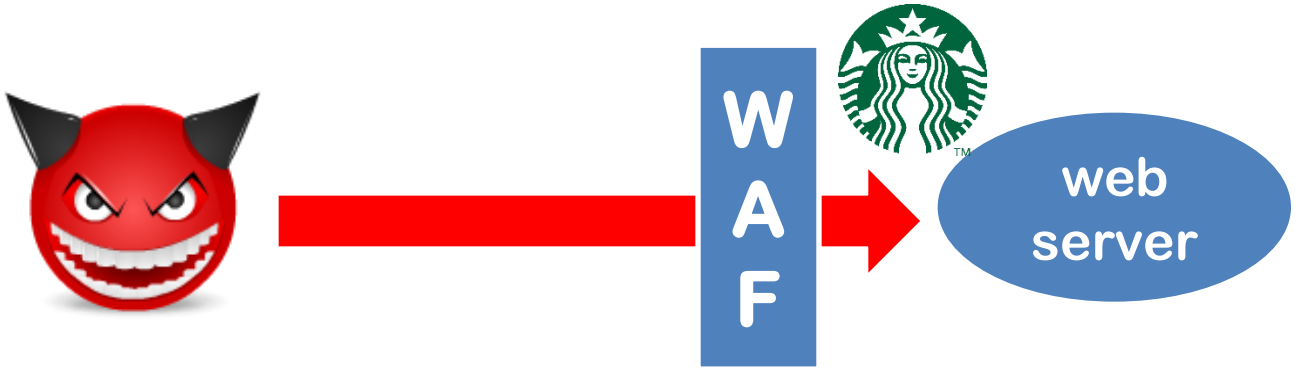
Security researcher earns $4k bug bounty after hacking into Starbucks database

John Leyden 22 June 2020 at 14:18 UTC

Path traversal weakness in a back-end API

Explanation at https://www.youtube.com/watch?v=sjvW79tjWoM

Fooling Starbuck's Web Application Firewall (WAF)



Starbuck's WAF disallows multiple . .

So you cannot include . . / . . in your malicious input ☹

How would you circumvent this?

Type . . / . / . . instead ☺

A WAF (Web Application Firewall) sits in front of the web server and tries to filter very generic malicious inputs. Some WAFs are pretty crappy…

Amazing that directory traversal still exists!

CISA & FBI published alert to get rid of them… in May 2024

Secure by Design Alert: Eliminating Directory Traversal Vulnerabilities in Software

America's Cyber Defense Agency
NATIONAL COORDINATOR FOR CRITICAL INFRASTRUCTURE SECURITY AND RESILIENCE

Publish Date: May 02, 2024

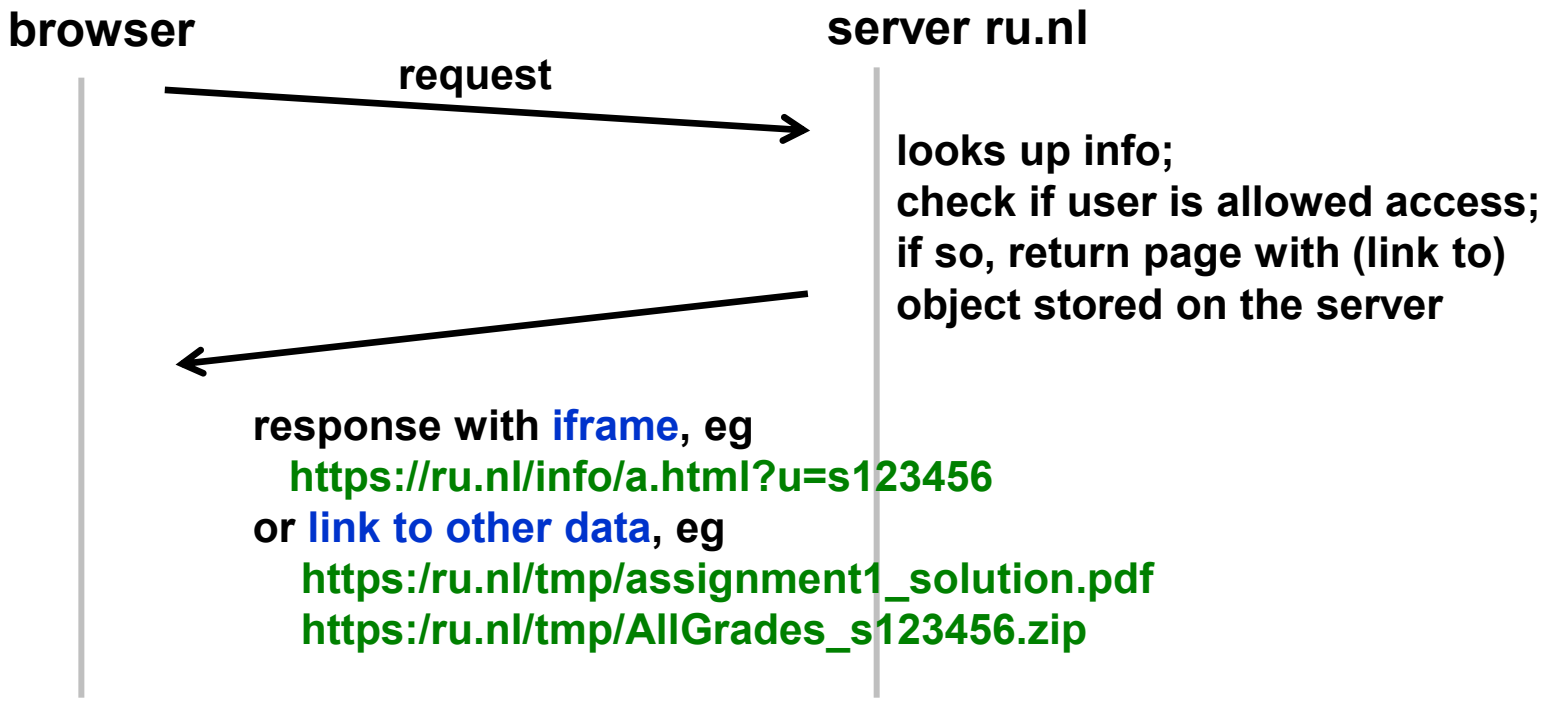
CISA and the Federal Bureau of Investigation (FBI) crafted this Alert in response to recent well-publicized threat actor campaigns that exploited directory traversal vulnerabilities in software (e.g., CVE-2024-1708, CVE-2024-20345) to compromise users of the software—impacting critical infrastructure sectors, including the Healthcare and Public Health Sector. Additionally, this Alert highlights the prevalence, and continued threat actor exploitation of, directory traversal defects.

