Welcome to

2. Network Security Threats

Communication and Network Security 2019

Henrik Lund Kramshøj hlk@zencurity.com

Slides are available as PDF, kramse@Github

2-Network-Security-Threats.tex in the repo security-courses

Plan for today

Subjects

- Network Security Threats
- ARP spoofing, ICMP redirects, the classics
- Person in the middle attacks
- Network Scanning
- Intro to routing protocols attacks
- BGP intro and hijacking
- DDoS and flooding

Exercises

- ARP spoofing and ettercap
- EtherApe
- Nmap and Nping
- Pcap-diff

Reading Summary

PPA chapter 5,6,7,8,12 - 124 pages
Strange Attractors and TCP/IP Sequence Number Analysis

The chapters read for this time, main things:

PPA chapter 5: Advanced Wireshark Features

- Networks have end-points and conversations on multiple layers
- Wireshark is advanced, try right-clicking different places
- Name resolution includes low level MAC addresses, and IP - names
- More than 1000 dissectors, but beware some have security issues!

also more than 20 illustrations in one chapter, not hard to read

Great network security comes from knowing networks!

Reading Summary, continued

PPA chapter 6: Packet Analysis on the Command Line

- TShark and Tcpdump, `tcpdump -nei eth0`
  `tshark -z expert -r download-slow.pcapng`
- Remote packet dumps, `tcpdump -i eth0 -w packets.pcap`

Story: tcpdump was originally written in 1988 by Van Jacobson, Sally Floyd, Vern Paxson and Steven McCanne who were, at the time, working in the Lawrence Berkeley Laboratory Network Research Group `https://en.wikipedia.org/wiki/Tcpdump`

Later in this course we will introduce:
Zeek (formerly Bro)[2] is a free and open-source software network analysis framework; it was originally developed in 1994 by Vern Paxson `https://en.wikipedia.org/wiki/Zeek`

Everything you do on the command line can be automated easily

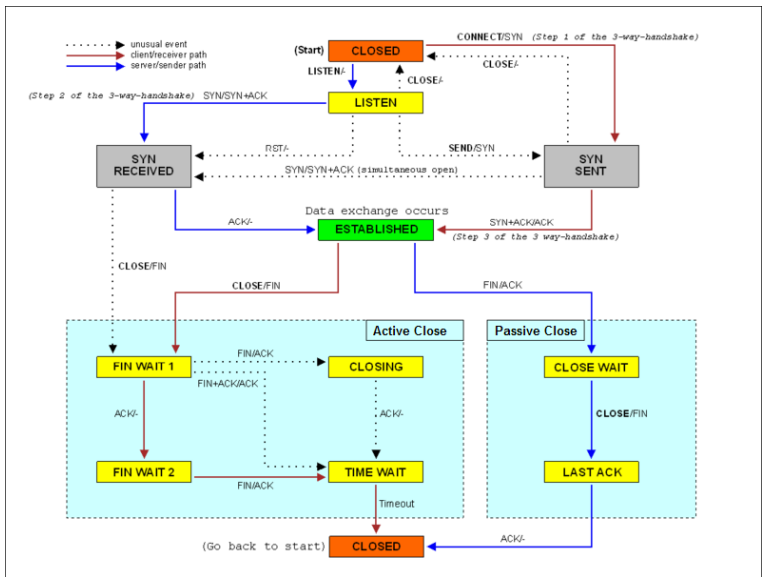
Reading Summary, continued

```
user@Projects:~$ ping -s 1472 -M do 91.102.91.18
PING 91.102.91.18 (91.102.91.18) 1472(1500) bytes of data.
1480 bytes from 91.102.91.18: icmp_seq=1 ttl=244 time=7.43 ms
1480 bytes from 91.102.91.18: icmp_seq=2 ttl=244 time=7.20 ms
...
user@Projects:~$ ping -s 1474 -M do 91.102.91.18
PING 91.102.91.18 (91.102.91.18) 1474(1502) bytes of data.
ping: local error: Message too long, mtu=1500
ping: local error: Message too long, mtu=1500
^C
--- 91.102.91.18 ping statistics ---
2 packets transmitted, 0 received, +2 errors, 100% packet loss, time 1025ms
```

PPA chapter 7: Network Layer Protocols Command Line

- What is normal network traffic?
- Great reference chapter for basic protocols
- Plus basic IPv6
- Re PATH MTU etc. Linux MTU 1500 check `ping -s 1472 -M do`

Reading Summary, continued



PPA chapter 8: Transport Layer Protocols Command Line

- Again the TCP 3-way handshake is described Note: can be done in 4 packets
- Closed TCP returns Reset (RST) packet, closed UDP returns ICMP port unreachable

Reading Summary, continued

Table 12-1: Common Passive Fingerprinting Values

Protocol header	Field	Default value	Platform
IP	Initial time to live	64	NMap, BSD, OS X, Linux
		128	Novell, Windows
		255	Cisco IOS, Palm OS, Solaris
IP	Don't fragment flag	Set	BSD, OS X, Linux, Novell, Windows, Palm OS, Solaris
		Not set	Nmap, Cisco IOS
TCP	Maximum segment size	0	Nmap
		1440–1460	Windows, Novell
		1460	BSD, OS X, Linux, Solaris

(continued)

PPA chapter 12: Packet Analysis for Security Command Line

- Syn scan
- the ARP protocol is inherently insecure
- All attacks have signatures, some more noisy than others

