

# Computer Systems Security

## exercises

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## Preface

This material is prepared for use in *Computer Systems Security workshop* and was prepared by Henrik Lund Kramshøj, <http://www.zencurity.com> . It describes the networking setup and applications for trainings and workshops where hands-on exercises are needed.

Further a presentation is used which is available as PDF from kramse@Github  
Look for system-security-exercises in the repo security-courses.

These exercises are expected to be performed in a training setting with network connected systems. The exercises use a number of tools which can be copied and reused after training. A lot is described about setting up your workstation in the repo

<https://github.com/kramse/kramse-labs>

## Prerequisites

This material expect that participants have a working knowledge of TCP/IP from a user perspective. Basic concepts such as web site addresses and email should be known as well as IP-addresses and common protocols like DHCP.

Have fun and learn

## Exercise content

Most exercises follow the same procedure and has the following content:

- **Objective:** What is the exercise about, the objective
- **Purpose:** What is to be the expected outcome and goal of doing this exercise
- **Suggested method:** suggest a way to get started
- **Hints:** one or more hints and tips or even description how to do the actual exercises
- **Solution:** one possible solution is specified
- **Discussion:** Further things to note about the exercises, things to remember and discuss

Please note that the method and contents are similar to real life scenarios and does not detail every step of doing the exercises. Entering commands directly from a book only teaches typing, while the exercises are designed to help you become able to learn and actually research solutions.

## Exercise 1

### Download Kali Linux Revealed (KLR) Book 10 min



*Kali Linux Revealed Mastering the Penetration Testing Distribution*

#### **Objective:**

We need a Kali Linux for running tools during the course. This is open source, and the developers have released a whole book about running Kali Linux.

This is named Kali Linux Revealed (KLR)

#### **Purpose:**

We need to install Kali Linux in a few moments, so better have the instructions ready.

#### **Suggested method:**

Create folders for educational materials. Go to <https://www.kali.org/download-kali-linux-revealed-book/> Read and follow the instructions for downloading the book.

#### **Solution:**

When you have a directory structure for download for this course, and the book KLR in PDF you are done.

#### **Discussion:**

Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

Kali Linux is a free pentesting platform, and probably worth more than \$10.000

The book KLR is free, but you can buy/donate, and I recommend it.

## Exercise 2

### Check your Kali VM, run Kali Linux 30 min



#### Objective:

Make sure your virtual machine is in working order.

We need a Kali Linux for running tools during the course.

#### Purpose:

If your VM is not installed and updated we will run into trouble later.

#### Suggested method:

Go to <https://github.com/kramse/kramse-labs/>

Read the instructions for the setup of a Kali VM.

#### Hints:

If you allocate enough memory and disk you won't have problems.

#### Solution:

When you have a updated virtualisation software and Kali Linux, then we are good.

#### Discussion:

Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

Kali Linux includes many hacker tools and should be known by anyone working in infosec.

## Exercise 3

### Check your Debian VM 10 min



#### Objective:

Make sure your virtual Debian 9 machine is in working order.

We need a Debian 9 Linux for running a few extra tools during the course.

**This is a bonus exercise - only one Debian is needed per team.**

#### Purpose:

If your VM is not installed and updated we will run into trouble later.

#### Suggested method:

Go to <https://github.com/kramse/kramse-labs/>

Read the instructions for the setup of a Kali VM.

#### Hints:

#### Solution:

When you have a updated virtualisation software and Kali Linux, then we are good.

#### Discussion:

Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.



## Exercise 4

### Investigate /etc 10 min

#### Objective:

We will investigate the /etc directory on Linux

We need a Debian 9 Linux and a Kali Linux, to compare

#### Purpose:

Start seeing example configuration files, including:

- User database /etc/passwd and /etc/group
- The password database /etc/shadow

#### Suggested method:

Boot your Linux VMs, log in

Investigate permissions for the user database files passwd and shadow

#### Hints:

Linux has many tools for viewing files, the most efficient would be less.

```
hlk@debian:~$ cd /etc
hlk@debian:/etc$ ls -l shadow passwd
-rw-r--r-- 1 root root 2203 Mar 26 17:27 passwd
-rw-r----- 1 root shadow 1250 Mar 26 17:27 shadow
hlk@debian:/etc$ ls
... all files and directories shown, investigate more if you like
```

Showing a single file: less /etc/passwd and press q to quit

Showing multiple files: less /etc/\* then :n for next and q for quit

Trying reading the shadow file as your regular user:

```
user@debian-9-lab:/etc$ cat /etc/shadow
cat: /etc/shadow: Permission denied
```

Why is that? Try switching to root, using su or sudo, and redo the command.

**Solution:**

When you have seen the most basic files you are done.

**Discussion:**

Linux is free and everywhere. The tools we will run in this course are made for Unix, so they run great on Linux.

## Exercise 5

### Discover active systems ping sweep 10 min



#### Objective:

Use nmap to discover active systems

#### Purpose:

Know how to use nmap to scan networks for active systems.

#### Suggested method:

Try different scans,

- Ping sweep to find active systems
- Port sweeps to find active systems with specific ports

#### Hints:

Try nmap in sweep mode - and you may run this from Zenmap

#### Solution:

Use the command below as examples:

- Ping sweep `nmap -sP 10.0.45.*`
- Port sweeps `nmap -p 80 10.0.45.*`

#### Discussion:

Quick scans quickly reveal interesting hosts, ports and services

Also now make sure you understand difference between single host scan `10.0.45.123/32`, a whole subnet `/24` 250 hosts `10.0.45.0/24` and other more advanced targeteting like `10.0.45.0/25` and `10.0.45.1-10`

## Exercise 6

### Execute nmap TCP and UDP port scan 20 min

**Objective:**

Use nmap to discover important open ports on active systems

**Purpose:**

Finding open ports will allow you to find vulnerabilities on these ports.

**Suggested method:**

Use `nmap -p 1-1024 server` to scan the first 1024 TCP ports and use Nmap without ports. What is scanned then?

Try to use `nmap -sU` to scan using UDP ports, not really possible if a firewall is in place.

If a firewall blocks ICMP you might need to add `-Pn` to make nmap scan even if there are no Ping responses

**Hints:**

Sample command: `nmap -Pn -sU -p1-1024 server` UDP port scanning 1024 ports without doing a Ping first

**Solution:**

Discover some active systems and most interesting ports, which are 1-1024 and the built-in list of popular ports.

