File Disclosure and Server-Side Request Forgery

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Goal

- Present common file disclosure vulnerabilities and their possible mitigations
- Learn how to perform a Server-Side Request Forgery attack

Prerequisites

- Lecture:
  - *WS_1.1 - HTTP Protocol and Web Security Overview*

Outline

- File Disclosure
  - Impact and Overview
  - Paths 101
  - Path traversal attacks
  - Fixes
- Server-Side Request Forgery

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File Disclosure

- A file disclosure is the **impact of certain vulnerabilities**
- As the name suggests, it consists of the ability to **disclose/leak important files from a server**
- Because it is an impact, there are **multiple classes of vulnerabilities** that **lead to file disclosure**
  - For example, remote code execution is another type of vulnerability that could results in a file disclosure

File Disclosure

- Files inside a server are critical information:
  - In many applications, users-uploaded files are the sensitive information that the application is protecting
  - The disclosure of such files can be a violation of the site policy

File Disclosure

- It is also possible to **steal configuration files** from the webserver **which might contain critical information items**
  - *Database configuration files* often contain the credentials to access the database
  - Files like the *tomcat-users.xml* contain the credentials to access the tomcat manager
  - Files like *flask configuration* or *web.config* in a .net application contain the secret used to sign the session

File Disclosure

- Finally, it is possible to **steal the source code** of the web application
  - For some business, the source code of the web application is its **product/asset**
  - An attacker in possession the source code is more effective
    - It is easier for the attacker to find other vulnerabilities, especially if the application was developed according to a *security by obscurity* model

File Disclosure

- How can a web app disclose internal files?
  - Basically, **everything that works with files can lead to a file disclosure vulnerability**
  - There are standard sinks, and some of them are a trivial
  - If a user-controlled input manages to go inside these sinks, the web app is at risk

File Disclosure

- Some sinks are trivial...
  - Every function in every programming language that manages files
    - Every flavor of **`open/fopen`** in every language
    - Flask **`send_file`**
    - …
- As said before, it is also possible to leak files if the web app suffers from **code execution**

File Disclosure

- Some sin
  - Every fu nguage that manage
    - Every f ge
    - Flask **s**
    - …
- As said b eak files if the web app **n**

```
fopen
tmpfile
bzopen
gzopen
SplFileObject->__construct
// write to filesystem (partially in combination with rea
chgrp
chmod
chown
copy
file_put_contents
lchgrp
lchown
link
mkdir
move_uploaded_file
rename
rmdir
```

File Disclosure

- Some sinl
  - Every fu anguage that manage
    - Every fl age
    - Flask **s**
    - …
- As said be leak files if the web app **on**

```
readfile
readlink
realpath
stat
gzfile
readgzfile
getimagesize
imagecreatefromgif
imagecreatefromjpeg
imagecreatefrompng
imagecreatefromwbmp
imagecreatefromxbm
imagecreatefromxpm
ftp_put
ftp_nb_put
exif_read_data
read_exif_data
exif_thumbnail
exif_imagetype
```

File Disclosure

- Other sinks are less trivial
  - **cURL** is used as a http client. But it can also be used to open files

```php
$fd = curl_init('file:///etc/passwd');
echo curl_exec($a);
```

File Disclosure

- It’s sometimes possible to leak important files just because they are publicly accessible
  - *.git* directory exposed
    - If you make your git directory open to the internet, everyone will be able to dump all files inside it
  - Web-server misrouting
    - It’s sometimes possible to trick a web server to return a .php file as an image...

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Paths 101

- Let us focus on what happens if a user-controlled input finds a way to an open-like function
- We first need to understand few things about how paths work

Paths 101

- An **absolute path** is a path that describes the location of a file regardless of the working directory

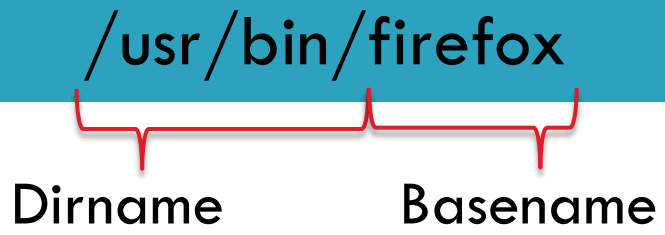
```
/etc/passwd
```

- A **relative path** is a path that describes the location of a file starting from the working directory

```
foo/bar
```

Paths 101

- Paths are composed by a **dirname** and a **basename**
  - The **dirname** is the portion of the path up to the last /
  - The **basename** is the portion of the path after the last /



Paths 101

- Every directory has two special subdirectories:
  - The **current directory**, whose name is .

