





Welcome to

10. Network Attacks

KEA Competence OB2 Software Security

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Slides are available as PDF, kramse@Github
10-network-attacks.tex in the repo security-courses

Plan for today



Subjects

- Auditing Application Protocols
- Example protocols and vulnerabilities
- Abstract Syntax Notation (ASN.1) problems
- Domain Name System (DNS) problems
- Firewalls and related issues
- Network Security Monitoring

Exercises

- Nmap and SYN flooding exercises

Reading Summary



Browse: *TCP Synfloods - an old yet current problem, and improving pf's response to it* Henning Brauer, BSDCan 2017 <http://quigon.bsws.de/papers/2017/bsdcan/>

Goals: Introduction to Auditing Application Protocols



```
Secure Sockets Layer
  TLSv1.2 Record Layer: Handshake Protocol: Client Hello
    Content Type: Handshake (22)
    Version: TLS 1.0 (0x0301)
    Length: 186
  Handshake Protocol: Client Hello
    Handshake Type: Client Hello (1)
    Length: 184
    Version: TLS 1.2 (0x0303)
    Random
    Session ID Length: 0
    Cipher Suites Length: 32
    Cipher Suites (16 suites)
    Compression Methods Length: 1
    Compression Methods (1 method)
    Extensions Length: 121
    Extension: Unknown SAE00
    Extension: renegotiation info
  Cipher Decryption
    Type: server_name (0x0005)
    Length: 18
    Server Name Indication extension
      Server Name list length: 14
      Server Name Type: host_name (0)
      Server Name Length: 11
      Server Name: halloer.com
    Extension: Ciphertext Master Secret
0000  04 10 52 8f 2c 18 90 91 54 88 8a 77 8d 95 73 64  ..R....Th.w..sd
0010  7d 00 00 20 5a 5a c0 2b c0 2f c0 2c c0 30 cc a9  }..Z2.+ /.,.0..
0020  cc 4d cc 14 cc 21 c0 13 c0 14 00 8c 00 00 00 2f  .....
0030  00 25 00 0a 01 00 00 79 0a da 00 00 ff 01 00 01  .....Y.....
0040  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  .....
0050  14 00 32 04 01 00 04 04 01 00 23 00 00 00 02 00  .....R.....
0060  14 00 32 04 01 00 04 04 01 00 23 00 00 00 02 00  .....R.....
```

Often you dont need to audit the whole protocol in detail

Sometimes people can't tell which protocols, ports and services they use ...

And you need to configure a firewall/network filter

Picture: Wireshark with TLS SNI, recent Exim CVE-2019-15846 was SNI parsing

Plus SYN flooding, and Denial of Service

Goals today: Networking with some pentesting



What is pentest

A penetration test, informally pen test, is an attack on a computer system that looks for security weaknesses, potentially gaining access to the computer's features and data.[1][2]

Source: quote from https://en.wikipedia.org/wiki/Penetration_test

Penetration testing is a simulation, with good intentions

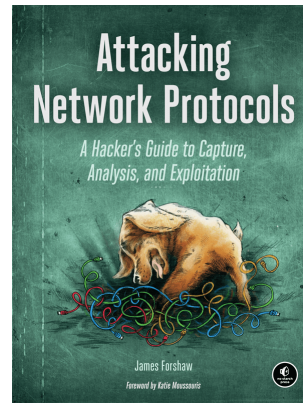
People around the world constantly *test your defenses*

Often better to test at planned times

How to create DDoS simulations, tools and process

I use and recommend Kali Linux as the base for this

Reversing and Attacking Network Protocols



A method with lots detail can be found in the book,
Attacking Network Protocols A Hacker's Guide to Capture, Analysis, and Exploitation
by James Forshaw December 2017, 336 pp. ISBN-13: 9781593277505

<https://nostarch.com/networkprotocols>

Auditing Application Protocols



- Collect documentation
- Identify Elements of Unknown Protocols
- Use packet sniffers, tcpdump and Wireshark
- Initiate the Connection Several Times
- Replay traffic, can sometimes replay even encrypted traffic, see wireless WEP attacks

Note: We investigate protocols, so we can see what is sent, so we can design *payloads* which create problems for implementations - applications

