

Networking, TCP/IP and Security for Beginners

exercises

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November 17, 2024



Note: exercises marked with **A** are considered important. These contain subjects that are essential for the course. Even if you don't work through the exercise, you might want to know the subjects covered by these.

Exercises marked with **I** are considered optional. These contain subjects that are related to the course, but less important. You may want to browse these and if interested work through them. They may require more time than we have available during the course.

Contents

1	❶ Download Debian Administrators Handbook (DEB) Book 10 min	3
2	❶ Check your Debian VM 10 min	4
3	❶ Configure Sudo	5
4	❶ Enable firewall - 15min	6
5	❶ Git tutorials - 15min	8
6	❶ Using ping and traceroute 10 min	9
7	❶ DNS and Name Lookups 10 min	10
8	❶ Whois databases 15 min	11
9	❶ IP address research 30 min	12
10	❶ Wireshark and Tcpdump 15 min	13
11	❶ Nping check ports 10 min	15
12	❶ Discover active systems ping sweep 10 min	17
13	❶ Execute nmap TCP and UDP port scan 20 min	18
14	❶ Perform nmap OS detection 10 min	19
15	❶ TCP SYN flooding 30min	20
16	❶ TCP other flooding 15min	22
17	❶ UDP flooding NTP, etc. 15min	23
18	❶ ICMP flooding 15min	24
19	❶ Misc - stranger attacks 15min	26
20	❶ SSL/TLS scanners 15 min	28
21	❶ Internet scanners 15 min	29
22	❶ Wireguard - 60 min	30
23	❶ Zeek on the web 10min	31
24	❶ Test a DNS server 30min	32
25	❶ Monitoring - setup LibreNMS 60 min	33
26	❶ Configure Mirror Port 10min	34

Preface

This material was originally prepared for use in a workshop *Networking, TCP/IP and Security for Beginners* and was prepared by Henrik Kramselund , <http://www.zecurity.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 basic-tcpip-and-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>

Dont be scared away by the many exercises, you can pick a few and have fun with those and ignore the rest. If you one day need to research network security the others may come in handy ☺

The exercise list includes my recommended tools I use myself and for teaching.

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



Figure 1: The NWWC village at BornHack 2024, next year 16-23rd of July 2025

Introduction to networking

IP - Internet protocol suite

It is extremely important to have a working knowledge about IP to implement secure and robust infrastructures. Knowing about the alternatives while doing implementation will allow the selection of the best features.

ISO/OSI reference model

A very famous model used for describing networking is the ISO/OSI model of networking which describes layering of network protocols in stacks.

This model divides the problem of communicating into layers which can then solve the problem as smaller individual problems and the solution later combined to provide networking.

Having layering has proven also in real life to be helpful, for instance replacing older hardware technologies with new and more efficient technologies without changing the upper layers.

In the picture the OSI reference model is shown along side with the Internet Protocol suite model which can also be considered to have different layers.

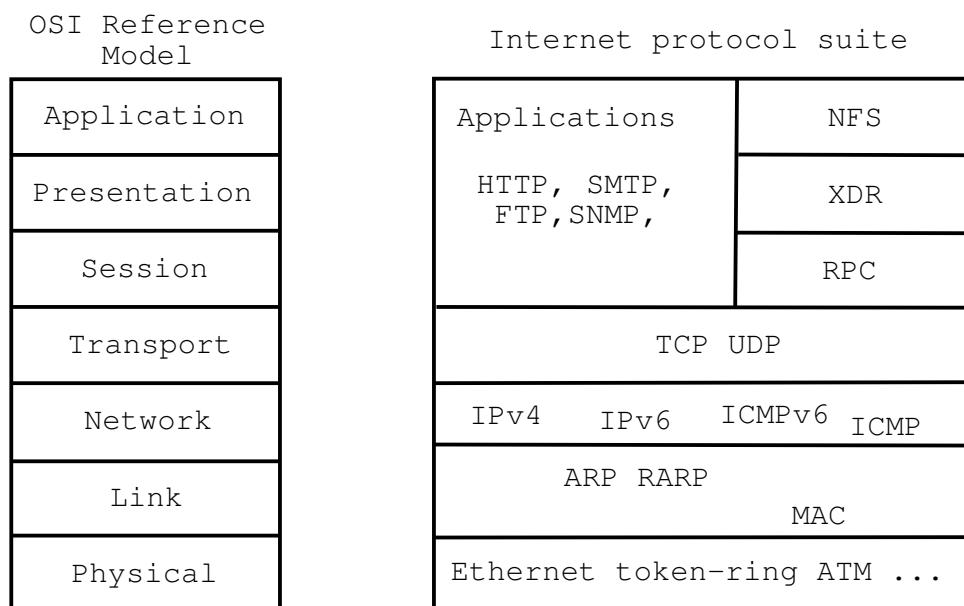


Figure 2: OSI og Internet Protocol suite

Exercise content

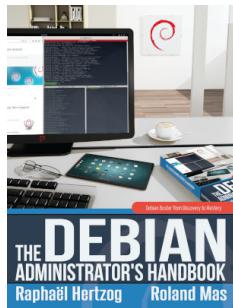
Most exercises follow the same procedure and has the following content:

- **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

❶ Download Debian Administrators Handbook (DEB) Book 10 min



Objective:

We need a Linux for running some tools during the course. I have chosen Debian Linux as this is open source, and the developers have released a whole book about running it.