Reading Summary, continued

Strange Attractors and TCP/IP Sequence Number Analysis, Michal Zalewski
`http://lcamtuf.coredump.cx/newtcp/`

Continued from last time TCP/IP Sequence Numbers

- Lets just check out the cool graphs
- Sending lots of packets from attack tools is very possible today

Basic port scanning

What is a port scan

Testing all values possible for port number from 0/1 to 65535

Goal is to identify open ports, listening and vulnerable services

Most often TCP og UDP scan

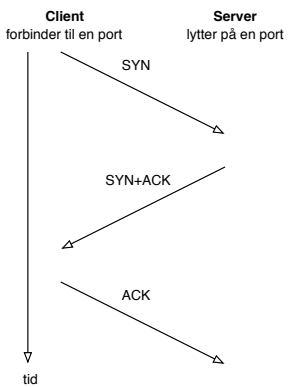
TCP scanning is more realiable than UDP scanning

TCP handshake must respond with SYN-ACK packets

UDP applications respond differently – if they even respond
so probes with real requests may get response, no firewall they respond withb ICMP on closed ports

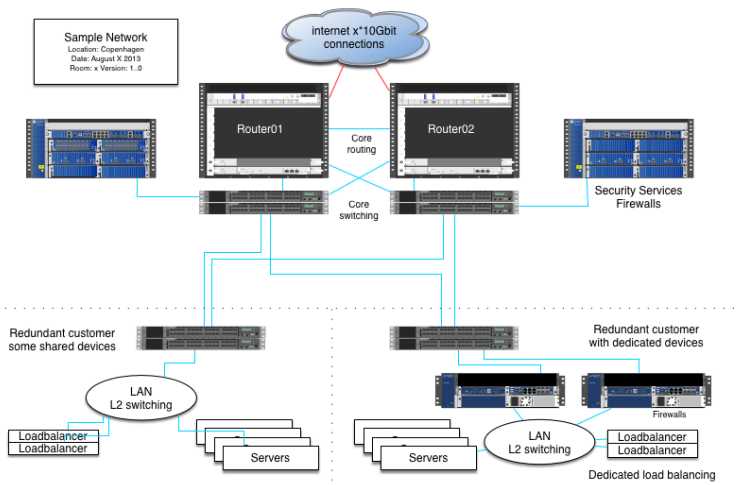
Use the GUI program Zenmap while learning Nmap

TCP three-way handshake



- **TCP SYN half-open** scans
- in the old days systems would only log when a full TCP connection was setup – so doing only half open it was a *stealth*-scans
- Today system and IDS intrusion detection can easily monitor for this
- Sending a lot of SYN packets can create a Denial of Service – **SYN-flooding**

Scope: select systems for testing



- Routers in front of critical systems and networks - availability
- Firewalls – are traffic flows restricted
- Mail servers – open for relaying
- Web servers – remote code execution in web systems, data download

Ping and port sweep

Scans across the network are named sweeps

Ping sweeps using ICMP Ping probes

Port sweep trying to find a specific service, like port 80 web

Quite easy to see in network traffic:

- Selecting two IP-adresser not in use
- Should not see any traffic, but if it does, its being scanned
- If traffic is received on both addresses, its a sweep – if they are a bit apart it is even better, like 10.0.0.100 and 10.0.0.200

Pro tip: a Great network intrusion detection engine (IDS), is Suricata `suricata-ids.org`

what is Nmap today

Nmap ("Network Mapper") is a free and open source (license) utility for network discovery and security auditing.

Initial release September 1997; 20 years ago

Today a package of programs for Windows, Mac, BSD, Linux, ... source

Flexible, powerful, and free! Includes other tools!

Lets check release notes, 7.70 pt.
http://seclists.org/nmap-announce/2018/0

Bonus info: you can help Nmap by submitting fingerprints

Nmap port sweep for web servers

```
root@cornerstone:~#  nmap -p80,443 172.29.0.0/24

Starting Nmap 6.47 ( http://nmap.org ) at 2015-02-05 07:31 CET
Nmap scan report for 172.29.0.1
Host is up (0.00016s latency).
PORT    STATE    SERVICE
80/tcp  open     http
443/tcp filtered https
MAC Address: 00:50:56:C0:00:08 (VMware)

Nmap scan report for 172.29.0.138
Host is up (0.00012s latency).
PORT    STATE  SERVICE
80/tcp  open   http
443/tcp closed https
MAC Address: 00:0C:29:46:22:FB (VMware)
```

Nmap port sweep for SNMP port 161/UDP

```
root@cornerstone:~# nmap -sU -p 161 172.29.0.0/24
Starting Nmap 6.47 ( http://nmap.org ) at 2015-02-05 07:30 CET
Nmap scan report for 172.29.0.1
Host is up (0.00015s latency).
PORT    STATE         SERVICE
161/udp open|filtered snmp
MAC Address: 00:50:56:C0:00:08 (VMware)

Nmap scan report for 172.29.0.138
Host is up (0.00011s latency).
PORT    STATE  SERVICE
161/udp closed snmp
MAC Address: 00:0C:29:46:22:FB (VMware)
...
Nmap done: 256 IP addresses (5 hosts up) scanned in 2.18 seconds
```