**Discussion:**

There is a lot of documentation about the nmap portscanner, even a book by the author of nmap. Make sure to visit <http://www.nmap.org>

TCP and UDP is very different when scanning. TCP is connection/flow oriented and requires a handshake which is very easy to identify. UDP does not have a handshake and most applications will not respond to probes from nmap. If there is no firewall the operating system will respond to UDP probes on closed ports - and the ones that do not respond must be open.

When doing UDP scan on the internet you will almost never get a response, so you cannot tell open (not responding services) from blocked ports (firewall drop packets). Instead try using specific service programs for the services, sample program could be `nsping` which sends DNS packets, and will often get a response from a DNS server running on UDP port 53.

## Exercise 7

### Perform nmap OS detection 10 min

**Objective:**

Use nmap OS detection and see if you can guess the brand of devices on the network

**Purpose:**

Getting the operating system of a system will allow you to focus your next attacks.

**Suggested method:**

Look at the list of active systems, or do a ping sweep.

Then add the OS detection using the option `-O`

Better to use `-A` all the time, includes even more scripts and advanced stuff See the next exercise.

**Hints:**

The nmap can send a lot of packets that will get different responses, depending on the operating system. TCP/IP is implemented using various constants chosen by the implementors, they have chosen different standard packet TTL etc.

**Solution:**

Use a command like `nmap -O -p1-100 10.0.45.45` or `nmap -A -p1-100 10.0.45.45`

**Discussion:**

nmap OS detection is not a full proof way of knowing the actual operating system, but in most cases it can detect the family and in some cases it can identify the exact patch level of the system.

## Exercise 8

### Run Armitage - Hail Mary 30min

**Objective:**

Try hacking using a graphical program, see how quick and easy it can be.

**Purpose:**

Show that when a vulnerability exist attacks can be quick and easy.

**Suggested method:**

Running Armitage as a gui on top of Metasploit is the easiest way to do this.

1. Boot up Kali Linux
2. Boot up Metasploitable - from ISO  
There may be a couple of systems already running this.
3. Run Armitage Hail-Mary against Metasploitable
4. Note which succeeded, describe those attacks that succeeded in relation to MITRE ATT&CK framework

**Hints:**

Running Metasploit against Metasploitable - which is a vulnerable system - should result in multiple vulnerabilities exploited.

Each of these may have different characteristics.

We are aiming at:

- Vulnerable application - root access
- Vulnerable application - non-root access, would need privilege escalation
- Bad password allowing Brute Force access, msfadmin/msfadmin - see also *Valid Accounts*

**Solution:**

When you have exploited and mapped at least one vulnerability you are done, but should spend more time.

**Discussion:**

Do we need these frameworks? What are the benefits? - can we become product blind - so we only see what these framework cover.

## Exercise 9

### SELinux Introduction up to 60min

**Objective:**

Check out the SELinux system

<https://www.debian.org/doc/manuals/debian-handbook/sect.selinux.en.html>

and the setup instructions at:

<https://wiki.debian.org/SELinux/Setup>

(Not working right now - Create a secret file, that you can read, but root cant.)

**Purpose:**

Everybody reads about Discretionary Access Control (DAC) and Mandatory Access Control (MAC) but few realize that Linux implements it.

**Suggested method:**

Try enabling and disabling the policies in your Debian VM.

First install prerequisites - approx 75MB download on my system:

```
apt-get install selinux-basics selinux-policy-default auditd
```

Then run activation of SELinux:

```
selinux-activate
```

```
root@debian-9-lab:~# selinux-activate
Activating SE Linux
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-4.9.0-9-amd64
Found initrd image: /boot/initrd.img-4.9.0-9-amd64
Found linux image: /boot/vmlinuz-4.9.0-8-amd64
Found initrd image: /boot/initrd.img-4.9.0-8-amd64
done
SE Linux is activated. You may need to reboot now.
root@debian-9-lab:~#
```

Perform the reboot, `shutdown -r now` then check again.

Not enabled will show this, try again:

```
root@debian-9-lab:~# sestatus
SELinux status: disabled
```



Enabled, but not the current mode and mode from config file discrepancy:

```
root@debian:~# sestatus
SELinux status:                enabled
SELinuxfs mount:              /sys/fs/selinux
SELinux root directory:       /etc/selinux
Loaded policy name:            default
Current mode:                  enforcing
Mode from config file:        permissive
Policy MLS status:            enabled
Policy deny_unknown status:    allowed
Max kernel policy version:     30
```

While playing I had changed the mode temporarily to *enforcing*! Next reboot would make SELinux run in the more *permissive* mode

### 9.0.1 Part 2 - do this when SELinux is enabled

Create a directory and a test file:

```
root@debian:~# setenforce 0    // set mode permissive!
root@debian:~# cd
root@debian:~# mkdir /etc/private
root@debian:~# echo "hey" > /etc/private/README
root@debian:~# cat /etc/private/README
hey
root@debian:~#
```

Root can read the file, yay!

Copy example files:

```
cp -r /usr/share/doc/selinux-policy-dev/examples .
cd examples/
```

Create a file `myprivate.te` with this content:

```
policy_module(myprivate, 1.0)

#####
#
# Declarations
#
type etc_private_t;
```

```
fs_associate(etc_private_t)

type sysadm_t;
type sysadm_exec_t;

userdom_admin_user_template(sysadm_t)

allow sysadm_t etc_private_t:dir file relabelto;
```

Note last line is missing a sysadm domain, does not work.

Then compile using this: make myprivate.pp

```
root@debian:~/examples# make myprivate.pp
Compiling default myprivate module
/usr/bin/checkmodule: loading policy configuration from tmp/myprivate.tmp
/usr/bin/checkmodule: policy configuration loaded
/usr/bin/checkmodule: writing binary representation (version 17) to tmp/myprivate.mod
Creating default myprivate.pp policy package
rm tmp/myprivate.mod.fc tmp/myprivate.mod
root@debian:~/examples#
```

then it should have been possible to enable/disable enforcing mode, and see the file becoming unreadable - even by root.