This book is named *The Debian Administrators Handbook*, - shortened DEB

Purpose:

Debian Linux is a mature Unix with great documentation. Kali Linux is based on Debian, so by learning Debian you can make infrastructure using Debian Linux, and test security using Kali Linux – and the administration will be the same commands.

in a few moments, so better have the instructions ready.

Suggested method:

Create folders for educational materials. Go to download from the link <https://debian-handbook.info/> Read and follow the instructions for downloading the book.

Solution:

When you have a directory structure for download for this course, and the book DEB 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.

Debian Linux is a free operating system platform.

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

Exercise 2

❶ Check your Debian VM 10 min



Objective:

I use Debian as the base for exercises – they are tested on Debian and Kali!

If you want to use Debian, make sure your virtual machine is in working order.

You don't need both a Debian Linux and Kali for running tools in this booklet, but some are better suited for either, so you can choose to install both.

Purpose:

If your VM is not installed and updated you might run into trouble later.

Suggested method:

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

Read the instructions for the setup of a Debian VM.

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

Hints:

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

I suggest 50G disk, 2CPU cores and 6Gb memory for this course, if you have this.

Solution:

When you have a updated virtualisation software and a running VM, 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.

Debian Linux allows us to run Ansible and provision a whole SIEM in very few minutes.

Exercise 3

i Configure Sudo

Objective:

Learn how to configure the tool Sudo to allow administrative commands.

Purpose:

Sudo is the most common method for switching from a normal user to root which is the administrative user for Unix. This command allows you to use your own password and execute highly privileged commands easily.

Suggested method:

Not in sudoers file, cannot run sudo command

This can be fixed quite easily.

If you use the su command first, to switch user to root and run the visudo command:

```
hlk@debian01:~$ su -  
// enter password  
# visudo
```

You will get an editor, where you enter below the root line, your username and a similar line:

```
# User privilege specification  
root ALL = (ALL:ALL) ALL  
hlk ALL = (ALL:ALL) NOPASSWD: ALL
```

In the example my user is hlk

Then use ctrl-x if using Nano, and exit the editor - saving this configuration file.

Hints:

Most books about Unix has a convention to use the dollar sign if you are logged in as a regular user and the hash tag sign when logged in as root.

```
hlk@debian01:~$ echo "Hi I am just a regular user"  
  
root@debian01:~# echo "this is a command being run by root"
```

Solution:

When you can switch between your user and root you are done.

Discussion:

Note sudo has had many security vulnerabilities, so you should keep your system up to date using apt regularly, read about updates in the DEB book.

Exercise 4

1 Enable firewall - 15min

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

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

Exercise 5

❶ Git tutorials - 15min



Objective:

Try the program Git locally on your workstation

Purpose:

Running Git will allow you to clone repositories from others easily. This is a great way to get new software packages, and share your own.

Git is the name of the tool, and Github is a popular site for hosting git repositories.

Suggested method:

Put Git on your list of technologies to learn.

If you feel like it, try the program from your Linux VM. You can also clone from your Windows or Mac OS X computer. Multiple graphical front-end programs exist too.

Most important are Git clone and pull:

```
user@Projects:tt$ git clone https://github.com/kramse/kramse-labs.git
Cloning into 'kramse-labs'...
remote: Enumerating objects: 283, done.
remote: Total 283 (delta 0), reused 0 (delta 0), pack-reused 283
Receiving objects: 100% (283/283), 215.04 KiB | 898.00 KiB/s, done.
Resolving deltas: 100% (145/145), done.

user@Projects:tt$ cd kramse-labs/
user@Projects:kramse-labs$ ls
LICENSE README.md core-net-lab lab-network suricatazeek work-station
user@Projects:kramse-labs$ git pull
Already up to date.
```

Hints:

Browse the Git tutorials on <https://git-scm.com/docs/gittutorial> and <https://guides.github.com/activities/hello-world/>

We will not do the tutorials, but get an idea of the command line, and see examples. Refer back to these tutorials when needed or do them at home.

Note: you don't need an account on Github to download/clone repositories, but having an account allows you to save repositories yourself and is recommended.

Solution:

When you have understood the importance of this tool and seen the tutorials you are done.