Reverse Engineer Applications



```
(gdb) disas main
```

```
Dump of assembler code for function main:
```

```
0x0000000000000580 <+0>: lea    0x1ed(%rip),%rdi    # 0x774
0x0000000000000587 <+7>: sub    $0x8,%rsp
0x000000000000058b <+11>: mov    $0x7fff,%esi
0x0000000000000590 <+16>: xor    %eax,%eax
0x0000000000000592 <+18>: callq  0x560 <printf@plt>
0x0000000000000597 <+23>: lea    0x1ed(%rip),%rdi    # 0x78b
0x000000000000059e <+30>: mov    $0xffff8000,%esi
0x00000000000005a3 <+35>: xor    %eax,%eax
0x00000000000005a5 <+37>: callq  0x560 <printf@plt>
0x00000000000005aa <+42>: xor    %eax,%eax
0x00000000000005ac <+44>: add    $0x8,%rsp
0x00000000000005b0 <+48>: retq
```

```
End of assembler dump.
```

- It is possible to debug, disassemble and reverse engineer applications
- Calling socket functions, seeing structs, data types etc.
- Examine strings: HTTP, FTP, SMTP etc. all uses semi-english words GET, EHLO, PASS

Special values



- Examine special values
- What are the defined/used values
- What happens if this is changed? Do they cover values outside of the used ranges? Case/switch constructs
- Use trace functions in the operating system, can capture, analyze and replay sometimes

Buffer Overflow when receiving



- When you see data enter the application, identify functions
 - Consider if they use dangerous functions, strcpy and friends
 - How much space is available, allocated etc.
 - Basic stuff and similar across applications
-
- Repeat everything we learned about string processing, integer overflows/underflows etc. Just from the network
 - Often trying to abuse will lead to denial of service
-
- If some rock solid service starts bouncing down and up, maybe look into traffic received.
 - This is what honeypots also do

Vigtigste protokoller



ARP Address Resolution Protocol

IP og ICMP Internet Control Message Protocol

UDP User Datagram Protocol

TCP Transmission Control Protocol

DHCP Dynamic Host Configuration Protocol

DNS Domain Name System

Ovenstående er omtrent minimumskrav for at komme på internet

Binary Protocols



- Some protocols use binary formats
- Example DNS, which is a complex protocol
- When parsing DNS use standard libraries!
- When attacking DNS applications, use standard libraries! 😊
- DNS is just an example, new protocols may not be implemented - but someone might have analyzed it or parts already!



IPMI Authentication Bypass via Cipher 0

Dan Farmer identified a serious failing of the IPMI 2.0 specification, namely that cipher type 0, an indicator that the client wants to use clear-text authentication, actually allows access with any password. Cipher 0 issues were identified in HP, Dell, and Supermicro BMCs, with the issue likely encompassing all IPMI 2.0 implementations. It is easy to identify systems that have cipher 0 enabled using the `ipmi_cipher_zero` module in the Metasploit Framework.

- Sometimes people add network functionality to existing applications
- - and do this badly
- We have seen applications like IPMI and others

Source: <https://blog.rapid7.com/2013/07/02/a-penetration-testers-guide-to-ipmi/>

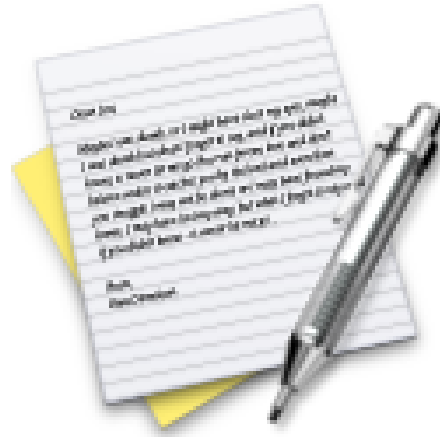
ISAKMP example



- IKE(v1) has been criticized as being overly complex
- Needed bake-off sessions where vendors meet and tried negotiating
- Searching for CVE ISAKMP show multiple vulnerabilities in various implementations, including firewalls and tcpdump
- Source: AoSSA chapter 16: Network Application Protocols

The Art of Software Security Assessment Identifying and Preventing Software Vulnerabilities Mark Dowd, John McDonald, Justin Schuh ISBN: 9780321444424

Exercise



Now lets do the exercise

Sniff Your Browser 15min

which is number **33** in the exercise PDF.