Something is wrong, when enabling enforcing mode, the chcon command fails:

```
root@debian:~/examples# setenforce 1
root@debian:~/examples# chcon -R -t etc_private_t /etc/private/README
chcon: failed to change context of '/etc/private/README' to 'system_u:object_r:etc_private_t:s0'
root@debian:~/examples# chcon -R -t etc_private_t /etc/private
chcon: failed to change context of 'README' to 'system_u:object_r:etc_private_t:s0': Invalid a
chcon: failed to change context of '/etc/private' to 'system_u:object_r:etc_private_t:s0': Inv

root@debian:~/examples# setenforce 0
root@debian:~/examples# chcon -R -t etc_private_t /etc/private/README
root@debian:~/examples#
// When Linux returns to the command prompt without messages no errors were observed
```

So SELinux IS preventing us from doing it :-D

this example is in parts based on this blog post:

<http://blog.siphos.be/2015/07/restricting-even-root-access-to-a-folder/>

#### Hints:

Keeping SELinux enabled may NOT be a good idea, since some tools may not work correctly, until policies are downloaded, written or installed.

**Temporarily disable SELinux:**

```
echo 0 > /sys/fs/selinux/enforce
```

**Temporarily enable SELinux:**

```
echo 1 > /sys/fs/selinux/enforce
```

or use the command `setenforce 0` or `setenforce 1`

The main config for setting permissive or enforcing mode is `/etc/selinux/config`:

```
root@debian-9-lab:~# cat /etc/selinux/config
# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
# enforcing - SELinux security policy is enforced.
# permissive - SELinux prints warnings instead of enforcing.
# disabled - No SELinux policy is loaded.
SELINUX=permissive
# SELINUXTYPE= can take one of these two values:
# default - equivalent to the old strict and targeted policies
# mls      - Multi-Level Security (for military and educational use)
# src      - Custom policy built from source
SELINUXTYPE=default

# SETLOCALDEFS= Check local definition changes
SETLOCALDEFS=0
```

**Solution:**

When you have enabled and seen the commands used, you are done.

It is easy to have multiple hours disappear when working with SELinux.

**Discussion:**

Yes, the root user can disable the SELinux protection :-D

I had Firefox crash at least once during this exercise, so beware - fancy and bigger applications may crash when using this!

## Exercise 10

### Example AUPs up to 30min

**Objective:**

See real world high level policies

**Purpose:**

When writing your first policy it may be hard to know what to include. Starting from an example is often easier.

**Suggested method:**

Find your AUP for the ISPs we use, you use, your company uses.

**Hints:**

Policies for different environments are often very different in scope and goals.

Book mentions military and commercial, but an ISP, University and a commercial enterprise have very different methods and requirements.

Example, how do you handle BYOD Bring your own devices, University you expect students to bring them, in a secure enterprise only company devices may be allowed.

**Solution:**

When you have seen at least two different policies you are done.

**Discussion:**

How do you both write AND create awareness about a policy?

## Exercise 11

### SYN flooding 101

#### Objective:

Start a webserver attack using SYN flooding tool hping3.

#### Purpose:

See how easy it is to produce packets on a network using hacker programs.

The tool we will use is very flexible and can produce ICMP, UDP and TCP using very few options.

```
-1 --icmp
    ICMP mode, by default hping3 will send ICMP echo-request, you can set other ICMP
    type/code using --icmptype --icmpcode options.

-2 --udp
    UDP mode, by default hping3 will send udp to target host's port 0.  UDP header  tunable
    options are the following: --baseport, --destport, --keep.
```

TCP mode is default, so no option needed.

#### Suggested method:

Connect to the LAB network using Ethernet! Borrow a USB network card if you dont have one.

Start your Kali VM in bridged mode, try a basic TCP flooding attack against the server provided by the instructor, or your own Debian server.

```
hping3 --flood -p 80 10.0.45.12
```

You should see something like this:

```
HPING 10.0.45.12: NO FLAGS are set, 40 headers + 0 data bytes
hping in flood mode, no replies will be shown
^C
--- 10.0.45.12 hping statistic ---
352339 packets transmitted, 0 packets received, 100% packet loss
round-trip min/avg/max = 0.0/0.0/0.0 ms
```

Try doing the most common attacks, RTFM hping3:

- ICMP flooding

- UDP flooding, try port 53 and port 123
- TCP flooding, try port 22 or port 80 on your debian perhaps

**Hints:**

The tool we use can do a lot of different things, and you can control the speed. You can measure at the server being attacked or what you are sending, commonly using ifpps or such programs can help.

This allows you to use the tool to test devices and find the breaking point, which is more interesting than if you can overload, because you always can.

```
-i --interval
    Wait the specified number of seconds or micro seconds between sending each packet.
    --interval X set wait to X seconds, --interval uX set wait to X micro seconds. The de-
    fault is to wait one second between each packet. Using hping3 to transfer files tune
    this option is really important in order to increase transfer rate. Even using hping3
    to perform idle/spoofing scanning you should tune this option, see HPING3-HOWTO for
    more information.

--fast Alias for -i u10000. Hping will send 10 packets for second.

--faster
    Alias for -i u1. Faster then --fast ;) (but not as fast as your computer can send pack-
    ets due to the signal-driven design).

--flood
    Sent packets as fast as possible, without taking care to show incoming replies. This
    is ways faster than to specify the -i u0 option.
```

**Solution:**

When your team has sent +1 million packets per second into the network, from one or two laptops - you are done.

**Discussion:**

Gigabit Ethernet can send up to 1.4 million packets per second, pps.

There is a presentation about DDoS protection with low level technical measures to implement at

<https://github.com/kramse/security-courses/tree/master/presentations/network/introduction-ddos-testing>

## Exercise 12

### RBAC Access permissions on GitHub 30-45min

**Objective:**

See actual real life example of permissions.

Note: This exercise requires a GitHub account, so make sure your group has one. Maybe do groups of 3-4 for more discussion.

**Purpose:**

GitHub is a very popular code sharing site.

**Suggested method:**

Go to GitHub web page:

<https://help.github.com/en/articles/access-permissions-on-github>

Follow links to other pages, like:

<https://help.github.com/en/articles/permission-levels-for-an-organization>

**Hints:**

Some might already have an account on GitHub - maybe work through adding a repository and adding collaborators.

If you have an organisation, even better.

**Solution:**

When you have discussed GitHub permissions and played with a repository you are done.

**Discussion:**

The internet is decentralized, but recent years see more centralization - GitHub, DNS Google DNS, Cloudflare.

What are some problems in this?