/foobar/./ ➡ /foobar/

  - And the **parent directory**, whose name is ..

/foobar/../baz ➡ /baz

- The parent directory is useful for file disclosure because it permits to access deeper directories inside the file system

Paths 101

- A path in its **shortest form** is called **normalized**
- For example:
  - */foo/bar* is normalized, there is no way to make it shorter
  - *//foo/bar* is not normalized, /foo/bar is shorter
  - */foo/./bar* is not normalized, /foo/bar is shorter
- What about /foo/test/../bar?

Paths 101

- What about /foo/test/../bar?
- Its shortest form would be /foo/bar, but what happens if /foo/test/ does not exist?
  - If the path is normalized before opened, then everything is fine: we can access /foo/bar without any problem
  - If the path is not normalized, then the open would fail because /foo/test/ does not exist, and so ..

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Path Traversal

- **Path traversal** is a vulnerability that leads to a file disclosure
- It happens when a user-controlled input finds its way into an *open()* or an equivalent function
- If there are no security checks or security sanitizations, an attacker could inject paths that are not meant to be opened

Path Traversal

- **Pat**
- It h
- If th

```
<nowiki>
<?php
$template = 'blue.php';
if ( isset( $_COOKIE['TEMPLATE'] ) )
    $template = $_COOKIE['TEMPLATE'];
include ( "/home/users/web/templates/" . $template );
?>
</nowiki>
```

sanitizations, an attacker could inject paths that are not meant to be opened

Path Traversal

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```

Entry point

ile disc

ds its way

sanitizations, an attacker could inject paths that are not meant to be opened

Path Traversal

- **Path** ile disc
- It h ds its way
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?>
</nowiki>
```

Sink

sanitizations, an attacker could inject paths that are not meant to be opened

Path Traversal

- Few cases might happen:
  - **Plain** injection — open($input)
  - **Prepended** injection — open($input + '/foobar')
  - **Appended** injection — open('/foobar' + $input)
  - **Appended** and **prepended** — open('/foo'+$input+'/bar)

Full Plain Path Traversal

- *open($input)*
- Without security checks, it is possible to leak every file on the filesystem
- Other problems:
  - Protocols like HTTP / gopher / ssh could be used, making it a Server-Side Request Forgery
  - For some functions, it is possible to execute arbitrary code. (For example if the injection is inside Perl's open[1])

1: https://perldoc.perl.org/functions/open

Full Plain Path Traversal

- The exploit for this kind of injection is trivial
  - Just put the path of the file to disclose
- A useful test file on Unix systems is **`/etc/passwd`**
- Why?
  - It always exists and is accessible by every user of the system
  - Is a good target to properly check if there is an actual injection inside an open-like function

Appended Path Traversal

- *open('/somedir/' . $input)*
- It is the most common one
- It is a plain injection without the possibility to use other protocols
- If there is no protection, it is possible to leak every file in the filesystem

Appended Path Traversal

- To exploit this, append some ../ in order to get to the root directory
- In this way, it is possible to access every file of the filesystem
- For example, try to inject:

```
../../../../../etc/passwd
```

Appended Path Traversal


```
https://[redacted]/html/js/editor/editor.jsp?editorImpl=../../../WEB-INF/web.xml?
```

```
HTTP/1.1 200 OK
Content-Type: text/html
Server: Microsoft-IIS/8.5
X-Powered-By: ASP.NET
Date: Thu, 30 Mar 2017 20:24:43 GMT
Connection: close
Content-Length: 54193


<?xml version="1.0"?>

<web-app xmlns="http://java.sun.com/xml/ns/j2ee" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" version="2.4"
    <context-param>
        <param-name>contextClass</param-name>
        <param-value>com.liferay.portal.spring.context.PortalApplicationContext</param-value>
```

Appended Path Traversal


```
https://[redacted]/html/js/editor/editor.jsp?editorImpl=../../../WEB-INF/web.xml?
```

```
HTTP/1.1 200 OK
Content-Type: text/html
Server: Microsoft-IIS/8.5
X-Powered-By: ASP.NET
Date: Thu, 30 Mar 2017 20:24:43 GMT
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<?xml version="1.0"?>