ASN.1 problems



- Abstract format designed for representing objects in a machine independent format
- Used for various technologies in use on the internet:
- Certificates and key encoding
- Simple Network Management Protocol (SNMP)
- ISAKMP part of IPsec
- Lightweight Directory Access Protocol (LDAP)

Linux Kernel ASN.1



- 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/

Type Length Value TLVs



TLV sequences are easily searched using generalized parsing functions; New message elements which are received at an older node can be safely skipped and the rest of the message can be parsed. This is similar to the way that unknown XML tags can be safely skipped; TLV elements can be placed in any order inside the message body; TLV elements are typically used in a binary format which makes parsing faster and the data smaller than in comparable text based protocols.

Source: <https://en.wikipedia.org/wiki/Type-length-value>

- Type Length Value is an encoding used in data communication
- For example in Link Layer Discovery Protocol (LLDP)

Cisco Application Centric Infrastructure, aka Security Device



The first time an APIC gets physically connected to one of the leaf switches of an ACI fabric, it will initiate a configuration process for the switches. The initial packets sent by the APIC are Link Layer Discovery Protocol (LLDP) packets containing information that is used by the leaf switch to initiate the configuration process. The LLDP protocol is used to advertise the identity, capabilities and certain other parameters of the APIC via TypeLength-Value (TLV) fields.

ERNW WHITEPAPER 68, SECURITY ASSESSMENT OF CISCO ACI, 2019

https://static.ernw.de/whitepaper/ERNW_Whitepaper68_Vulnerability_Assessment_Cisco_ACI_signed.pdf

- Cisco Nexus 9000 Series Fabric Switches ACI Mode Fabric Infrastructure VLAN Unauthorized Access Vulnerability (CVE-2019-1890)
- Cisco Nexus 9000 Series Fabric Switches Application Centric Infrastructure Mode Link Layer Discovery Protocol Buffer Overflow Vulnerability (CVE-2019-1901)

DNS problems



The Domain Name System (DNS) [32][33] provides for a distributed database mapping host names to IP addresses. An intruder who interferes with the proper operation of the DNS can mount a variety of attacks, including denial of service and password collection. There are a number of vulnerabilities.

Source: *Security Problems in the TCP/IP Protocol Suite*, S.M. Bellovin 1989

<https://www.cs.columbia.edu/~smb/papers/ipext.pdf>

We have a lot of the same problems in DNS today

Plus some more caused by middle-boxes, NAT, DNS size, DNS inspection

- DNS must allow both UDP and TCP port 53
- Your DNS servers must have updated software, see DNS flag day
<https://dnsflagday.net/> after which kludges will be REMOVED!
- DNS is unencrypted

DNS server software



Berkeley Internet Name Daemon server used to be the de facto name server

Still available and multiple versions

Now I recommend using NSD for authoritative servers and Unbound for recursive, both from NLnetlabs <https://www.nlnetlabs.nl/>

- Older reference, but great book about DNS:
DNS and BIND, Paul Albitz & Cricket Liu, O'Reilly, 5th edition Maj 2006
- BIND has had sooo many vulnerabilities across versions and releases

Unbound and NSD



Unbound is a validating, recursive, caching DNS resolver. It is designed to be fast and lean and incorporates modern features based on open standards.

To help increase online privacy, Unbound supports DNS-over-TLS which allows clients to encrypt their communication. In addition, it supports various modern standards that limit the amount of data exchanged with authoritative servers.

<https://www.nlnetlabs.nl/projects/unbound/about/>

My preferred local DNS server.

Also check out uncensored DNS and his DNS over TLS setup!

Even has pinning information available:

<https://blog.censurfridns.dk/blog/32-dns-over-tls-pinning-information-for-unicastcensurfridnsdk/>

DNS over TLS vs DNS over HTTPS - DNS encryption



Protocols exist that encrypt DNS data, like dnscrypt which is not RFC standard <https://dnscrypt.info/> <https://en.wikipedia.org/wiki/DNSCrypt>

Today we have competing standards:

Specification for DNS over Transport Layer Security (TLS) (DoT), RFC 7858 MAY 2016

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

DNS Queries over HTTPS (DoH) RFC 8484

How to configure DoT <https://dnsprivacy.org/wiki/display/DP/DNS+Privacy+Clients>

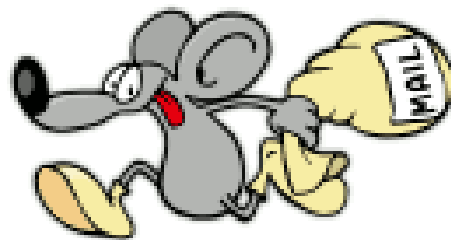
DNS problems



- Failure to Deal with Invalid Label Lengths
- Insufficient Destination Lengths Check
- Insufficient Source Length Checks
- Pointer Values Not Verified In Packet
- Special Pointer Values
- Length Variables
- These are from the book: AoSSA chapter 16: Network Application Protocols
The Art of Software Security Assessment Identifying and Preventing Software Vulnerabilities Mark Dowd, John McDonald, Justin Schuh ISBN: 9780321444424

Labels and pointers within packets save bytes, but make it more complex!