## Exercise 13

### SSL/TLS scanners 15 min

**Objective:**

Try the Online Qualys SSLabs scanner <https://www.ssllabs.com/> Try the command line tool sslscan checking servers - can check both HTTPS and non-HTTPS protocols!

**Purpose:**

Learn how to efficiently check TLS settings on remote services.

**Suggested method:**

Run the tool against a couple of sites of your choice.

```
root@kali:~# sslscan --ssl2 web.kramse.dk
Version: 1.10.5-static
OpenSSL 1.0.2e-dev xx XXX xxxx

Testing SSL server web.kramse.dk on port 443
...
  SSL Certificate:
Signature Algorithm: sha256WithRSAEncryption
RSA Key Strength:    2048

Subject: *.kramse.dk
AltNames: DNS:*.kramse.dk, DNS:kramse.dk
Issuer:  AlphaSSL CA - SHA256 - G2
```

Also run it without --ssl2 and against SMTPTLS if possible.

**Hints:**

Originally sslscan is from <http://www.titania.co.uk> but use the version on Kali, install with apt if not installed.

**Solution:**

When you can run and understand what the tool does, you are done.

**Discussion:**

SSLscan can check your own sites, while Qualys SSLabs only can test from hostname



## Exercise 14

### Nmap Ikescan IPsec

unfinished, will be updated later

**Objective:**

Try Nmap and Ikescan

**Purpose:**

**Suggested method:**

**Hints:**

**Solution:**

**Discussion:**

## Exercise 15

### SSH scanners

unfinished, will be updated later

**Objective:**

Try ssh scanners, similar to sslscan and Nmap sshscan

**Purpose:**

**Suggested method:**

**Hints:**

**Solution:**

**Discussion:**

## Exercise 16

### Password Cracking

unfinished, will be updated later

**Objective:**

ex:priv-esc-cron Crack your own passwords **Purpose:**

**Suggested method:**

**Hints:**

**Solution:**

**Discussion:**

## Exercise 17

### Perform privilege escalation using files 30min

**Objective:**

Perform a simple privilege escalation attack

**Purpose:**

Try and test a back door script.

**Suggested method:**

1. Make a non-privileged user
2. make a system directory writable
3. create root cronjob without path
4. Insert a malicious script as one of the commands from the root cron job

**Hints:**

A cron job runs scheduled commands. They usually perform cleanup functions, removing old files, doing a backup or similar

In this exercise first try out the malicious commands for creating a back door shell program. Login in as root, then:

```
root@debian:~# rm /tmp/.xxsh
root@debian:~# cp /bin/dash /tmp/.xxsh
root@debian:~# chmod +sw /tmp/.xxsh
```

Then test using a normal user, another window:

```
hlk@debian:~$ /tmp/.xxsh
# id
uid=1000(hlk) gid=1000(hlk) euid=0(root) egid=0(root) groups=0(root),24(cdrom),25(floppy),29
s0:c0.c1023
#
```

The effective user id should be 0 which is root.

When this manual process work. Then automate it, make it into a script like in the book. Imagine if the root user was running automated scripts, and you could add yours to a directory used in the PATH for these automated ones.

This happens in a lot of devices and hosts today.

The main takeaway is that root scripts should ALWAYS have a PATH defined, and ALL directories used by root script should only be writable by root!

**Solution:**

When you have created the script for doing the shell copy you are done.

Further advanced steps would be to add this into some PATH writable by you, and letting a cron job escalate.

Then do a cron job that uses this command - a cron job running every 5 minutes using the `ls` command and introduce your malicious script by putting it before the real command in the PATH.

**Discussion:**

This was chosen as I found a similar vulnerability in a professional product, in 2019

## Exercise 18

### Anti-virus and "endpoint security" 20min

**Objective:**

Discuss when to use Anti-virus and "endpoint security"

**Purpose:**

Anti-virus programs have been shown to catch some viruses, useful.

Anti-virus programs have been shown to be insecure programs that also slows down systems, counter-productive and increases target surface and exposure.

**Suggested method:**

Sit in groups 3-5 – discuss among yourselves. Write down plus and minus for using anti-virus – especially which use-cases should use AV, and which shouldn't.

**Hints:**

In some cases people have installed AV products for check-mark security, the check-list said to have AV, so we installed a mail scanner on this web server – bad security.

**Solution:**

When we have done a collected talk and discussion we are done.

**Discussion:**

I dont use anti-virus products at all. I do use a lot of backup though.

Which is more trust-worthy - a restored system or a system cleaned by random anti-virus program?

## Exercise 19

### Email Security 2019 up to 45min

#### Objective:

Talk and plan roll-out of security mechanisms based on DNS records. Domain Name System. Check you personal domain and domain used for work. If you are new to this I suggest experimenting with your own personal domain, or create one.

#### Purpose:

Make sure everyone attending know about methods to restrict sending of false emails, how to secure this using DNSSEC, SPF, DMARC - DNS based updates to your email domain security

#### Email security 2019 - Goals

- SPF Sender Policy Framework  
[https://en.wikipedia.org/wiki/Sender\\_Policy\\_Framework](https://en.wikipedia.org/wiki/Sender_Policy_Framework)
- DKIM DomainKeys Identified Mail  
[https://en.wikipedia.org/wiki/DomainKeys\\_Identified\\_Mail](https://en.wikipedia.org/wiki/DomainKeys_Identified_Mail)
- DMARC Domain-based Message Authentication, Reporting and Conformance  
<https://en.wikipedia.org/wiki/DMARC>
- DANE DNS-based Authentication of Named Entities  
[https://en.wikipedia.org/wiki/DNS-based\\_Authentication\\_of\\_Named\\_Entities](https://en.wikipedia.org/wiki/DNS-based_Authentication_of_Named_Entities)
- Brug allesammen, check efter ændringer!

#### DNS-based Authentication of Named Entities (dane)

"TLSA records store hashes of remote server TLS/SSL certificates. The authenticity of a TLS/SSL certificate for a domain name is verified by DANE protocol (RFC 6698). DNSSEC and TLSA validation results are displayed by using several icons."

#### Suggested method:

Use services on the internet, such as <https://internet.nl/> and <https://dmarcian.com/> to see current status for your domains.

#### Hints:

I suggest the following strategy when you implement these methods, if you dare do it right now. If you make a plan.