Discussion:

Before Git there has been a range of version control systems, see https://en.wikipedia.org/wiki/Version_control for more details.

Exercise 6

❶ Using ping and traceroute 10 min

Objective:

Be able to do initial debugging of network problems using commands ping and traceroute

Purpose:

Being able to verify connectivity is a basic skill.

Suggested method:

Use `ping` and `traceroute` to test your network connection - can be done one Windows and UNIX.

Hints:

```
$ ping 10.0.42.1
PING 10.0.42.1 (10.0.42.1) 56(84) bytes of data.
64 bytes from 10.0.42.1: icmp_seq=1 ttl=62 time=1.02 ms
64 bytes from 10.0.42.1: icmp_seq=2 ttl=62 time=0.998 ms
^C
--- 10.0.42.1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.998/1.012/1.027/0.034 ms
```

Dont forget that UNIX ping continues by default, press ctrl-c to break.

Do the same with traceroute.

Solution:

Run both programs to local gateway and some internet address by your own choice.

Discussion:

Note the tool is called tracert on Windows, shortened for some reason.

ICMP is the Internet Control Message Protocol, usually used for errors like host unreachable. The ECHO request ICMP message is the only ICMP message that generates another.

The traceroute programs send packets with low Time To Live (TTL) and receives ICMP messages, unless there is a problem or a firewall/filter. Also used for mapping networks.



Whats the difference between:

- `traceroute` and `traceroute -I`
- NB: traceroute -I is found on UNIX - traceroute using ICMP pakker
- Windows tracert by default uses ICMP
- Unix by default uses UDP, but can use ICMP instead.
- Lots of traceroute-like programs exist for tracing with TCP or other protocols

Exercise 7

❶ DNS and Name Lookups 10 min

Objective:

Be able to do DNS lookups from specific DNS server

Purpose:

Try doing DNS lookup using different programs

Suggested method:

Try the following programs:

- nslookup - UNIX and Windows, but not recommended
`nslookup -q=txt -class=CHAOS version.bind. 0`
- dig - syntax @server domain query-type query-class
`dig @8.8.8.8 www.example.com`
- host - syntax host [-l] [-v] [-w] [-r] [-d] [-t querytype] [-a] host [server]
`host www.example.com 8.8.8.8`

Hints:

Dig is the one used by most DNS admins, I often prefer the host command for the short output.

Solution:

Shown inline, above.

Discussion:

The nslookup program does not use the same method for lookup as the standard lookup libraries, results may differ from what applications see.

What is a zone transfer, can you get one using the host command?

Explain forward and reverse DNS lookup.

Exercise 8

❶ Whois databases 15 min

Objective:

Learn to lookup data in the global Whois databases

Purpose:

We often need to see where traffic is coming from, or who is responsible for the IP addresses sending attacks.

Suggested method:

Use a built-in command line, like: `host www.zencurity.dk` to look up an IP address and then `whois` with the IP address.

Hints:

Another option is to use web sites for doing Whois lookups <https://apps.db.ripe.net/db-web-ui/#/query> or their RIPEStat web site which can give even more information <https://stat.ripe.net/>

Solution:

When you can find our external address and look it up, you are done.

Discussion:

Whois databases are global and used for multiple purposes, the ones run by the Regional Internet Registries ARIN, RIPE, AfriNIC, LACNIC og APNIC have information about IP addresses and AS numbers allocated.

Exercise 9

❶ IP address research 30 min

Objective:

Work with IP addresses

Purpose:

What is an IP address?

Investigate the following IP addresses

- 192.168.1.1
- 192.0.2.0/24
- 172.25.0.1
- 182.129.62.63
- 185.129.62.63

Write down everything you can about them!

Suggested method:

Search for the addresses, look for web sites that may help.

Hints:

Download the fun guide from Julia Evans (b0rk) <https://jvns.ca/networking-zine.pdf>

Pay attention to Notation Time page

Lookup ripe.net they may have a service called stats or stat – something like that.

What is the Torproject? good, bad, neutral?

Solution:

When you have found some information about each of the above, say 2-3 facts about each you are done.

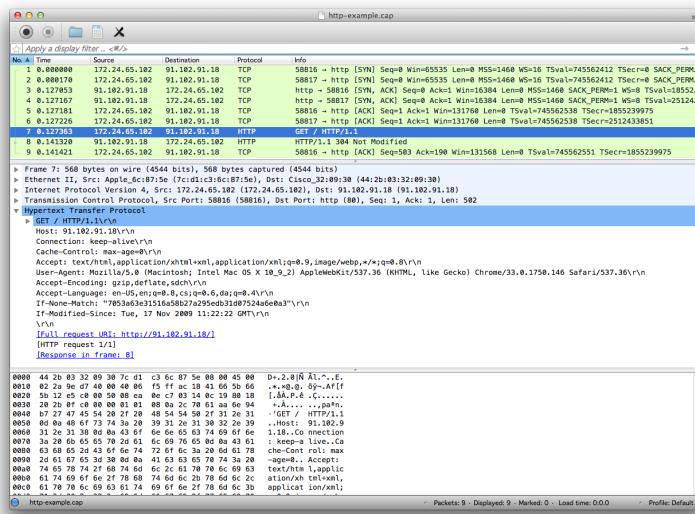
Discussion:

IP addresses are much more than an integer used for addressing system interfaces and routing packets.