Postfix postserveren



POSTFIX

Lavet af Wietse Venema for IBM

Nem at konfigurere og sikker

`main.cf` findes typisk i kataloget `/etc/postfix`

Audit af postservere



Typisk findes konfigurationsfilerne til postservere under /etc

- /etc/mail
- /etc/postfix

Det vigtigste er at den er opdateret og IKKE tillader relaying

Der findes diverse test-scripts til relaycheck på internet

Husk også at checke domæne records, MX og A

Test af e-mail server

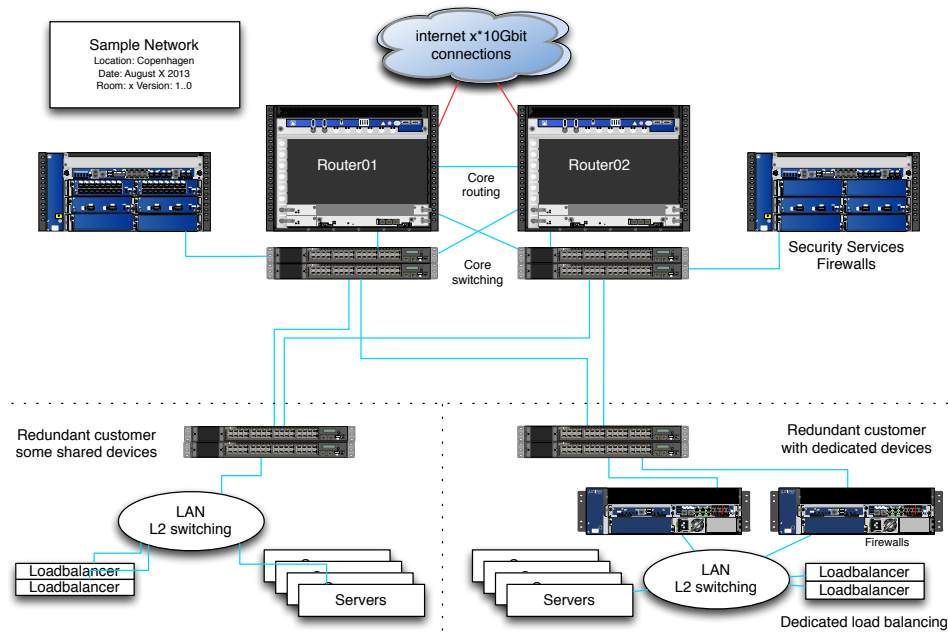


```
[hlk]$ telnet localhost 25
Connected.
Escape character is '^]'.
220 server ESMTP Postfix
  helo test
250 server
  mail from: postmaster@pentest.dk
250 Ok
  rcpt to: root@pentest.dk
250 Ok
  data
354 End data with <CR><LF>.<CR><LF>
  skriv en kort besked
.
250 Ok: queued as 91AA34D18
quit
```

Skal ikke tillade relaying, og vil blive misbrugt meget hurtigt.

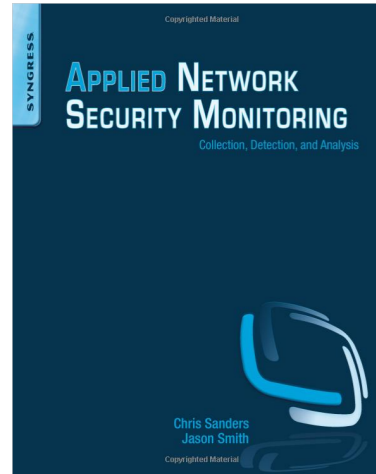
Idag benyttes ofte en stjålet brugerkonto med brugernavn og kodeord til at sende spam.