## Basic mail security 2019

1. Implement DNSSEC - turn it on, most likely easy
2. Configure Sender Policy Framework, perhaps only `~all` tilde means soft fail
3. Configure DomainKeys Identified Mail
4. Configure receiving email address for DMARC
5. Configure Domain-based Message Authentication - reject none

Spend some time trying different tools for DMARC reporting. A month or a week, depending on the domain and your users. Github alone has 100s of projects concerned with parsing, reporting and working with DMARC.

Then after some time has passed, and you have reviewed reporting from DMARC, turn it on for real:

1. Configure SPF to disallow with hard fail use `-all` minus
2. Configure DMARC with reject - reject emails not following policy

## Advanced mail security 2019

1. Create real certificates for DANE
2. Publish them ☺

Helpful hints from <https://blog.apnic.net/2017/01/06/lets-encrypt-dane/>

### Solution:

When the internet is ridden of falsified spam you are done ☺ - its up to you.

### Discussion:

You need to research before making changes to important domains.

If you have domains that *never send email* then add the following SPF and DMARC to avoid misuse.

from my own DSN template for *parked domains*:

```
gdns.template v=spf1 -all 43200
_dmarc.gdns.template v=DMARC1; p=reject; 43200
```



## Exercise 20

### Research Virtual Machine Escapes 20min

#### Objective:

Research how exploits currently as escaped from Guest Virtual Machine to Host operating system. Multiple examples exist for both client virtualisation and datacenter virtualisation.

#### Purpose:

Research VM escapes - understand that isolation and separation does not always work. Think about how to design systems with this in mind.

Perhaps virtualisation should be built using two clusters, one for external services and one for internal?

#### Suggested method:

Find list of CVE or do internet search. Perform searches using the virtualisation technology used in your networks. Note: even though Virtual box is used as example below other technologies like Microsoft HyperV, VMware, Xen etc. have similar problems!

examples:

- <https://cve.mitre.org/cgi-bin/cvekey.cgi?keyword=virtualbox> list multiple vulnerabilities.
- [https://github.com/MorteNoir1/virtualbox\\_e1000\\_0day](https://github.com/MorteNoir1/virtualbox_e1000_0day) *VirtualBox E1000 Guest-to-Host Escape* The E1000 has a vulnerability allowing an attacker with root/administrator privileges in a guest to escape to a host ring3. Then the attacker can use existing techniques to escalate privileges to ring 0 via /dev/vboxdrv.

#### Hints:

Providing virtualisation is today done using hardware features in the CPU of the system. Along with the hardware features are drivers and features provided by the virtualisation system, which has errors.

Having drivers and kernel modules with errors can sometimes result in flaws exploitable by guest virtual machines.

#### Solution:

There is no solution other than to patch systems, when new vulnerabilities are found - update your virtualisation NOW if you are missing updates.

Never open virtual machines from untrusted sources on your laptop with confidential

data. Don't trust that the security provided is enough for researching live malware on virtual systems.

**Discussion:**

Is it possible to create multiple virtualisation cluster? - yes, some organisations already have multiple clusters for various reasons. Some might have development, staging and production as different clusters.

Also be aware that a lot of malware has checks trying to find out if it is running in a virtual machine, or isolated in a lab.

## Exercise 21

### Centralized syslog 15min

#### Objective:

See how server syslog is configured on regular Unix/Linux.

Centralized syslogging and example system can demonstrate how easy it is to get started

#### Purpose:

The main idea of this exercise is to understand how easy network connected systems can send log data.

This should be the common case, sending logs off system - to avoid an attacker being able to hide tracks and logs from exploits performing intrusion and escalation.

#### Suggested method:

Log into your local Linux systems or network devices, see how syslog is configured.

#### Hints:

Look in the config file, may be in /etc/syslog or /etc/syslog-ng/syslog-ng.conf

Sample output from old-skool syslogd

```
*.err;kern.debug;auth.notice;authpriv.none;mail.crit    /dev/console
*.notice;auth,authpriv,cron,ftp,kern,lpr,mail,user.none /var/log/messages
kern.debug;user.info;syslog.info                        /var/log/messages
auth.info                                               /var/log/authlog
authpriv.debug                                         /var/log/secure
...
# Uncomment to log to a central host named "loghost".
#*.notice;auth,authpriv,cron,ftp,kern,lpr,mail,user.none @loghost
#kern.debug,user.info,syslog.info                        @loghost
#auth.info,authpriv.debug,daemon.info                  @loghost
```

#### Solution:

When you understand how to configure syslog from a couple of devices and has looked up which protocol and port it uses. (default is 514/udp)

#### Discussion:

There are syslog senders for Windows too. Other systems define their own format for sending, example Beats - lightweight data shippers <https://www.elastic.co/products/beats>

I recommend using the elastic stack, previously the ELK stack, <https://www.elastic.co/products/>. The products can be used without license and can give a lot of experience with this kind of product. This will enable you to better describe your logging needs for evaluating other products.

This is done using Logstash as the server - can also receive SNMP traps!

Logstash is an open source, server-side data processing pipeline that ingests data from a multitude of sources simultaneously, transforms it, and then sends it to your favorite “stash.” - often Elasticsearch <https://www.elastic.co/products/logstash>

Other very popular systems are:

- Splunk <https://www.splunk.com>
- Graylog <https://www.graylog.org/>
- InfluxDB <https://www.influxdata.com/>
- Grafana The open platform for analytics and monitoring <https://grafana.com/>
- Prometheus Monitoring system & time series database <https://prometheus.io/>

Remember doing logging og performance metrics can also become a security characteristics. Availability is a critical metric for most commercial systems.

## Exercise 22

### Create Kibana Dashboard 15min



**Objective:**  
See Kibana and understand how it is configured.

**Purpose:**  
Kibana is a very popular system for creating dashboards from data in elasticsearch.

Learning how to create and import dashboards is a good exercise.

**Suggested method:**  
Instructor will provide a running Elasticsearch and Kibana for this exercise.

Note: usually Kibana should be available on port 5601 on localhost (127.0.0.1) only!  
It is recommended to keep this configuration and then add a web server like Nginx or Apache in front. This will further allow authentication and other features.

Using Firefox visit Kibana on the link provided by the instructor.

If this is the first time you need to select `logstash-*` as a default index. Note: Kibana is an advanced and powerful tool in itself.