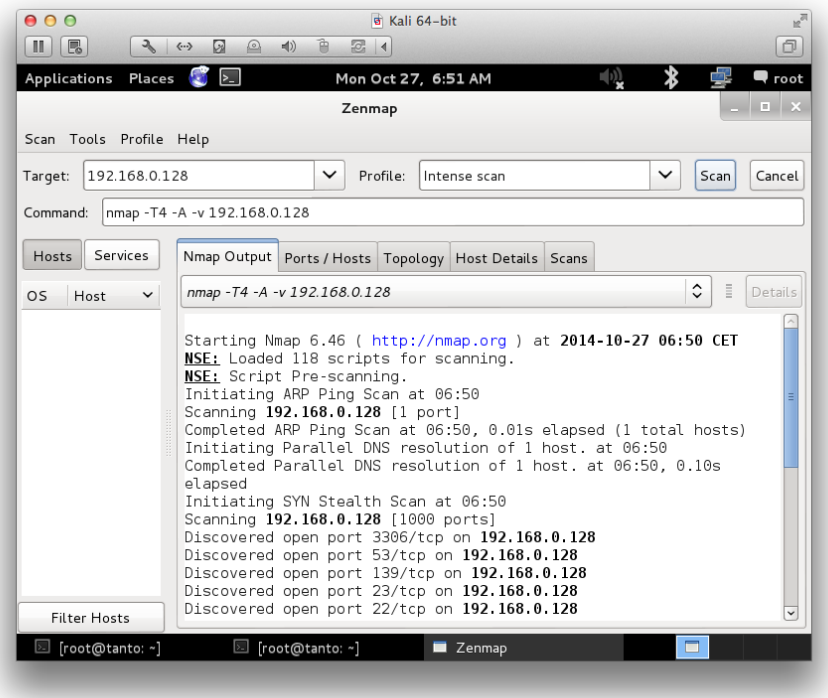
More reliable to use Nmap script with probes like –script=snmp-info

Nmap Advanced OS detection

```
root@cornerstone:~# nmap -A -p80,443 172.29.0.0/24
Starting Nmap 6.47 ( http://nmap.org ) at 2015-02-05 07:37 CET
Nmap scan report for 172.29.0.1
Host is up (0.00027s latency).
PORT    STATE    SERVICE VERSION
80/tcp  open     http    Apache httpd 2.2.26 ((Unix) DAV/2 mod_ssl/2.2.26 OpenSSL/0.9.8zc)
|_http-title: Site doesn't have a title (text/html).
443/tcp filtered https
MAC Address: 00:50:56:C0:00:08 (VMware)
Device type: media device|general purpose|phone
Running: Apple iOS 6.X|4.X|5.X, Apple Mac OS X 10.7.X|10.9.X|10.8.X
OS details: Apple iOS 6.1.3, Apple Mac OS X 10.7.0 (Lion) - 10.9.2 (Mavericks)
or iOS 4.1 - 7.1 (Darwin 10.0.0 - 14.0.0), Apple Mac OS X 10.8 - 10.8.3 (Mountain Lion)
or iOS 5.1.1 - 6.1.5 (Darwin 12.0.0 - 13.0.0)
OS and Service detection performed.
Please report any incorrect results at http://nmap.org/submit/
```

- Low-level way to identify operating systems, also try/use `nmap -A`
- Send probes and observe responses, lookup in table of known OS and responses
- Techniques known since at least: *ICMP Usage In Scanning* Version 3.0, Ofir Arkin, 2001

Portscan using Zenmap GUI



Zenmap included in the full Nmap package `https://nmap.org`

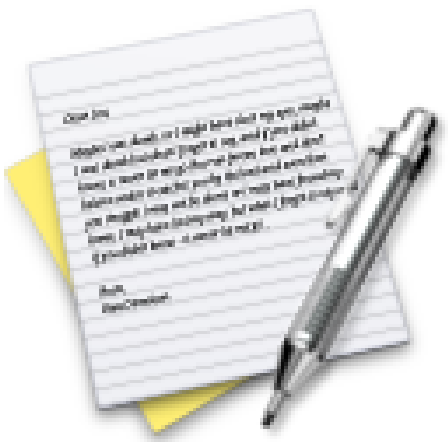
What happens now?

Think like a hacker

Recon phase – gather information reconnaissance

- Traceroute, Whois, DNS lookups
- Ping sweep, port scan
- OS detection – TCP/IP and banner grabbing
- Service scan – rpcinfo, netbios, ...
- telnet/netcat interact with services

Exercise

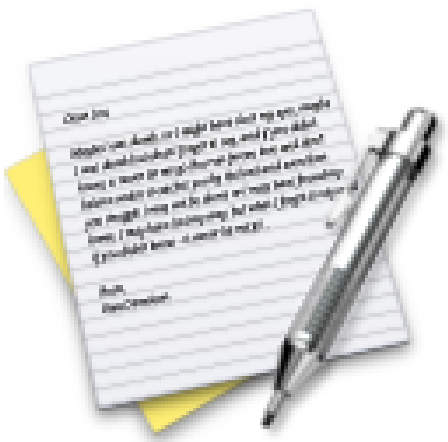


Now lets do the exercise

Nping check ports 15 min

which is number 9 in the exercise PDF.