Networks today



Conclusion: Do as much as possible with your existing devices
Tuning and using features like stateless router filters works wonders

Book: Applied Network Security Monitoring (ANSM)

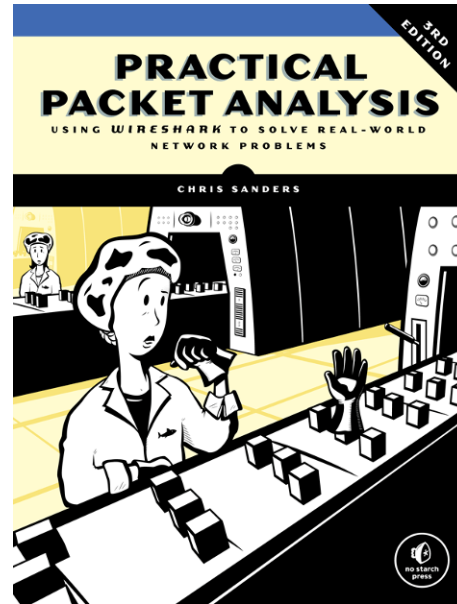


Applied Network Security Monitoring: Collection, Detection, and Analysis 1st Edition

Chris Sanders, Jason Smith eBook ISBN: 9780124172166 Paperback ISBN: 9780124172081 496 pp. Imprint: Syngress, December 2013

<https://www.elsevier.com/books/applied-network-security-monitoring/unknown/978-0-12-417208-1>

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>

Internet is Open Standards!



We reject kings, presidents, and voting.

We believe in rough consensus and running code.

– The IETF credo Dave Clark, 1992.

Request for comments - RFC - er en serie af dokumenter

RFC, BCP, FYI, informational

de første stammer tilbage fra 1969

Ændres ikke, men får status Obsoleted når der udkommer en nyere version af en standard

Standards track:

Proposed Standard → Draft Standard → Standard

Åbne standarder = åbenhed, ikke garanti for sikkerhed

IPv4 pakken - header - RFC-791

[illegible]

Example Internet Datagram Header

IPv6 pakken - header - RFC-2460



- Simplere - fixed size - 40 bytes
- Sjældent brugte felter (fra v4) udeladt (kun 6 vs 10 i IPv4)
- Ingen checksum!
- Adresser 128-bit
- 64-bit aligned, alle 6 felter med indenfor første 64

Mindre kompleksitet for routere på vejen medfører mulighed for flere pakker på en given router

IPv6 pakken - header - RFC-2460



```
+-----+
|Version| Traffic Class |           Flow Label           |
+-----+-----+-----+-----+-----+-----+-----+
|           Payload Length           | Next Header |   Hop Limit   |
+-----+-----+-----+-----+-----+-----+-----+
|                                     |               |
+                                     +               +
|                                     |               |
+                                     +               +
|                               Source Address              |
|                                     |               |
+                                     +               +
|                                     |               |
+-----+-----+-----+-----+-----+-----+-----+
|                                     |               |
+                                     +               +
|                                     |               |
+                               Destination Address         +
|                                     |               |
+                                     +               +
|                                     |               |
+-----+-----+-----+-----+-----+-----+-----+
```

IPv6 pakken - extension headers RFC-2460



Fuld IPv6 implementation indeholder:

- Hop-by-Hop Options
- Routing (Type 0) - deprecated
- Fragment - fragmentering KUN i end-points!
- Destination Options
- Authentication
- Encapsulating Security Payload

Ja, IPsec er en del af IPv6!

Hvordan bruger man IPv6



www.zencurity.com

hlk@zencurity.com

DNS AAAA record tilføjes

www	IN A	91.102.91.17
	IN AAAA	2001:16d8:ff00:12f::2
mail	IN A	91.102.91.17
	IN AAAA	2001:16d8:ff00:12f::2

IPv6 adresser og skrivemåde



subnet prefix	interface identifier
---------------	----------------------

2001:16d8:ff00:012f:0000:0000:0000:0002

2001:16d8:ff00:12f::2

- 128-bit adresser, subnet prefix næsten altid 64-bit
- skrives i grupper af 4 hexcifre ad gangen adskilt af kolon :
- foranstillede 0 i en gruppe kan udelades, en række 0 kan erstattes med ::
- dvs 0:0:0:0:0:0:0:0 er det samme som
0000:0000:0000:0000:0000:0000:0000:0000
- Dvs min webservers IPv6 adresse kan skrives som: 2001:16d8:ff00:12f::2
- Specielle adresser: ::1 localhost/loopback og :: default route
- Læs mere i RFC-3513