Read how dashboards can be loaded using shell command, example the ones from:  
<https://github.com/StamusNetworks/KTS6>

The commands are similar to

```
git clone https://github.com/StamusNetworks/KTS6.git
cd KTS6
bash load.sh
```

**Hints:**

Logstash and Elastic stack are a great way to get started with dashboarding.

However, running a big installation is harder than it looks. Make sure to have multiple servers and good monitoring.

**Solution:** When you have browsed Kibana, seen how you can add graphs and combine them into dashboards - using the GUI you are done. Previously creating dashboards was harder and often required programming knowledge.

**Discussion:**

Making dashboard are an art form. We will NOT start creating beautiful dashboards.

If you want, there is a SELKS LiveCD dedicated to suricata which also includes more tools for administration of rules and getting alerts:  
<https://www.stamus-networks.com/open-source/>

## Exercise 23

### File System Forensics 30min



**Objective:**

Open a file system dump

**Purpose:**

Learn a bit of computer forensics using a free tool.

**Suggested method:**

We will use a free toolkit, and an older version - easier to install.

The Sleuth Kit® is a collection of command line tools and a C library that allows you to analyze disk images and recover files from them. It is used behind the scenes in Autopsy and many other open source and commercial forensics tools.

Autopsy® is an easy to use, GUI-based program that allows you to efficiently analyze hard drives and smart phones. It has a plug-in architecture that allows you to find add-on modules or develop custom modules in Java or Python.

<http://www.sleuthkit.org/>

1. Install tools
2. Acquire test images - download file system images
3. Open test images using tools

Installing the tools is described on the web page, but using apt on Kali Linux should be OK. Note: this is not the newest version!

Test images can be found at:

<http://dftt.sourceforge.net/>

Example, the EXT3FS file system:

<http://dftt.sourceforge.net/test4/index.html>

For this do the following - tested on Kali Linux:

1. Install tools

```
apt-get install autopsy sleuthkit testdisk
```

2. Acquire test images - download and unzip

```
cd ~; mkdir forensic; cd ~/forensic; unzip
```

3. Start autopsy from command line

4. Open test images using tools, use a browser <http://localhost:9999/autopsy>

5. Add a new case, fill out wizards case: "My case", investigator: "hlk"

6. Add host, fill out wizard, name: "host1", time zone: "CEST"

7. Add image file - location full path to the file containing a file system, choose type: "partition" with symlink is fine

8. Then use the analyze button to start analyzing this file system

9. Click and get a feel for the tool

```
user@KaliVM:~$
user@KaliVM:~$ mkdir forensic
user@KaliVM:~$ cd forensic/
user@KaliVM:~/forensic$ unzip ../Downloads/4-kwsrch-ext3.zip
Archive:  ../Downloads/4-kwsrch-ext3.zip
  inflating: 4-kwsrch-ext3/COPYING-GNU.txt
  inflating: 4-kwsrch-ext3/README.txt
  inflating: 4-kwsrch-ext3/ext3-img-kw-1.dd
  inflating: 4-kwsrch-ext3/index.html
user@KaliVM:~/forensic$ pwd
/home/user/forensic
user@KaliVM:~/forensic$
```

**Note:** I run as user hlk, so note down the full path for the imagefile, in my case `/home/user/forensic/4-kwsrch-ext3/ext3-img-kw-1.dd`

```
root@KaliVM:~# autopsy
```

```
=====

Autopsy Forensic Browser
http://www.sleuthkit.org/autopsy/
ver 2.24

=====
```

```
Evidence Locker: /var/lib/autopsy
Start Time: Wed Jun  5 16:16:12 2019
Remote Host: localhost
Local Port: 9999
```



Open an HTML browser on the remote host and paste this URL in it:

`http://localhost:9999/autopsy`

Keep this process running and use <ctrl-c> to exit

### Hints:

Generating a time line of timestamps with date created, modification etc. can sometimes highlight the interesting times. A hacker breaking in and replacing a file would often end up having modified time stamps.

If you want to automate or use the command line for other reasons there are some documentation available, example [http://wiki.sleuthkit.org/index.php?title=FS\\_Analysis](http://wiki.sleuthkit.org/index.php?title=FS_Analysis)

### Solution:

When you team has opened at least one file system from an image file, you are done.

Hopefully you should be able reach something like this:

The screenshot shows the Autopsy web interface in a Mozilla Firefox browser. The address bar displays the URL `localhost:9999/autopsy?mod=1&submod=2&case=test&host=host1&inv=hlk&vol=vol1`. The interface includes a top navigation bar with tabs for FILE ANALYSIS, KEYWORD SEARCH, FILE TYPE, IMAGE DETAILS, META DATA, DATA UNIT, and HELP. The main content area is titled 'Current Directory: /mnt/removable/' and contains a table of file and directory listings.

DEL	Type	NAME	WRITTEN	ACCESSED	CHANGED	SIZE	UID	GID	META
	dir / in								
			2003-11-23 20:06:28 (CEST)	2003-11-23 20:06:21 (CEST)	2003-11-23 20:06:28 (CEST)	1024	500	500	2
			2003-11-23 20:06:28 (CEST)	2003-11-23 20:06:21 (CEST)	2003-11-23 20:06:28 (CEST)	1024	500	500	2
	r / r	file1	2003-11-23 20:03:54 (CEST)	2003-11-23 20:03:54 (CEST)	2003-11-23 20:03:54 (CEST)	601	0	0	12
	r / r	file2	2003-11-23 20:06:03 (CEST)	2003-11-23 20:04:06 (CEST)	2003-11-23 20:06:03 (CEST)	1300	0	0	13
✓	r / r	file3	2003-11-23 20:06:28 (CEST)	2003-11-23 20:04:23 (CEST)	2003-11-23 20:06:28 (CEST)	0	0	0	14
	r / r	first	2003-11-23 20:04:36 (CEST)	2003-11-23 20:04:36 (CEST)	2003-11-23 20:04:36 (CEST)	63	0	0	15
	d / d	lost+found/	2003-11-23 19:54:16 (CEST)	2003-11-23 19:54:16 (CEST)	2003-11-23 19:54:16 (CEST)	12288	0	0	11

Below the table, the interface indicates 'File Browsing Mode' and provides instructions: 'In this mode, you can view file and directory contents. File contents will be shown in this window. More file details can be found using the Metadata link at the end of the list (on the right). You can also sort the files using the column headers'.

### Discussion:

## Exercise 24

### Clean or rebuild a server 20min

**Objective:**

Think about a hacked system, how can you clean such a system?