We will later talk more about *IP reputation*

Exercise 10

❶ Wireshark and Tcpdump 15 min



Objective:

Try the program Wireshark locally your workstation, or tcpdump

You can run Wireshark on your host too, if you want.

Purpose:

Installing Wireshark will allow you to analyse packets and protocols

Tcpdump is a feature included in many operating systems and devices to allow packet capture and saving network traffic into files.

Suggested method:

Run Wireshark or tcpdump

The PPA book page 41 describes Your First Packet Capture.

Hints:

PCAP is a packet capture library allowing you to read packets from the network. Tcpdump uses libpcap library to read packet from the network cards and save them. Wireshark is a graphical application to allow you to browse through traffic, packets and protocols.

Both tools are already on your Kali Linux, or do: `apt-get install tcpdump wireshark`

Solution:

When Wireshark is installed sniff some packets. We will be working with both live traffic and saved packets from files in this course.

If you want to capture packets as a non-root user on Debian, then use the command to add a Wireshark group:

```
sudo dpkg-reconfigure wireshark-common
```

and add your user to this:

```
sudo gpasswd -a $USER wireshark
```

Dont forget to logout/login to pick up this new group.

Discussion:

Wireshark is just an example other packet analyzers exist, some commercial and some open source like Wireshark

We can download a lot of packet traces from around the internet, we might use examples from
<https://old.zeek.org/community/traces.html>

Exercise 11

❶ Nping check ports 10 min

Objective:

Show the use of Nping tool for checking ports through a network

Purpose:

Nping can check if probes can reach through a network, reporting success or failure. Allows very specific packets to be sent. It is part of the Nmap package.

Suggested method:

Run the command using a common port like Web HTTP:

```
root@KaliVM:~# nping --tcp -p 80 www.zencurity.com

Starting Nping 0.7.70 ( https://nmap.org/nping ) at 2018-09-07 19:06 CEST
SENT (0.0300s) TCP 10.137.0.24:3805 > 185.129.60.130:80 S ttl=64 id=18933 iplen=40 seq=2984847972 win=1480
RCVD (0.0353s) TCP 185.129.60.130:80 > 10.137.0.24:3805 SA ttl=56 id=49674 iplen=44 seq=3654597698 win=16384 <mss
SENT (1.0305s) TCP 10.137.0.24:3805 > 185.129.60.130:80 S ttl=64 id=18933 iplen=40 seq=2984847972 win=1480
RCVD (1.0391s) TCP 185.129.60.130:80 > 10.137.0.24:3805 SA ttl=56 id=50237 iplen=44 seq=2347926491 win=16384 <mss
SENT (2.0325s) TCP 10.137.0.24:3805 > 185.129.60.130:80 S ttl=64 id=18933 iplen=40 seq=2984847972 win=1480
RCVD (2.0724s) TCP 185.129.60.130:80 > 10.137.0.24:3805 SA ttl=56 id=9842 iplen=44 seq=2355974413 win=16384 <mss
SENT (3.0340s) TCP 10.137.0.24:3805 > 185.129.60.130:80 S ttl=64 id=18933 iplen=40 seq=2984847972 win=1480
RCVD (3.0387s) TCP 185.129.60.130:80 > 10.137.0.24:3805 SA ttl=56 id=1836 iplen=44 seq=3230085295 win=16384 <mss
SENT (4.0362s) TCP 10.137.0.24:3805 > 185.129.60.130:80 S ttl=64 id=18933 iplen=40 seq=2984847972 win=1480
RCVD (4.0549s) TCP 185.129.60.130:80 > 10.137.0.24:3805 SA ttl=56 id=62226 iplen=44 seq=3033492220 win=16384 <mss

Max rtt: 40.044ms | Min rtt: 4.677ms | Avg rtt: 15.398ms
Raw packets sent: 5 (200B) | Rcvd: 5 (220B) | Lost: 0 (0.00%)
Nping done: 1 IP address pinged in 4.07 seconds
```

Hints:

A lot of options are similar to Nmap

Solution:

When you have tried it towards an open port, a closed port and an IP/port that is filtered you are done.

Discussion:

A colleague of ours had problems sending specific IPsec packets through a provider. Using a tool like Nping it is possible to show what happens, or where things are blocked.