IP karakteristik



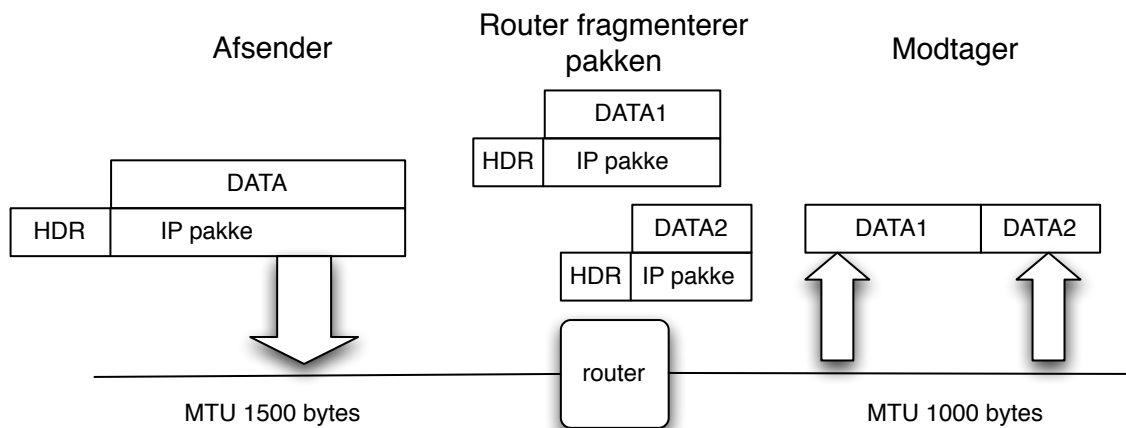
Fælles adresserum, dog version 4 for sig, og IPv6 for sig.

Best effort - kommer en pakke fra er det fint, hvis ikke må højere lag klare det

Kræver ikke mange services fra underliggende teknologi *dumt netværk*

Defineret gennem åben standardiseringsprocess og RFC-dokumenter

Fragmentering og PMTU



Hidtil har vi antaget at der blev brugt Ethernet med pakkestørrelse på 1500 bytes

Pakkestørrelsen kaldes MTU Maximum Transmission Unit

Skal der sendes mere data opdeles i pakker af denne størrelse, fra afsender

Men hvad hvis en router på vejen ikke bruger 1500 bytes, men kun 1000

ICMP Internet Control Message Protocol



Kontrolprotokol og fejlmeldinger

Nogle af de mest almindelige beskedtyper

- echo
- netmask
- info

Bruges generelt til *signalering*

Defineret i RFC-792

NB: nogle firewall-administratorer blokerer alt ICMP - det er forkert!

ICMP beskedtyper



Type

- 0 = net unreachable;
- 1 = host unreachable;
- 2 = protocol unreachable;
- 3 = port unreachable;
- 4 = fragmentation needed and DF set;
- 5 = source route failed.

Ved at fjerne ALT ICMP fra et net fjerner man nødvendig funktionalitet!

Tillad ICMP types:

- 3 Destination Unreachable
- 4 Source Quench Message
- 11 Time Exceeded
- 12 Parameter Problem Message

Firewalls and related issues

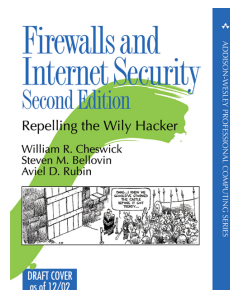


In computing, a firewall is a network security system that monitors and controls incoming and outgoing network traffic based on predetermined security rules.[1] A firewall typically establishes a barrier between a trusted internal network and untrusted external network, such as the Internet.[2]

Source: Wikipedia

- [https://en.wikipedia.org/wiki/Firewall_\(computing\)](https://en.wikipedia.org/wiki/Firewall_(computing))
- <http://www.wilyhacker.com/> Cheswick chapter 2 PDF *A Security Review of Protocols: Lower Layers*
- Network layer, packet filters, application level, stateless, stateful

Firewalls are by design a choke point, natural place to do network security monitoring!