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    <context-param>
        <param-name>contextClass</param-name>
        <param-value>com.liferay.portal.spring.context.PortalApplicationContext</param-value>
```

Prepended Path Traversal

- *open($input . 'someotherdata')*
- A little bit trickier than the previous one, normally in two forms:
  - With an appended extension
    - file_get_content($input . '.txt')
  - Or with an appended filename/directory
    - file_get_contents($input . '/somefile.txt')

Prepended Path Traversal

- Allows the disclosure of files whose path finish with a hardcoded suffix
- There are some tricks

Prepended Path Traversal

- Some languages support the file:// scheme.
- Particularly interesting because it is parsed as a URL
  - file://localhost**/path/to/file**?someotherdata == /path/to/file

```
ubuntu@ip-172-31-24-48:~$ curl file://localhost/etc/passwd\?someotherdata
root:x:0:0:root:/root:/bin/bash
daemon:x:1:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:2:bin:/bin:/usr/sbin/nologin
sys:x:3:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/bin/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
```

Prepended Path Traversal

- Some scripting languages internally use the C function *open*
- Because of how C handles strings, open will **ignore everything after a NULL character** (*\x00*)

```
http://foo.bar/?file=../../etc/passwd%00
```

- This trick worked very well for older versions of PHP, but now is patched

Path Traversal

- A **blacklist** is a common mitigation against these types of vulnerabilities
- A blacklist is used to look for "dangerous" words inside a user-supplied input
- If a dangerous word is found, the system rejects the input or sanitizes it, thus removing the dangerous word

Path Traversal

- Blacklists **are insecure**, because they are error prone
  - You will never be able to insert all the edge cases!
- For example, does a blacklist that contains the word '*proc*' prevent access to the '*/proc/*' directory?
  - No, */dev/fd/* is a link to */proc/self/fd*, so you can access every file of */proc/* with the directory */def/fd/../../*

Path Traversal

- What if we blacklist single dangerous characters like “.” or “/” ?
  - The problem here is congruency. Some languages, javascript in particular, don't handle malformed unicode characters.
  - For example, the unicode character *u012e* (Į), when converted to ascii, is incorrectly transformed to the byte *x2e* (.)
  - You can see that if the blacklist is using *unicode* but the open function is using the *ASCII* encoding then there is a problem

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Fixes

- **Normalize paths**
- In this way there are no "nasty points" inside paths, and it is possible to **enforce a dirname**
  - Pay attention that the function used for normalization parses paths the same way of the open function
    - In this way, you will be able to avoid problems caused by incongruences

Fixes

- Another good mitigation is a **chroot**
- Chroots are "jails" enforced by the OS or by some programming languages
- If a path is set as a chroot, then every access outside this path would be denied by the OS/interpreter
- If an attacker manages to bypass all security checks, he/she will be stopped by the chroot

Fixes

- In summary
  - **Blacklists are insecure**, as they can be bypassed in different ways
  - **Whitelists work better**, but defeat the purpose of passing user input inside an open function
  - **Avoid incongruency**, check paths in the same way you open them

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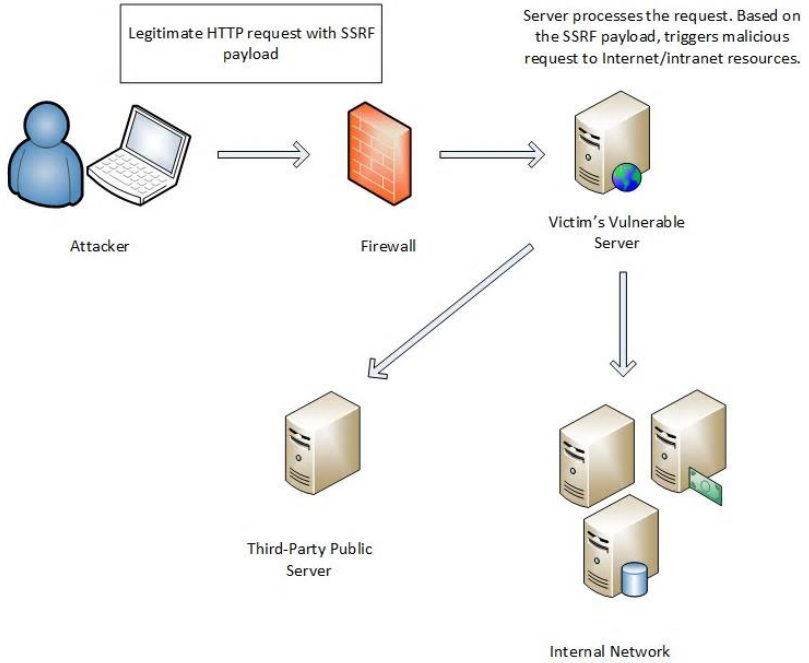
Server-Side Request Forgery

- A **Server-Side Request Forgery** is a vulnerability that allows an attacker to send a network request from the remote application



Server-Side Request Forgery

- The impact varies a lot, depending on the control the attacker has on the forged request:
  - Control over the whole **TCP packet**