Exercise

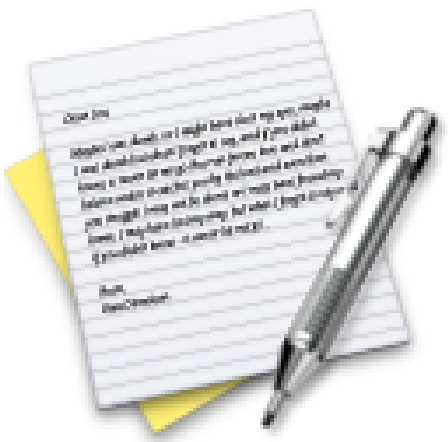


Now lets do the exercise

Try pcap-diff 10 min

which is number **10** in the exercise PDF.

Exercise

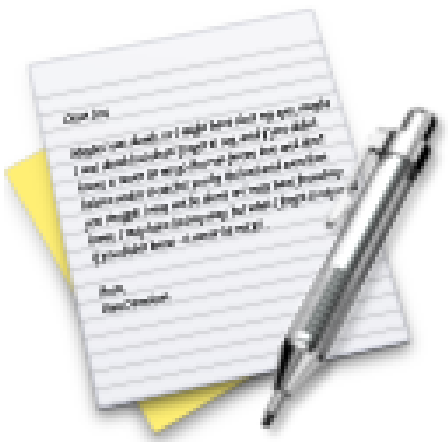


Now lets do the exercise

Discover active systems ping sweep 10 min

which is number **11** in the exercise PDF.

Exercise

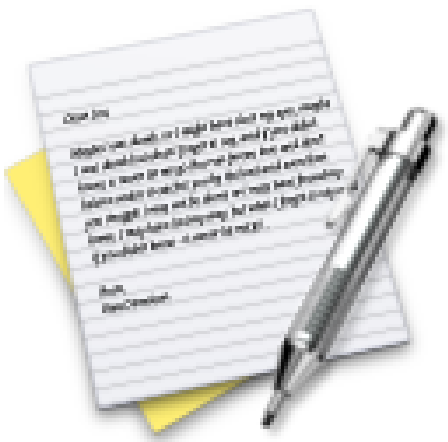


Now lets do the exercise

Execute nmap TCP and UDP port scan 20 min

which is number **12** in the exercise PDF.

Exercise

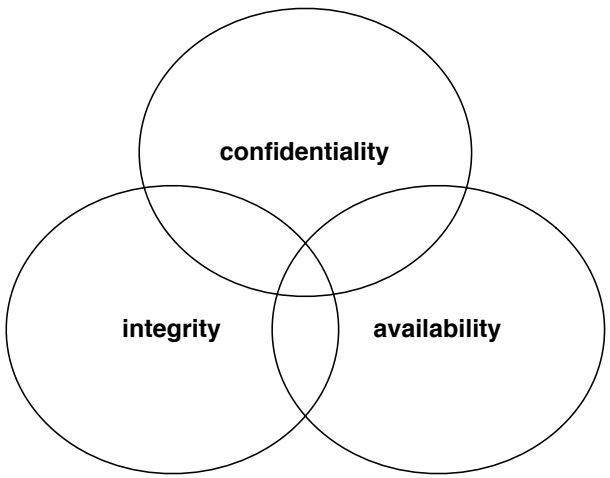


Now lets do the exercise

Perform nmap OS detection 10 min

which is number **13** in the exercise PDF.

Confidentiality Integrity Availability



We want to protect something

Confidentiality - data holdes hemmelige

Integrity - data ændres ikke uautoriseret

Availability - data og systemet er tilgeængelig når de skal bruges

Unencrypted data protocols

Examples

- TFTP bruges til boot af netværksklienter uden egen harddisk
- TFTP use UDP and is unencrypted
- DNS sending unencrypted on UDP and TCP
  Proposals for encrypted DNS over TCP and DNS over HTTPS being worked on

TFTP Trivial File Transfer Protocol

Trivial File Transfer Protocol - uautentificerede filoverførsler

De bruges især til:

- TFTP bruges til boot af netværksklienter uden egen harddisk
- TFTP benytter UDP og er derfor ikke garanteret at data overføres korrekt

TFTP sender alt i klartekst, hverken password
USER brugernavn og
PASS hemmeligt-kodeord

Still used for configuration files and firmwares

FTP File Transfer Protocol

File Transfer Protocol - filoverførsler

Bruges især til:

- FTP - drivere, dokumenter, rettelser - Windows Update? er enten HTTP eller FTP

FTP sender i klartekst
USER brugernavn og
PASS hemmeligt-kodeord

Der findes varianter som tillader kryptering, men brug istedet SCP/SFTP over Secure Shell protokollen

FTP Daemon konfiguration

Meget forskelligt!

WU-FTPD er meget udbredt

BSD FTPD ligeså meget anvendt

anonym ftp er når man tillader alle at logge ind
men husk så ikke at tillade upload af filer!

På BSD oprettes blot en bruger med navnet `ftp` så er der åbent!