Firewalls har været kendt siden starten af 90'erne

Første bog *Firewalls and Internet Security* udkom i 1994 men kan stadig anbefales, læs den på <http://www.wilyhacker.com/>

2003 kom den i anden udgave *Firewalls and Internet Security* William R. Cheswick, Steven M. Bellovin, Aviel D. Rubin, Addison-Wesley, 2nd edition

Reading about firewalls



<http://www.wilyhacker.com/> Cheswick chapter 3 PDF *Security Review: The Upper Layers*

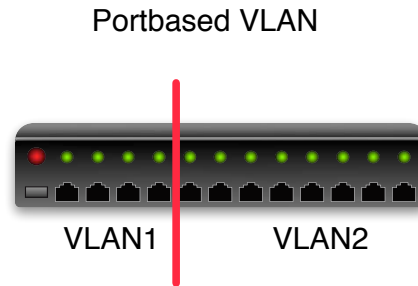
- How to configure firewalls often boil down to, should we allow protocol X
- If we allow SMB through an internet firewall, we are asking for trouble

Skim chapters from 1st edition:

<http://www.wilyhacker.com/1e/chap03.pdf>

<http://www.wilyhacker.com/1e/chap04.pdf>

Together with Firewalls - VLAN Virtual LAN



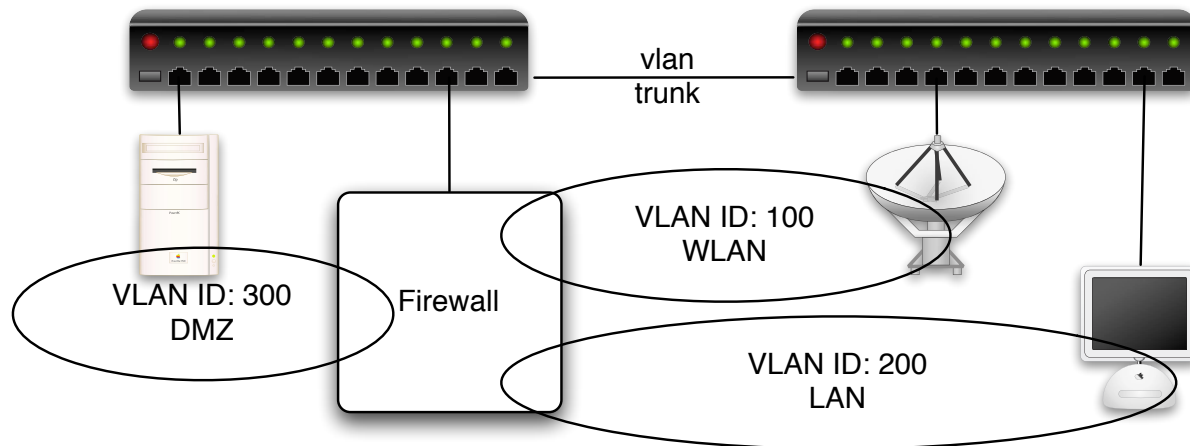
Nogle switche tillader at man opdeler portene