Things like changing the TTL may provoke ICMP messages, like this:

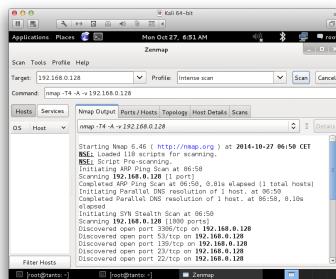
```
root@KaliVM:~# nping --tcp -p 80 --ttl 3 www.zencurity.com
```

```
Starting Nping 0.7.70 ( https://nmap.org/nping ) at 2018-09-07 19:08 CEST
SENT (0.0303s) TCP 10.137.0.24:37244 > 185.129.60.130:80 S ttl=3 id=60780 iplen=40 seq=1997801125 win=1480
RCVD (0.0331s) ICMP [10.50.43.225 > 10.137.0.24 TTL=0 during transit (type=11/code=0) ] IP [ttl=62 id=28456 iplen=72]
SENT (1.0314s) TCP 10.137.0.24:37244 > 185.129.60.130:80 S ttl=3 id=60780 iplen=40 seq=1997801125 win=1480
RCVD (1.0337s) ICMP [10.50.43.225 > 10.137.0.24 TTL=0 during transit (type=11/code=0) ] IP [ttl=62 id=28550 iplen=72]
SENT (2.0330s) TCP 10.137.0.24:37244 > 185.129.60.130:80 S ttl=3 id=60780 iplen=40 seq=1997801125 win=1480
RCVD (2.0364s) ICMP [10.50.43.225 > 10.137.0.24 TTL=0 during transit (type=11/code=0) ] IP [ttl=62 id=28589 iplen=72]
SENT (3.0346s) TCP 10.137.0.24:37244 > 185.129.60.130:80 S ttl=3 id=60780 iplen=40 seq=1997801125 win=1480
RCVD (3.0733s) ICMP [10.50.43.225 > 10.137.0.24 TTL=0 during transit (type=11/code=0) ] IP [ttl=62 id=29403 iplen=72]
SENT (4.0366s) TCP 10.137.0.24:37244 > 185.129.60.130:80 S ttl=3 id=60780 iplen=40 seq=1997801125 win=1480
RCVD (4.0558s) ICMP [10.50.43.225 > 10.137.0.24 TTL=0 during transit (type=11/code=0) ] IP [ttl=62 id=30235 iplen=72]

Max rtt: 38.574ms | Min rtt: 2.248ms | Avg rtt: 13.143ms
Raw packets sent: 5 (200B) | Rcvd: 5 (360B) | Lost: 0 (0.00%)
Nping done: 1 IP address pinged in 4.07 seconds
```

Exercise 12

❶ 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 targeting like 10.0.45.0/25 and 10.0.45.1-10

Exercise 13

❶ 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 14

❶ 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` – or `-A` which also add even more good stuff.

Hints:

The nmap tool 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.

Better to use `-A` all the time, includes even more scripts and advanced stuff You can also save prefixes to scan in a text file, I usually name it `targets`

I also recommend adding `-oA` for writing output files. So a regular Nmap command might be:
`nmap -p 1-65535 -A -oA full-tcp-scan -iL targets`

Exercise 15

❶ TCP SYN flooding 30min

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. This tool is my primary one for doing professional DDoS testing.

```
-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 don't 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.

Try doing the most common attacks TCP SYN flood using hping3:

```
hping3 --flood -p 80 -S 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
```

You can try different ports with TCP flooding, try port 22/tcp or HTTP(S) port 80/tcp and 443/tcp

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.

By changing the speed we can find out how much traffic is needed to bring down a service. This measurement can then be re-checked later and see if improvements really worked.

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 default 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 than --fast ;) (but not as fast as your computer can send packets 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>

Receiving systems, and those en route to the service, should be checked for resources like CPU load, bandwidth, logging. Logging can also overload the logging infrastructure, so take care when configuring this in your own networks.

Exercise 16

① TCP other flooding 15min

Objective:

Start a webserver attack using TCP flooding tool hping3.

Purpose:

Run various other common attacks

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 -R 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
```

Hints:

Common attacks use the SYN, as shown in previous exercise, but other popular TCP attacks are RST, PUSH, URG, FIN, ACK attacks - setting one or more flags in the packets.

-L	--setack	set TCP ack
-F	--fin	set FIN flag
-S	--syn	set SYN flag
-R	--rst	set RST flag
-P	--push	set PUSH flag
-A	--ack	set ACK flag
-U	--urg	set URG flag
-X	--xmas	set X unused flag (0x40)
-Y	--ymas	set Y unused flag (0x80)

Solution:

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

Discussion:

If an attacker varies the packets they can be harder to filter out, and the attacks succeed.

Exercise 17

❶ UDP flooding NTP, etc. 15min

Objective:

Start a webserver attack using UDP 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. This tool is my primary one for doing professional DDoS testing.