Person in the middle attacks

ARP spoofing, ICMP redirects, the classics

Used to be called Man in The Middle MiTM

- ICMP redirect
- ARP spoofing
- Wireless listening and spoofing higher levels like airpwn-ng `https://github.com/ICSec/airpwn-ng`

Usually aimed at unencrypted protocols

Today we only talk about getting the data, not how to perform higher level attacks

ICMP redirect

Routere understøtter ofte ICMP Redirect

Med ICMP Redirect kan man til en afsender fortælle en anden vej til destination

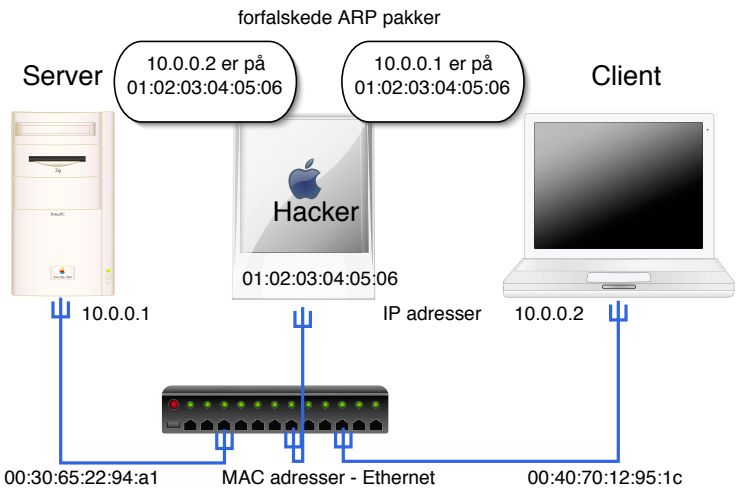
Den angivne vej kan være smartere eller mere effektiv

Det er desværre uheldigt, idet der ingen sikkerhed er

Idag bør man ikke lytte til ICMP redirects, ej heller generere dem

Det svarer til ARP spoofing, idet trafik omdirigeres

Hvordan virker ARP spoofing?



Hackeren sender forfalskede ARP pakker til de to parter

De sender derefter pakkerne ud på Ethernet med hackerens MAC adresse som modtager - som får alle pakkerne

Forsvar mod ARP spoofing

Hvad kan man gøre?

låse MAC adresser til porte på switche

låse MAC adresser til bestemte IP adresser

Efterfølgende administration!

arpwatch er et godt bud - overvåger ARP

bruge protokoller som ikke er sårbare overfor opsamling

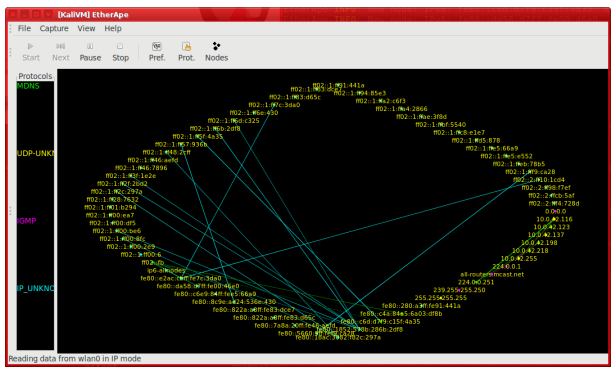
Lufthavns wifi

Åbne trådløse netværk er dejlige, vi bruger dem allesammen.

`http://wifi.aal.dk/fs/customwebauth/login.html?`
`switch_url=http://wifi.aal.dk/login.html&ap_mac=70:db:98:73:e5:a0&`
client_mac=30:10:b3:XX:YY:ZZ&wlan=AALfree&redirect=www.gstatic.com/generate_204

- Når du forbinder til netværket, bruger din enhed sin MAC adresse
- Denne indeholder en OUI som er den første halvdel af de 48-bit
- Dette ID er gemt i din enhed, fra fabrikken, kan sjældent ændres
- Alle i nærheden kan se denne MAC, og dermed din enheds unikke hardwareadresse.
- Kendere ved at man kan skifte sin MAC midlertidigt, og det gør telefoner ofte når de scanner efter netværk idag - hvis de overhovedet scanner

Demo Attacks fun with nodes

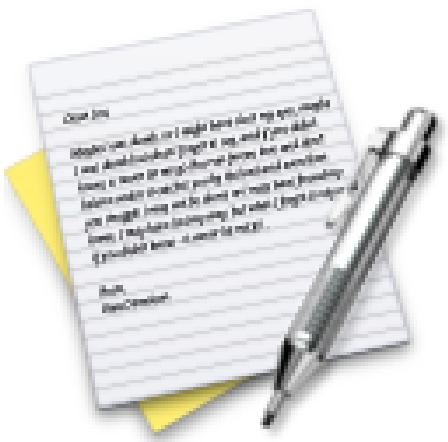


EtherApe is a graphical network monitor for Unix modeled after etherman. Featuring link layer, IP and TCP modes, it displays network activity graphically. Hosts and links change in size with traffic. Color coded protocols display.

How do we find nodes to perform ARP spoofing?

The main page for the tool is: `https://etherape.sourceforge.io/`

Exercise

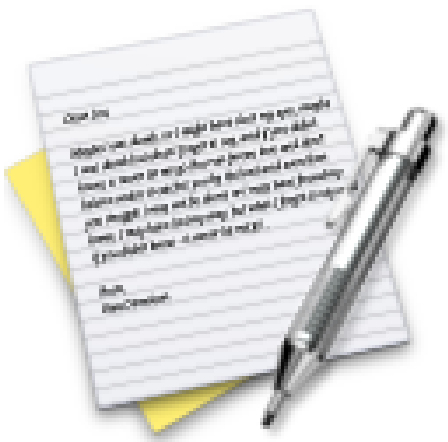


Now lets do the exercise

EtherApe 10 min

which is number **14** in the exercise PDF.