  - Control over some parts of an **HTTP request**
  - Control only over the **host/port** to which the request is made
  - …

Server-Side Request Forgery

- SSRFs are dangerous because they allow bypassing the firewall
- If the internal network is not properly designed, it is possible to **access to sensible hosts**, like internal web applications and control panels

Server-Side Request Forgery

- If the vulnerable web application is hosted on a **cloud instance**, things become more interesting
- Some instances have access to specials *URLs* that often contain **critical data**

Server-Side Request Forgery

- For example, AWS instances can access the **metadata API**, at the URL http://169.254.169.254/
- This host contains sensible information such as the **IAM security credentials** and general information about the vulnerable instance[1]

1: https://blog.appsecco.com/an-ssrf-privileged-aws-keys-and-the-capital-one-breach-4c3c2cded3af

Server-Side Request Forgery

- If there is no output, the SSRF is called **blind SSRF**
- It is less dangerous than a normal SSRFs
- With a blind SSRF it is possible to
  - Map the internal network
  - **Trigger actions** on hosts behind the firewall[1]

1: A nice collection of payloads to use:
https://blog.assetnote.io/2021/01/13/blind-ssrf-chains/

Server-Side Request Forgery

- It is possible to map the internal network by trying *URLs/ports*, and by looking at the response time
  - This can be done if the response time of the vulnerable endpoint **depends** on the response time of the SSRF request

Server-Side Request Forgery

- To find an SSRf, you should:
  - Find suspicious endpoints: If you see a URL inside a parameter try to put a URL controlled by you. You can use a tool like ngrok
  - If you have a pingback at your host, then probably you have an SSRF. Then you should try to insert internal hostnames, like "localhost" or common internal IPs (192.168.1.1,10.0.0.1, and so on..)
  - Examine the response time!

Server-Side Request Forgery

alyssa_herrera submitted a report to **U.S. Dept Of Defense**. Mar 15th (2 years ago)

Summary:

An end point on [redacted] allows an internal access to the network thus revealing sensitive data and allowing internal tunneling

Description:

OAuth Plugin allows you to provide a url that gives a snap shot of the web page. We can pass internal URLS and conduct SSRF.

Impact

Critical

Step-by-step Reproduction Instructions

https://[redacted]/plugins/servlet/oauth/users/icon-uri?consumerUri=http://169.254.169.254/latest/meta-data/hostname

We can see the follow data

ip-172-31-12-254.[redacted].compute.internal

https://[redacted]/plugins/servlet/oauth/users/icon-uri?consumerUri=http://169.254.169.254/latest/meta-data/public-ipv4

[redacted]

Server-Side Request Forgery

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https://[redacted]/plugins/servlet/oauth/users/icon-uri?consumerUri=http://169.254.169.254/latest/meta-data/public-ipv4

[redacted]

Server-Side Request Forgery

- Every piece of code that can issue a connection can lead to this vulnerability
- Common functions/libraries are:
  - PHP open-like functions
  - CURL
  - Python's urllib
  - ...

Server-Side Request Forgery


```
def send_email(request):
    try:
        recipients = request.GET['to'].split(',')
        url = request.GET['url']
        proto, server, path, query, frag = urlsplit(url)
        if query: path += '?' + query
        conn = HTTPConnection(server)
        conn.request('GET',path)
        resp = conn.getresponse()
```

Server-Side Request Forgery

Snipped of code from Graphite

```
def send_email(request):
    try:
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```

Server-Side Request Forgery

- Generally speaking, SSRFs are really difficult to avoid
- The most effective way is to check the user-supplied host against a **whitelist**
- Another good mitigation is to make requests from a host that is **isolated from sensitive internal hosts**

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