**Purpose:**

Realize that you can never be completely sure the system really is secure.

**Suggested method:**

Consider the system from exercise 17

We created a back door in this system: (We created it in /tmp so it may have been deleted, but lets say it was created in /sbin instead)

**Commands executed:**

```
root@debian:~# rm /tmp/.xxsh
root@debian:~# cp /bin/dash /tmp/.xxsh
root@debian:~# chmod +sw /tmp/.xxsh
```

Is this the only file left by the attacker?

Did he change other files, configurations, added users, changed user passwords?

**Hints:**

A forensics investigation might perform a complete dump of the file systems and use TASK/Autopsy. Then by generating a timeline it might be possible to find the back door files. Perhaps.

**Solution:**

Rebuild your Debian server. Automate the setup of critical systems. Have good backup of critical data.

**Discussion:**

Cleaning systems and whole environments is very hard.

An attacker may have spent only 30 minutes, but the investigation might take 100 hours. This is a huge difference in resources spent.

No such thing as *Was just browsing the system*

## Exercise 25

### Cloud environments influence on incident response 20min

**Objective:**

Talk about the difference in computer forensics in cloud environments.

Cloud environments, or mixed environments between cloud and traditional environments present new challenges.

**Purpose:**

Discuss what sources of information is available.

Traditional computer forensics often use these sources:

- Network forensics
- Applications logs
- Operating system logs
- Disk imaging

Cloud environments can often use these sources:

- Logging from authentication
- Limited network forensics
- Applications logs

This relies more on the capabilities of the cloud vendor and often cloud environments are also much more dynamic. Some services are also provided by the cloud vendor, separating the management away from the customer configured environment - with good or bad consequences for computer forensics.

**Suggested method:**

Discuss in your group, how would you investigate an incident in your solutions.

Has any in our group performed incident handling in cloud environments.

**Hints:**

NIST has a few papers about this subject.

Example: *Identifying Evidence for Implementing a Cloud Forensic Analysis Framework* <https://www.nist.gov/publications/identifying-evidence-implementing-cloud-forensic-analysis-framework>

**Solution:**

Download the linked paper and browse it. It contains an example cloud and the conclusion scratches the surface of what a cloud maybe should provide.

**Discussion:**

Cloud computer forensics seem immature, but must be researched.

If you organization relies on cloud computing it is critical to update incident handling procedures for these new challenges.

## Exercise 26

### Switch configuration and uplink

We will now perform multiple exercises as part of the System Security in Practice.

**Overall Objective:**

Try some of the security mechanisms used in real networks today.

First is to configure VLAN. This feature is well-known in network.

You can read more about the technology at  
[https://en.wikipedia.org/wiki/IEEE\\_802.1Q](https://en.wikipedia.org/wiki/IEEE_802.1Q)

**Overall Purpose:**

Learn that a few changes make a huge difference.

**Suggested method:**

Work on our model network, each team has a server and an attacker - reduce attack surface on the server by configuration.

- Configure VLAN on switch for the uplink
- Enable central logging
- Configure SSH keys for more secure access
- Enable firewall

### Switch configuration and uplink

Each team has a switch they own

- Add VLAN 2770 to switch
- Configure uplink port to be a tagged VLAN trunk - port 8
- Configure port to connect to local Debian server, port 1.  
Note: if tagged Debian must be configured with tag too! You can instead configure as Access port without tag. You decide.
- Insert USB Ethernet into Debian server virtual machine

## Switch config initial steps to get started

**Only connect switch ports when told to do so!**

1. First – install the VLAN support on your Debian server!  
`apt-get install vlan`
2. Power the switch - wait for the switch to boot, a few minutes should be OK
3. Reset the switch to default setting - press reset for 15 seconds before doing any configuration
4. Cable a laptop to any port, except the first one - port 1/0/1 or last one port 1/0/8
5. Take control of the switch, default settings are in place, see label on bottom and use Ethernet
6. Add VLAN with ID: 2770 Name: KramslX
7. Configure the Uplink port 1/0/8 with VLAN tag: 2770
8. Configure the first port 1/0/1 with VLAN tag: 2770  
If you keep the port in VLAN 1 you should be able to connect to the switch management via this port using tagged or untagged, as you prefer ☺
9. Configure VLAN interface on your server with the IP in the LAN 10.10.10.45.0/24  
- if your team ID is 14, then your IP is 10.10.10.14/24
10. Add 10.10.10.1 as your default gateway
11. Use 10.10.10.1 as DNS resolver
12. Connect uplink to common switch, KramslX. Use port 8 Connect port 1 to your laptop. Use USB Ethernet if your laptop does not have Ethernet port. Configure your virtualisation to have this device connected to your Debian server
13. Ping 10.10.10.1 from your server

Switch administration - see under switch for IP and username.

VLAN Config

VLAN ID:  (2-4094, format: 2,4-5,8)

VLAN Name:  (1-16 characters)

Untagged Ports

---

Port:  (Format: 1/0/1, input or choose below)

UNIT1

1

2

3

4

5

LAGS

6

7

8

9

10

☐ Select All

Selected

Unselected

Not Available

Tagged Ports

---

Port:  (Format: 1/0/1, input or choose below)

UNIT1

1

2

3

4

5

LAGS

6

7

8

9

10

☐ Select All

Selected

Unselected

Not Available

Cancel

Create

Your network config should look something like this:

```
$ cat /etc/network/interfaces
# interfaces(5) file used by ifup(8) and ifdown(8)
# Include files from /etc/network/interfaces.d:
source-directory /etc/network/interfaces.d

auto enx00249b1b2991
iface enx00249b1b2991 inet static
    address 192.168.0.2
    netmask 255.255.255.0

auto vlan2770
iface vlan2770 inet static
vlan-raw-device enx00249b1b2991
address 10.10.10.14
netmask 255.255.255.0
gateway 10.10.10.1
```

The IP configuration without VLAN tag shown will allow you to reach the switch from the Debian server.

### Hints:

If you don't want to do this exercise then don't. Just connect your Debian server to

the normal network using a bridge or even NAT.

**Solution:**

When your Debian server can reach the course network 10.0.45.0/24 you are done.

**Discussion:**

VLAN separation using the IEEE 802.1q standard is a common method to isolate servers from each other. Commonly used in DMZ networks in server parts, and in Voice over IP networks in LAN setup with clients.