This time we will select UDP mode:

```
-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.
```

Suggested method:

Connect to the LAB network using Ethernet! Borrow a USB network card if you don't 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 -2 -p 53 10.0.45.12
```

Hints:

Try doing the most common attacks:

- UDP flooding, try port 53/udp DNS, 123/udp NTP and port 161/udp SNMP

Solution:

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

Discussion:

Many networks don't send and receive a lot of UDP traffic. If you measure a baseline of the protocols needed on a daily basis you might be able to configure a profile for normal usage, and filter out bad traffic in case of attacks.

A starting point might be to allow full bandwidth for TCP, 10% UDP and 1% ICMP. This will ensure that even if an attacker is sending more than 1% ICMP only a fraction reaches your network and systems.

This is especially effective for protocols like ICMP which is not used for large data transfers.

Exercise 18

❶ ICMP flooding 15min

Objective:

Start a webserver attack using ICMP 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. This tool is my primary one for doing professional DDoS testing.

This time we will select UDP mode:

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

Suggested method:

Connect to the LAB network using Ethernet! Borrow a USB network card if you don't 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.

Try doing the most common attack:

- ICMP flooding with echo

```
hping3 --flood -1 10.0.45.12
```

Hints:

Common attacks use ICMP ECHO, but other types can be sent in the packets.

```
ICMP
-C  --icmptype  icmp type (default echo request)
-K  --icmpcode  icmp code (default 0)
--force-icmp  send all icmp types (default send only supported types)
--icmp-gw    set gateway address for ICMP redirect (default 0.0.0.0)
--icmp-ts    Alias for --icmp --icmptype 13 (ICMP timestamp)
--icmp-addr   Alias for --icmp --icmptype 17 (ICMP address subnet mask)
--icmp-help   display help for others icmp options
```

Solution:

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

Discussion:

If you have a 10G network connection, do you REALLY need 10Gbps of ICMP traffic?

Probably not, and routers can often filter this in wirespeed.

Routers have extensive Class-of-Service (CoS) tools today and a starting point might be as shown in Juniper Junos policer config:

```
term limit-icmp {
    from {
        protocol icmp;
    }
    then {
        policer ICMP-100M;
        accept;
    }
}
term limit-udp {
    from {
        protocol udp;
    }
    then {
        policer UDP-1000M;
        accept;
    }
}
```

This effectively limit the damage an attacker can do. Your firewall and IDS devices will be free to spend more processing on the remaining protocols.

Exercise 19

❶ Misc - stranger attacks 15min

Various other attacks are possible, sending illegal combinations of flags etc.

Objective:

Start a webserver attack using the packet generator and flooding tool t50.

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. This tool is another primary one for doing professional DDoS testing.

Apart from TCP, UDP and ICMP this tool can also produce packets for dynamic routing testing, OSPF, EIGRP and other esoteric RSVP, IPSEC, RIP and GRE.

```
$ t50 -help
T50 Experimental Mixed Packet Injector Tool v5.8.3
Originally created by Nelson Brito <nbrito@sekure.org>
Previously maintained by Fernando Mercês <fernando@mentebinaria.com.br>
Maintained by Frederico Lamberti Pissarra <fredericopissarra@gmail.com>

Usage: t50 <host[/cidr]> [options]
Common Options:
  --threshold NUM          Threshold of packets to send      (default 1000)
  --flood                  This option supersedes the 'threshold'
  --encapsulated           Encapsulated protocol (GRE)      (default OFF)
-B,--bogus-csum           Bogus checksum                      (default OFF)
  --shuffle                Shuffling for T50 protocol       (default OFF)
-q,--quiet                Disable INFOs
  --turbo                 Extend the performance        (default OFF)
-l,--list-protocols       List all available protocols
-v,--version              Print version and exit
-h,--help                 Display this help and exit
...
Some considerations while running this program:
1. There is no limitation of using as many options as possible.
2. Report t50 bugs at https://gitlab.com/fredericopissarra/t50.git.
3. Some header fields with default values MUST be set to '0' for RANDOM.
4. Mandatory arguments to long options are mandatory for short options too.
5. Be nice when using t50, the author DENIES its use for DoS/DDoS purposes.
6. Running t50 with '--protocol T50' option sends ALL protocols sequentially.
```

Suggested method:

Connect to the LAB network using Ethernet! Borrow a USB network card if you don't 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.

Run the help page, and browse options.