Exercise

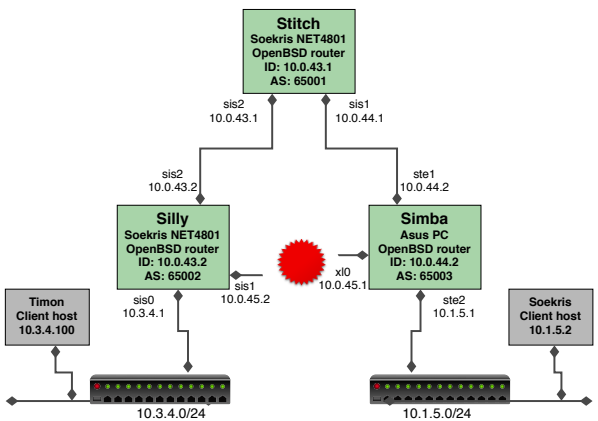


Now lets do the exercise

ARP spoofing and ettercap 20 min

which is number **15** in the exercise PDF.

Intro to routing protocols attacks



Når netværkene vokser bliver det administrativt svært at vedligeholde

Det skalerer dårligt med statiske routes til netværk

Samtidig vil man gerne have redundante forbindelser

Til dette brug har man STP på switch niveau og dynamisk routing på IP niveau

BGP intro

What is BGP Border Gateway Protocol

Dynamic routing protocol, BGPv4 used on whole internet

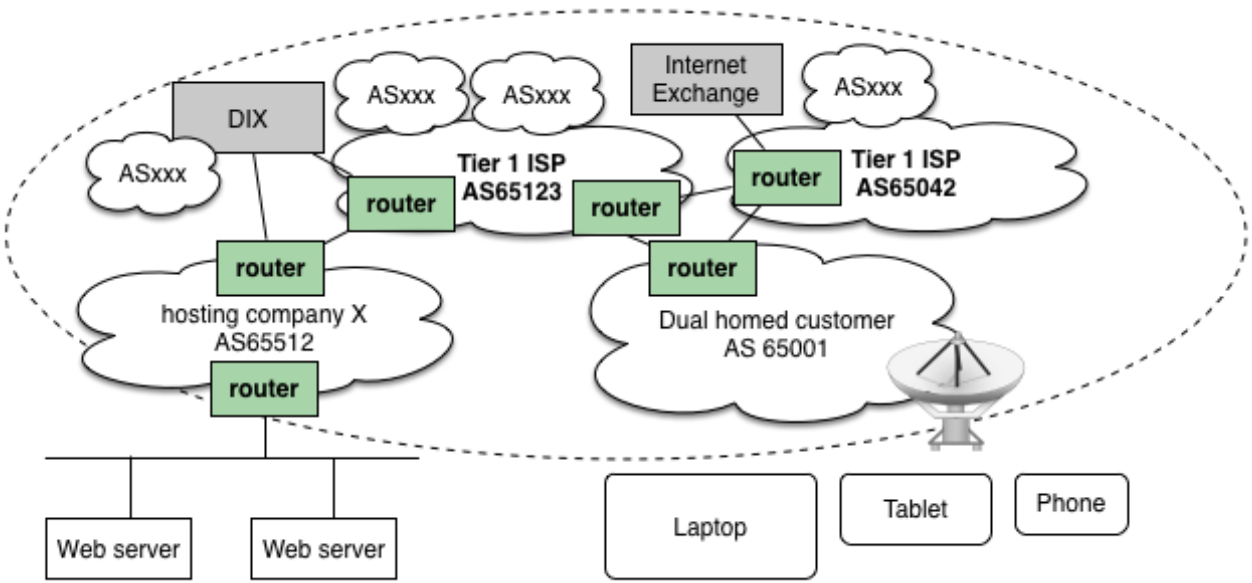
Networks identified using AS numbers ASNs

Autonomous System (AS) can be small or very big, world wide

BGP version 4 RFC-4271 uses TCP connections *peering*

`http://en.wikipedia.org/wiki/Border_Gateway_Protocol`

Hosting og internet-udbydere



- Jeg var engang i en position hvor vi transporterede data for mange kunder
- Det var data som information, just eat, kino.dk, ...

OSPF Open Shortest Path First

Er en dynamisk routing protocol som benyttes til intern routing

OSPF version 3 er beskrevet i RFC-2740

OSPF bruger hverken TCP eller UDP, men sin egen protocol med ID 89

OSPF bruger en metric/cost pr link for at udregne smart routing

`http://en.wikipedia.org/wiki/Open_Shortest_Path_First`

Vores setup svarer til OpenBGPD setup, blot med OpenOSPFD

Routingproblemer, angreb

Fake routing updates Secure IOS template der findes på adressen:

`http://www.cymru.com/Documents/secure-ios-template.html`

Network Security Threats

Low level and Network Layer Attacks

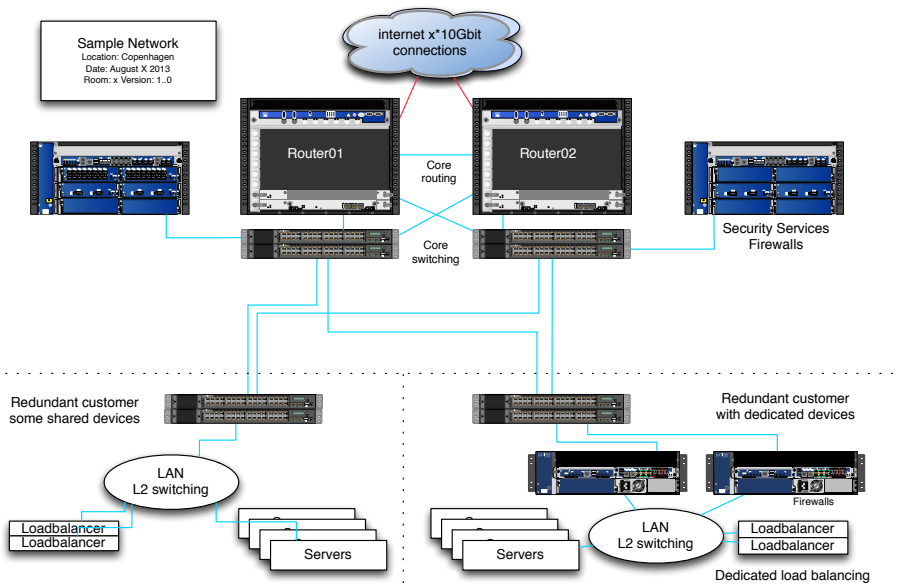
- Yersinia
- IP
- LAND, m.fl.

Some preventions

RPKI

Authenticated routing protocols passwords, secrets etc.

DDoS and flooding



- Transport Layer Attacks TCP SYN flood TCP sequence numbers
- High level attacks like Slowloris - keep TCP/HTTP connection for a long time.

Båndbreddestyring og policy based routing

Mange routere og firewalls idag kan lave båndbredde allokering til protokoller, porte og derved bestemte services

Specielt relevant for DDoS beskyttelse

Findes på F5 BigIP, Cisco, Junos osv.

Mest kendte er i Open Source:

- OpenBSD - integreret i PF
- FreeBSD har dummynet
- Linux Traffic Control

Det kaldes også traffic shaping

hping3 packet generator

```
usage: hping3 host [options]
  -i  --interval  wait (uX for X microseconds, for example -i u1000)
      --fast      alias for -i u10000 (10 packets for second)
      --faster    alias for -i u1000 (100 packets for second)
      --flood      sent packets as fast as possible. Don't show replies.
...
hping3 is fully scriptable using the TCL language, and packets
can be received and sent via a binary or string representation
describing the packets.
```

- Hping3 packet generator is a very flexible tool to produce simulated DDoS traffic with specific charateristics
- Home page: `http://www.hping.org/hping3.html`
- Source repository `https://github.com/antirez/hping`

My primary DDoS testing tool, easy to get specific rate pps

t50 packet generator

```
root@cornerstone03:~# t50 -?
T50 Experimental Mixed Packet Injector Tool 5.4.1
Originally created by Nelson Brito <nbrito@sekure.org>
Maintained by Fernando Mercês <fernando@mentebinaria.com.br>

Usage: T50 <host> [/CIDR] [options]

Common Options:
    --threshold NUM        Threshold of packets to send     (default 1000)
    --flood                This option supersedes the 'threshold'
...
6. Running T50 with '--protocol T50' option, sends ALL protocols sequentially.
root@cornerstone03:~# t50 -? | wc -l
264
```

- T50 packet generator, another high speed packet generator can easily overload most firewalls by producing a randomized traffic with multiple protocols like IPsec, GRE, MIX
  home page: `http://t50.sourceforge.net/resources.html`

Extremely fast and breaks most firewalls when flooding, easy 800k pps/400Mbps

Process: monitor, attack, break, repeat

- Pre-test: Monitoring setup - from multiple points
- Pre-test: Perform full Nmap scan of network and ports
- Start small, run with delays between packets
- Turn up until it breaks, decrease delay - until using `--flood`
- Monitor speed of attack on your router interface pps/bandwidth
- Give it maximum speed
  `hping3 --flood -1` and `hping3 --flood -2`
- Have a common chat with network operators/customer to talk about symptoms and things observed
- Any information resulting from testing is good information

Ohh we lost our VPN into the environment, ohh the fw console is dead

Running Attacks with hping3

```
# export CUST_IP=192.0.2.1
# date;time hping3 -q -c 1000000  -i u60 -S -p 80  $CUST_IP


# date;time hping3 -q -c 1000000  -i u60 -S -p 80  $CUST_IP
Thu Jan 21 22:37:06 CET 2016
HPING 192.0.2.1 (eth0 192.0.2.1): S set, 40 headers + 0 data bytes

--- 192.0.2.1 hping statistic ---
1000000 packets transmitted, 999996 packets received, 1% packet loss
round-trip min/avg/max = 0.9/7.0/1005.5 ms

real    1m7.438s
user    0m1.200s
sys     0m5.444s
```

Dont forget to do a killall hping3 when done ☺

Recommendations During Test

Run each test for at least 5 minutes, or even 15 minutes
Some attacks require some build-up before resource run out

Take note of any change in response, higher latency, lost probes

If you see a change, then re-test using the same parameters, or a little less first

We want to know the approximate level where it breaks

If you want to change environment, then wait until all scenarios tested

Comparable to real DDoS?

Tools are simple and widely available but are they actually producing same result as high-powered and advanced criminal botnets. We can confirm that the attack delivered in this test is, in fact, producing the traffic patterns very close to criminal attacks in real-life scenarios.

- We can also monitor logs when running a single test-case
- Gain knowledge about supporting infrastructure
- Can your syslog infrastructure handle 800.000 events in $<$ 1 hour?