## Exercise 27

### Centralized Logging

**Objective:**

See how server syslog is configured on regular Unix/Linux, and send logs to centralized server.

**Purpose:**

The main idea of this exercise is to understand how easy network connected systems can send log data.

**Suggested method:**

Log into your local Linux systems or network devices, see how syslog is configured.

**Hints:**

Look in the config file, may be in `/etc/syslog` or `/etc/syslog-ng/syslog-ng.conf`

Sample output from old-skool syslogd

```
*.err;kern.debug;auth.notice;authpriv.none;mail.crit    /dev/console
*.notice;auth,authpriv,cron,ftp,kern,lpr,mail,user.none /var/log/messages
kern.debug;user.info;syslog.info                        /var/log/messages
auth.info                                               /var/log/authlog
authpriv.debug                                          /var/log/secure
...
# Uncomment to log to a central host named "loghost".
#*.notice;auth,authpriv,cron,ftp,kern,lpr,mail,user.none @loghost
#kern.debug,user.info,syslog.info                        @loghost
#auth.info,authpriv.debug,daemon.info                  @loghost
```

Advanced users will configure the logging also.

Either add the host given by the instructor 10.0.45.200 in the `/etc/hosts` with the name loghost or give it a name and then use that name in the config file.

**Solution:**

When you understand how to configure syslog to send towards a central host you are done.

Feel free to re-visit the exercise [Create Kibana Dashboard 15min](#)

**Discussion:**

There are syslog senders for Windows too.

## Exercise 28

### Configure SSH keys for more secure access

**Objective:**

See how SSH keys can be used.

**Purpose:**

Secure Shell is a very powerful administration tool. Administrators use this for managing systems. If an attacker gains access they can perform the same tasks.

Using SSH keys for access and disabling password based logins effectively prevents brute-force login attacks from succeeding.

**Suggested method:**

First generate a SSH key, use:

```
$ ssh-keygen
Generating public/private rsa key pair.
Enter file in which to save the key (/root/.ssh/id_rsa):
Created directory '/root/.ssh'.
Enter passphrase (empty for no passphrase):
Enter same passphrase again:
Your identification has been saved in /home/hlk/.ssh/id_rsa.
Your public key has been saved in /home/hlk/.ssh/id_rsa.pub.
The key fingerprint is:
SHA256:l5esp66lQArF0lXq0oHnxpg8zRS6shK8nx9KGf+oSp4 root@debian01
The key's randomart image is:
+---[RSA 2048]-----+
|      .              |
|    . o              |
|    . =             |
| .. =.      o .     |
|o.*o. . S o +      |
|oB==+o    . o      |
|+*B=.o.    o .      |
|==+.o +. o o       |
|oEo=oo .ooo        |
+-----[SHA256]-----+
```

The use the utility tool `ssh-copy-id` for copying the public key to the server. Install tool if not available using `apt` :

```
hlk@kunoichi:hlk$ ssh-copy-id -i /home/hlk/.ssh/id_rsa hlk@10.0.42.147
```

```
/usr/local/bin/ssh-copy-id: INFO: Source of key(s) to be installed: ".ssh/kramse.pub"
The authenticity of host '10.0.42.147 (10.0.42.147)' can't be established.
ECDSA key fingerprint is SHA256:DP6jqadDWEJW/3FY84cpTKmEW7XoQ4zDNf/RdTu6M.
Are you sure you want to continue connecting (yes/no)? yes
/usr/local/bin/ssh-copy-id: INFO: attempting to log in with the new key(s),
to filter out any that are already installed
/usr/local/bin/ssh-copy-id: INFO: 1 key(s) remain to be installed -- if you
are prompted now it is to install the new keys
hlk@10.0.42.147's password:
```

```
Number of key(s) added:      1
```

Now try logging into the machine, with: `"ssh -o 'IdentitiesOnly yes' 'hlk@10.0.42.147'"`  
and check to make sure that only the key(s) you wanted were added.

This is the best tool for the job!

The public must exist in the `authorized_keys` file, in the right directory, with the correct permissions ... use `ssh-copy-id`

**Hints:**

You can publish your SSH keys in public places such as Github and Ubuntu installation can fetch this during install, making the use of SSH keys extremely easy.

**Solution:**

When you can login using key you are done.

**Discussion:**

We have not discussed using passphrase on the key, neither how to turn off password based logins by reconfiguring the SSH daemon. This is left as an exercise for the reader.

## Exercise 29

### Enable firewall

**Objective:**

Turn on a firewall and configure a few simple rules.

**Purpose:**

See how easy it is to restrict incoming connections to a server.

**Suggested method:**

Install a utility for firewall configuration.

You should also perform Nmap port scan with the firewall enabled and disabled.

**Hints:**

Using the ufw package it is very easy to configure the firewall on Linux.

Install and configuration can be done using these commands.

```
root@debian01:~# apt install ufw
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  ufw
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 164 kB of archives.
After this operation, 848 kB of additional disk space will be used.
Get:1 http://mirrors.dotsrc.org/debian stretch/main amd64 ufw all 0.35-4 [164 kB]
Fetched 164 kB in 2s (60.2 kB/s)
...
root@debian01:~# ufw allow 22/tcp
Rules updated
Rules updated (v6)
root@debian01:~# ufw enable
Command may disrupt existing ssh connections. Proceed with operation (y|n)? y
Firewall is active and enabled on system startup
root@debian01:~# ufw status numbered
Status: active
```

	To	Action	From
	--	-----	----
[ 1]	22/tcp	ALLOW IN	Anywhere
[ 2]	22/tcp (v6)	ALLOW IN	Anywhere (v6)

Also allow port 80/tcp and port 443/tcp - and install a web server. Recommend Nginx `apt-get install nginx`

**Solution:**

When firewall is enabled and you can still connect to Secure Shell (SSH) and web service, you are done.

**Discussion:**

Further configuration would often require adding source prefixes which are allowed to connect to specific services. If this was a database server the database service should probably not be reachable from all of the Internet.

Web interfaces also exist, but are more suited for a centralized firewall.

Configuration of this firewall can be done using ansible, see the documentation and examples at [https://docs.ansible.com/ansible/latest/modules/ufw\\_module.html](https://docs.ansible.com/ansible/latest/modules/ufw_module.html)

Should you have both a centralized firewall in front of servers, and local firewall on each server? Discuss within your team.