```
t50 -h
```

Hints:

The tools we use can do a lot of different things and using the command line options can produce high speed packet attacks without having to program in C ourselves.

Try doing a special attack:

- t50 with '--protocol T50' option sends ALL protocols, so try:
t50 --protocol T50 10.0.45.12

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>

Receiving systems, and those en route to the service, should be checked for resources like CPU load, bandwidth, logging. Logging can also overload the logging infrastructure, so take care when configuring this in your own networks.

Exercise 20

❶ SSL/TLS scanners 15 min

Objective:

Try the Online Qualys SSL Labs 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 --ssl12 www.kramse.dk
Version: 1.10.5-static
OpenSSL 1.0.2e-dev xx XXX xxxx

Testing SSL server www.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 `--ssl12` 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 SSL Labs only can test from hostname

Exercise 21

❶ Internet scanners 15 min

Objective:

Try the Online scanners <https://internet.nl/> and a few more.

Purpose:

Learn how to efficiently check settings on remote services.

Suggested method:

There are multiple portals and testing services which allow you to check a domain, mail settings or web site.

Run tools against a couple of sites of your choice.

- <https://internet.nl/> Generic checker
- <https://www.hardenize.com/> Generic checker
- https://www.wormly.com/test_ssl Test TLS
- <https://observatory.mozilla.org/> Web site headers check
- <https://dnsviz.net/> DNS zone check
- <https://rpki.cloudflare.com/> Check RPKI - route validator enter IP address
More information about this: https://labs.ripe.net/author/nathalie_nathalie/rpki-test/

Others exist, feel free to suggest some.

Hints:**Solution:**

When you can run and understand what at least one tool does, you are done.

Discussion:

Which settings are most important, which settings are your responsibility?

Exercise 22

❶ Wireguard - 60 min

Objective:

Research the *new* wireguard between two Linux servers

Purpose:

Know there is alternative to connect servers securely.

Wireguard is very easy to setup, as it requires very little configuration.

Suggested method:

Find devices and operating systems that support Wireguard

Linux and OpenBSD can do it out-of-the-box <https://www.wireguard.com/quickstart/>

Hints:

They have a Demo Server which allows you to try out Wireguard

Solution:

When you have a working connection between them, you are done.

Discussion:

We wont do this in class, but I have a lot of friends that use Wireguard in production for complex setups.

Exercise 23

❶ Zeek on the web 10min

Objective:

Try Zeek Network Security Monitor - without installing it.

Purpose:

Show a couple of examples of Zeek scripting, the built-in language found in Zeek Network Security Monitor

Suggested method:

Go to <http://try.zeek.org/#/?example=hello> and try a few of the examples.

Hints:

The exercise *The Summary Statistics Framework* can be run with a specific PCAP.

192.168.1.201 did 402 total and 2 unique DNS requests in the last 6 hours.

Solution:

You should read the example *Raising a Notice*. Getting output for certain events may be interesting to you.

Discussion:

Zeek Network Security Monitor is an old/mature tool, but can still be hard to get started using. I would suggest that you always start out using the packages available in your Ubuntu/Debian package repositories. They work, and will give a first impression of Zeek. If you later want specific features not configured into the binary packages, then install from source.

The tool was renamed in 2018 from Bro to Zeek. Some commands and files still reference the old names.

Also Zeek uses a zeekctl program to start/stop the tool, and a few config files which we should look at. From a Debian system they can be found in /opt/zeek/etc :

This is from the Debian 11 package, checked May 2022

/opt/zeek/etc:

```
root@debian-lab-11:/opt/zeek/etc# ls -la
total 24
drwxrwsr-x  3 root  zeek  4096 Apr 16 20:03 .
drwxr-xr-x 10 root  root  4096 Apr 16 20:03 ..
-rw-rw-r--  1 root  zeek   262 Jan 28 2015 networks.cfg
-rw-rw-r--  1 root  zeek   651 Jan 28 2015 node.cfg
-rw-rw-r--  1 root  zeek 3052 Jan 28 2015 zeekctl.cfg
drwxr-xr-x  2 root  zeek  4096 Apr 16 20:03 zkg
```

Exercise 24

❶ Test a DNS server 30min

Objective:

Try communicating with DNS commands.

Purpose:

Learn how basic the setup of Unbound DNS server is.

Suggested method:

Setup Unbound on Debian using the instructions from
<https://nlnetlabs.nl/documentation/unbound/howto-setup/>

Note: there is a binary unbound package which can be installed with `apt install unbound` so use that, and config is then in `/etc/unbound`.

Use command line tools to test your server, if not available try `ping -` which will do a lookup. Retry the commands from exercise: [❷ DNS and Name Lookups 10 min](#) which is number **7**.

The server to use is then `127.0.0.1`, use it to ask for a domain like this:

```
$ host www.dr.dk 127.0.0.1
```

Hints:

The documentation for Unbound includes a small example with the access-control directive, which is the most important one for recursive use.