Running the tools

A basic test would be:

- TCP SYN flooding
- TCP other flags, PUSH-ACK, RST, ACK, FIN
- ICMP flooding
- UDP flooding
- Spoofed packets src=dst=target ☺
- Small fragments
- Bad fragment offset
- Bad checksum
- Be creative
- Mixed packets - like `t50 --protocol T50`
- Perhaps esoteric or unused protocols, GRE, IPSec

Test-cases / Scenarios

The minimal run contains at least these:

- SYN flood: `hping3 -q -c 1000000  -i u60 -S -p 80  $CUST_IP &`
- SYN+ACK: `hping3 -q -c 1000000  -i u60 -S -A -p 80  $CUST_IP &`
- ICMP flood: `hping3 -q -c --flood -1 $CUST_IP &`
- UDP flood: `hping3 -q -c --flood -1 $CUST_IP &`

Vary the speed using the packet interval `-i u60` up/down

Use flooding with caution, runs max speeeeeeeeeeeed ☺

TCP testing use a port which is allowed through the network, often 80/443

Focus on attacks which are hard to block, example TCP SYN must be allowed in

Also if you found devices like routers in front of environment

```
hping3 -q -c 1000000  -i u60 -S -p 22 $ROUTER_IP
hping3 -q -c 1000000  -i u60 -S -p 179 $ROUTER_IP
```

Experiences from testing

How much bandwidth can big danish companies handle!

- B) **100Mbps -1Gbit**

How much abuse in pps can big danish companies handle!

- B) **50.000 - 500k pps** TCP attacks
- B) **500.000 - 1mill pps** UDP or ICMP attacks
- Ohhh and often we can spoof using their addresses in the first test

Even the DDoS protection services are a bit too small, can handle perhaps only 10G. Multiple times admins lost access to network, VPN, log overflow etc.

Note: attackers can send full 10Gbit 14mill pps from Core i7 with 3 cores ...

Improvements seen after testing

Turning off unneeded features - free up resources

Tuning sesions, max sessions src / dst

Tuning firewalls, max sessions in half-open state, enabling services

Tuning network, drop spoofed src from inside net ☺

Tuning network, can follow logs, manage network during attacks

...

And organisation has better understanding of DDoS challenges

Including vendors, firewall consultants, ISPs etc.

After tuning of **existing devices/network** improves results 10-100 times

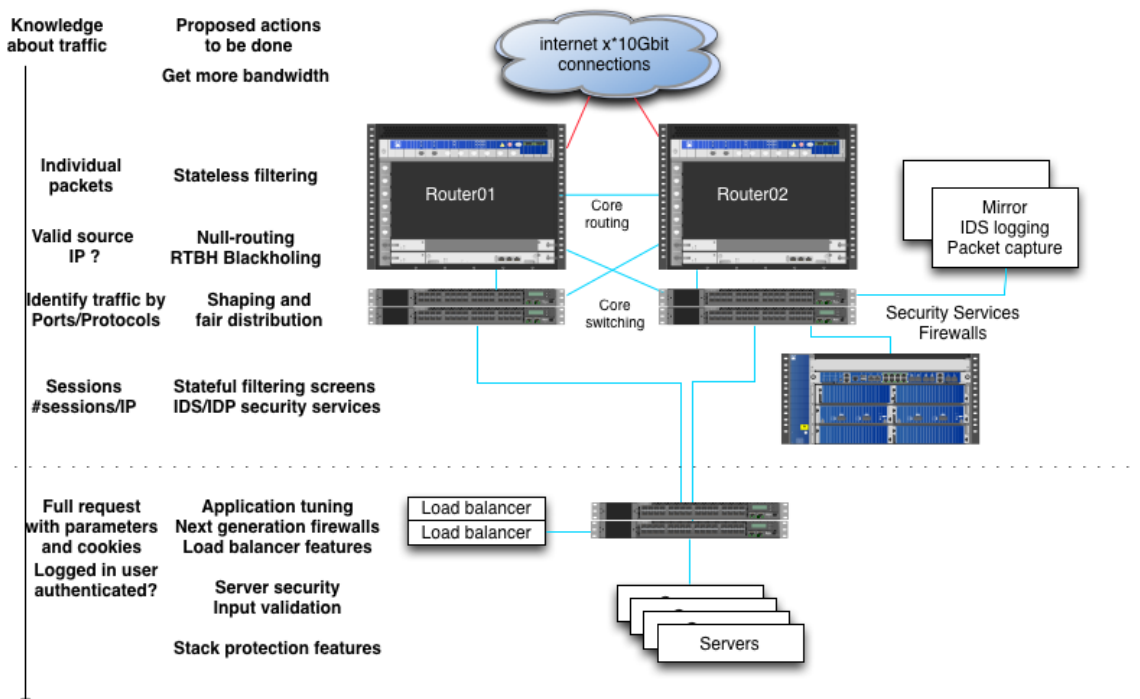
Conclusion DDoS and network attacks

.

You really should try testing

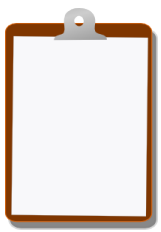
Investigate your existing devices
all of them, RTFM, upgrade firmware

Choose which devices does which
part - discard early to free resources
for later devices to dig deeper



And dont forget that DDoS testing is as much a firedrill for the organisation

For Next Time



Think about the subjects from this time, write down questions

Check the plan for chapters to read in the books
Most days have about 100 pages or less, but one day has 4 chapters to read!

Visit web sites and download papers if needed

Retry the exercises to get more confident using the tools