Currently, CISA has listed 55 directory traversal vulnerabilities in our Known Exploited Vulnerabilities (KEV) catalog. Approaches to avoid directory traversal vulnerabilities are known, yet threat actors continue to exploit these vulnerabilities which have impacted the operation of critical services, including hospital and school operations.

For more information on recommended principles and best practices to achieve this goal, visit CISA's Secure by Design page. To catch up on the publications in this series, visit Secure by Design Alerts.

https://www.cisa.gov/resources-tools/resources/secure-design-alert-eliminating-directory-traversal-vulnerabilities-software

IDOR (Insecure Direct Object Reference)



Attacker could modify the links

and by-pass access control to access other objects

Countermeasure: re-do access control checks for every access!

Path traversal can be viewed as a special case of IDOR

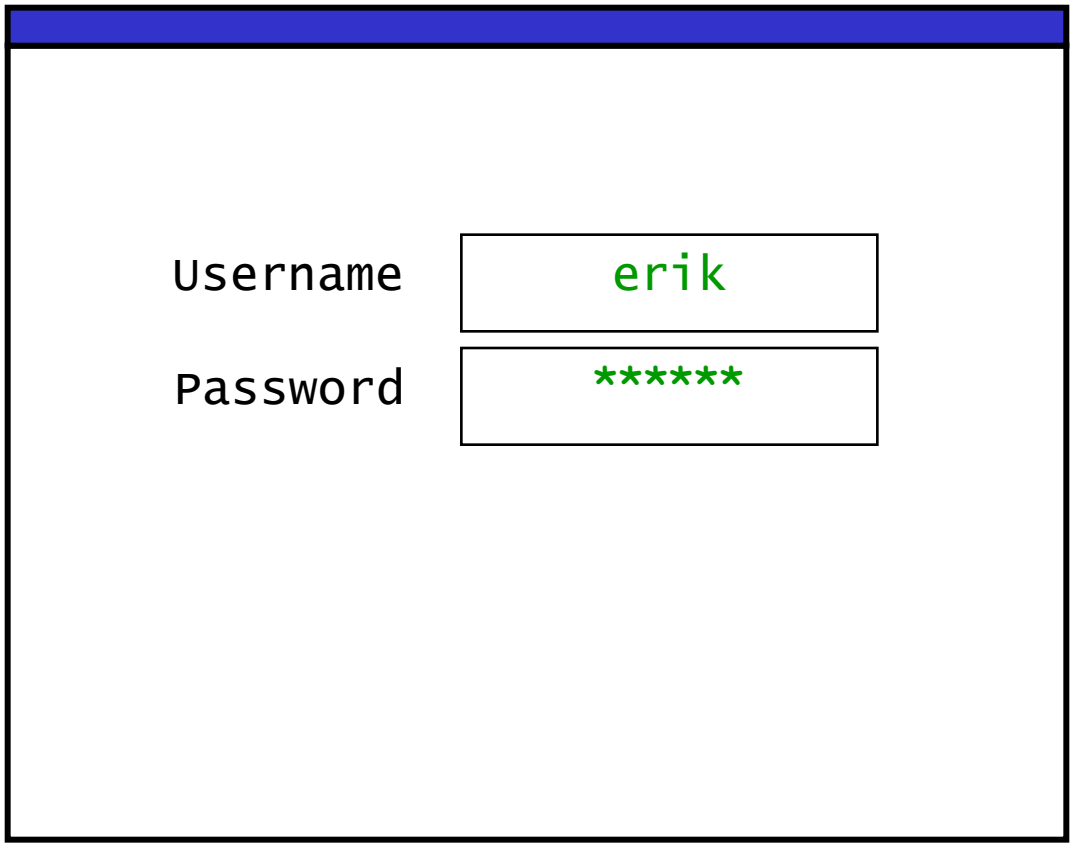
More types of injection attacks

OS command injection and path traversal are only two forms of injection attacks. Others includes

- SQL injection (SQLi)
- XML injection: Xpath injection, XML external entity injection (XXE)
- LDAP injection
- PHP file injection
- JNDI injection
- ..