```
# unbound.conf for a local subnet.  
server:  
    interface: 0.0.0.0  
    interface: ::0  
    access-control: 192.168.0.0/16 allow  
    access-control: ::1 allow  
    verbosity: 1
```

Solution:

When you have tried sending a few DNS requests you are done, asking for a remote name, from a DNS server running on localhost: `host www.dr.dk 127.0.0.1`

Discussion:

How do we enforce new versions of protocol - as old as DNS?!

If you like, purge the Unbound software including config, with
`apt-get purge unbound`

and try installing Pi-Hole <https://pi-hole.net/>

Exercise 25

❶ Monitoring - setup LibreNMS 60 min

Objective:

See and work with LibreNMS - for a little while.

Purpose:

Show that initial setup of LibreNMS is quite easy, and immediately gives some results.

Note: this requires an endpoint compatible with LibreNMS to get data in.

Suggested method:

Choose installation method from:

<https://docs.librenms.org/Installation/>

Prebuilt docker and VM images will be fastest.

Hints:

As they themselves write on the web page <https://www.librenms.org/>

LibreNMS is a fully featured network monitoring system that provides a wealth of features and device support.

If you feel this is too much work, ask for login to the central one used for the core network.

Solution:

When you have played around with LibreNMS you are done.

It is recommended to look at:

- How basic information about devices are presented, from devices when added - and nothing more. See how to add a device and add your own. <https://docs.librenms.org/Support/Adding-a-Device/>
- How SNMP location is used to categorize devices and provide maps, see <https://docs.librenms.org/Extensions/World-Map/>
- How protocols like LLDP allow LibreNMS to make maps, see <https://docs.librenms.org/Extensions/Network-Map/>
- How port description can be used for describing ports, <https://docs.librenms.org/Extensions/Interface-Description-Parsing/>

Most of this happens with very little effort. Just configure devices consistently and they will be presented nicely.

Discussion:

Have you configured port description? Try it!

Real networks have policies for port description settings.

Exercise 26

❶ Configure Mirror Port 10min

Objective:

Mirror ports are a way to copy traffic to Suricata and other devices - for analyzing it. Below are the steps document on a Juniper switch to show how. This could be used for an Intrusion Detection System (IDS).

Most switches which are configurable have this possibility.

Purpose:

We want to capture traffic for multiple systems, so we select an appropriate port and copy the traffic. In our setup, we select the uplink port to the internet/router.

It is also possible to buy passive taps, like a fiber splitter, which then takes part of the signal, and is only observable if you look for signal strength on the physical layer.

Suggested method:

Configuring a mirror port on a Juniper EX2200-C running Junos could look like this:

```
root@ex2200-c# show ethernet-switching-options | display set
set ethernet-switching-options analyzer mirror01 input ingress interface ge-0/1/1.0
set ethernet-switching-options analyzer mirror01 input egress interface ge-0/1/1.0
set ethernet-switching-options analyzer mirror01 output interface ge-0/1/0.0
set ethernet-switching-options storm-control interface all
```

If using the TP-Link T1500G-10PS then this link should describe the process:

https://www.tp-link.com/en/configuration-guides/mirroring_traffic/?configurationId=18210

Which describe:

1. Choose the menu MAINTENANCE > Mirroring
2. Select Edit for the Mirror Session 1
3. In the Destination Port Config section, specify a destination port for the mirroring session, and click Apply
4. In the Source Interfaces Config section, specify the source interfaces and click Apply

Using the command line would be similar to this:

```
Switch#configure
Switch(config)#monitor session 1 destination interface gigabitEthernet 1/0/7
Switch(config)#monitor session 1 source interface gigabitEthernet 1/0/1-4 both
Switch(config)#monitor session 1 source cpu 1 both
```

Hints:

When checking your own devices this is often called SPAN ports, Mirror ports or similar.

https://en.wikipedia.org/wiki/Port_mirroring

Solution:

When we can see the traffic from the network, we have the port configured - and can run any tool we like. Note: specialized capture cards can often be configured to spread the load of incoming packets onto separate CPU cores for performance. Capturing 100G and more can also be done using switches like the example found on the Zeek web site using an Arista switch 7150.

Discussion:

When is it ethical to capture traffic?

Cisco has called this Switched Port Analyzer (SPAN) or Remote Switched Port Analyzer (RSPAN), so many will refer to them as SPAN-ports.

Remote SPAN (RSPAN): An extension of SPAN called remote SPAN or RSPAN. RSPAN allows you to monitor traffic from source ports distributed over multiple switches, which means that you can centralize your network capture devices. RSPAN works by mirroring the traffic from the source ports of an RSPAN session onto a VLAN that is dedicated for the RSPAN session. This VLAN is then trunked to other switches, allowing the RSPAN session traffic to be transported across multiple switches. On the switch that contains the destination port for the session, traffic from the RSPAN session VLAN is simply mirrored out the destination port.

Source: <https://community.cisco.com/t5/networking-documents/understanding-span-rspan-and-erspan/ta-p/3144951>