General principle

SQL injection



SQL injection

Typical PHP code to see if a combination of username/password exists in a database table `Accounts`

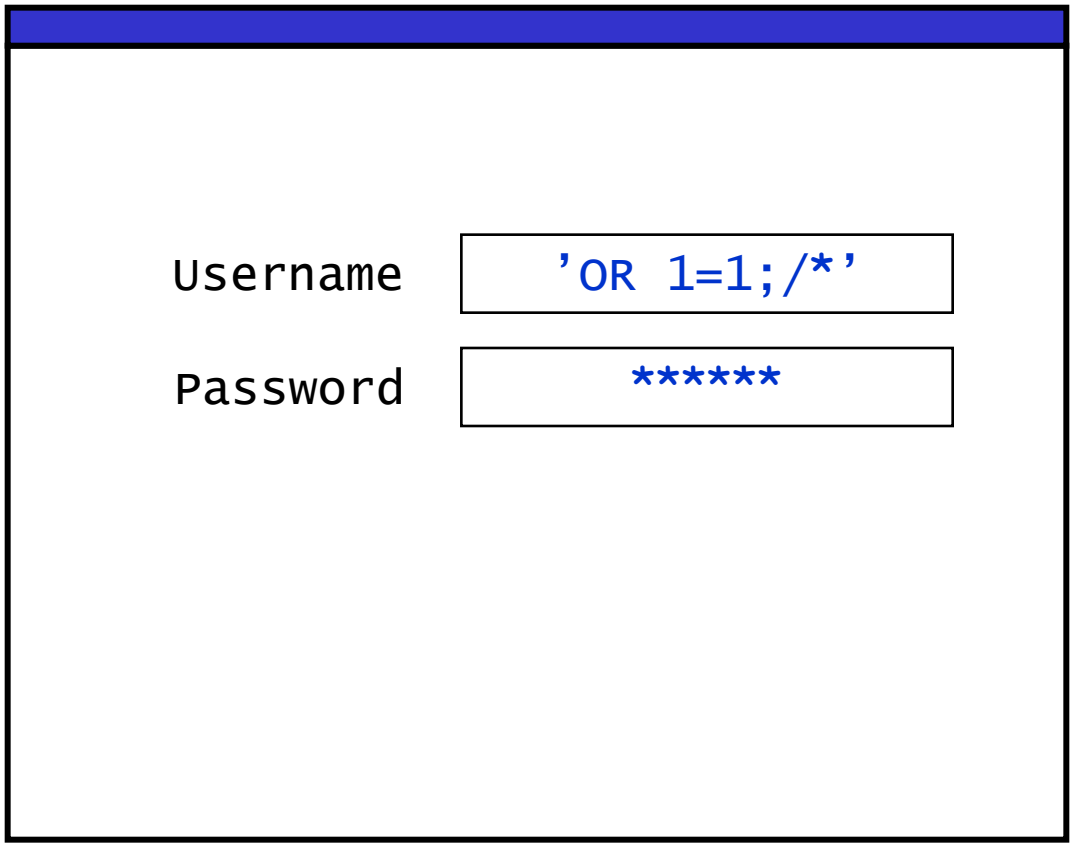
```
$result = mysql_query(
     "SELECT * FROM Accounts".
     "WHERE Username = '$username'".
     "AND Password = '$password';");
if (mysql_num_rows($result)>0)
          $login = true;
```

SQL injection

Resulting SQL query

```
SELECT * FROM Accounts
WHERE Username = 'erik'
AND Password = 'secret';
```

SQL injection



SQL injection

Resulting SQL query

```
SELECT * FROM Accounts
WHERE Username = '' OR 1=1;/*'
AND Password = 'secret';
```

SQL injection

Resulting SQL query

```
SELECT * FROM Accounts
WHERE Username = '' OR 1=1;
/*'AND Password = 'secret';
```

Oops!

Another standard trick to use is to use a SQL `UNION` instead of `'`

SQL injection

SQL injection affect *any* web application written in *any* programming language that connects to SQL database using *dynamic SQL*

- ie the SQL query is constructed dynamically, at runtime

Warning: typical books such as "PHP & MySQL for Dummies" contain sample code with SQL injection vulnerabilities!

Common theme to many injection attacks:

Concatenating strings, some of them user input and then interpreting the result (eg rendering, executing, using as path, ...) is a VERY BAD IDEA

Injection attacks