Denne opdeling kaldes VLAN og portbaseret er det mest simple

Port 1-4 er et LAN

De resterende er et andet LAN

Data skal omkring en firewall eller en router for at krydse fra VLAN1 til VLAN2

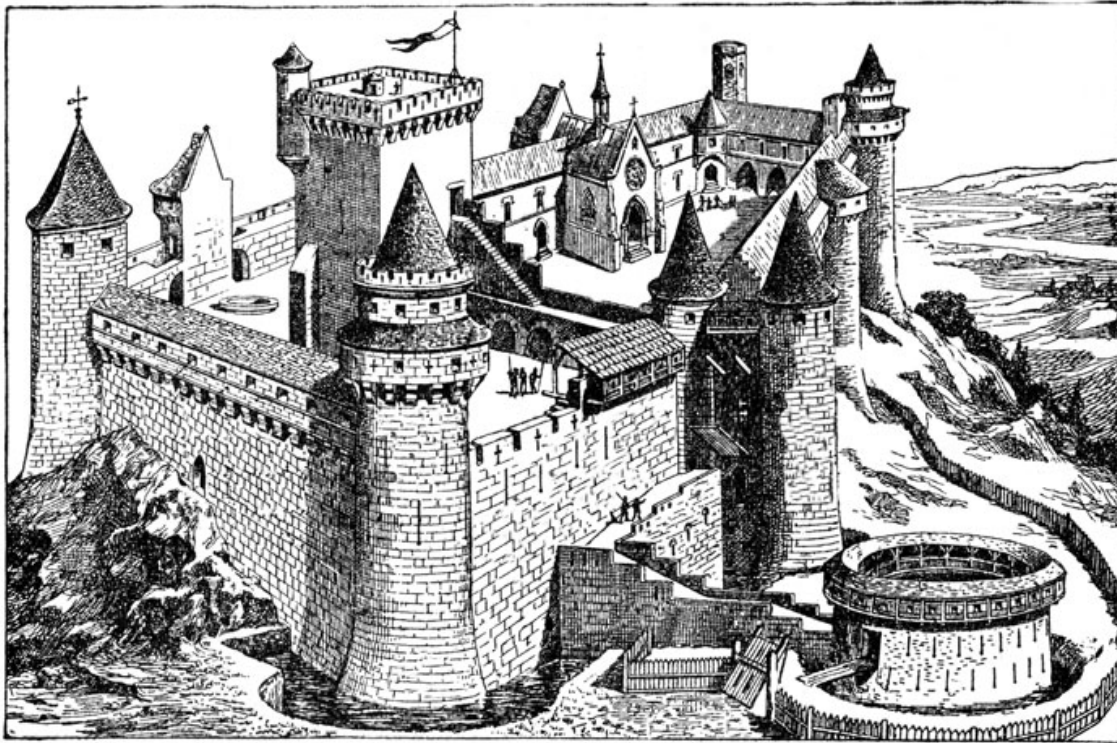


Med 802.1q tillades VLAN tagging på Ethernet niveau

Data skal omkring en firewall eller en router for at krydse fra VLAN1 til VLAN2

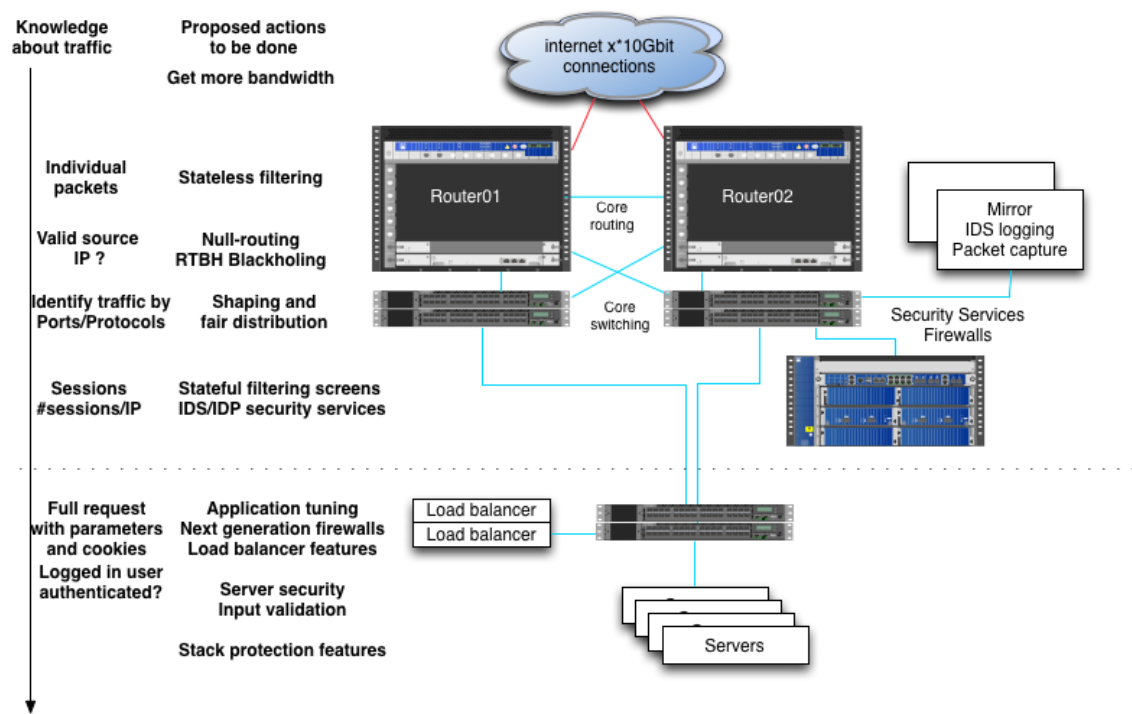
VLAN trunking giver mulighed for at dele VLANs ud på flere switches

Defense in depth

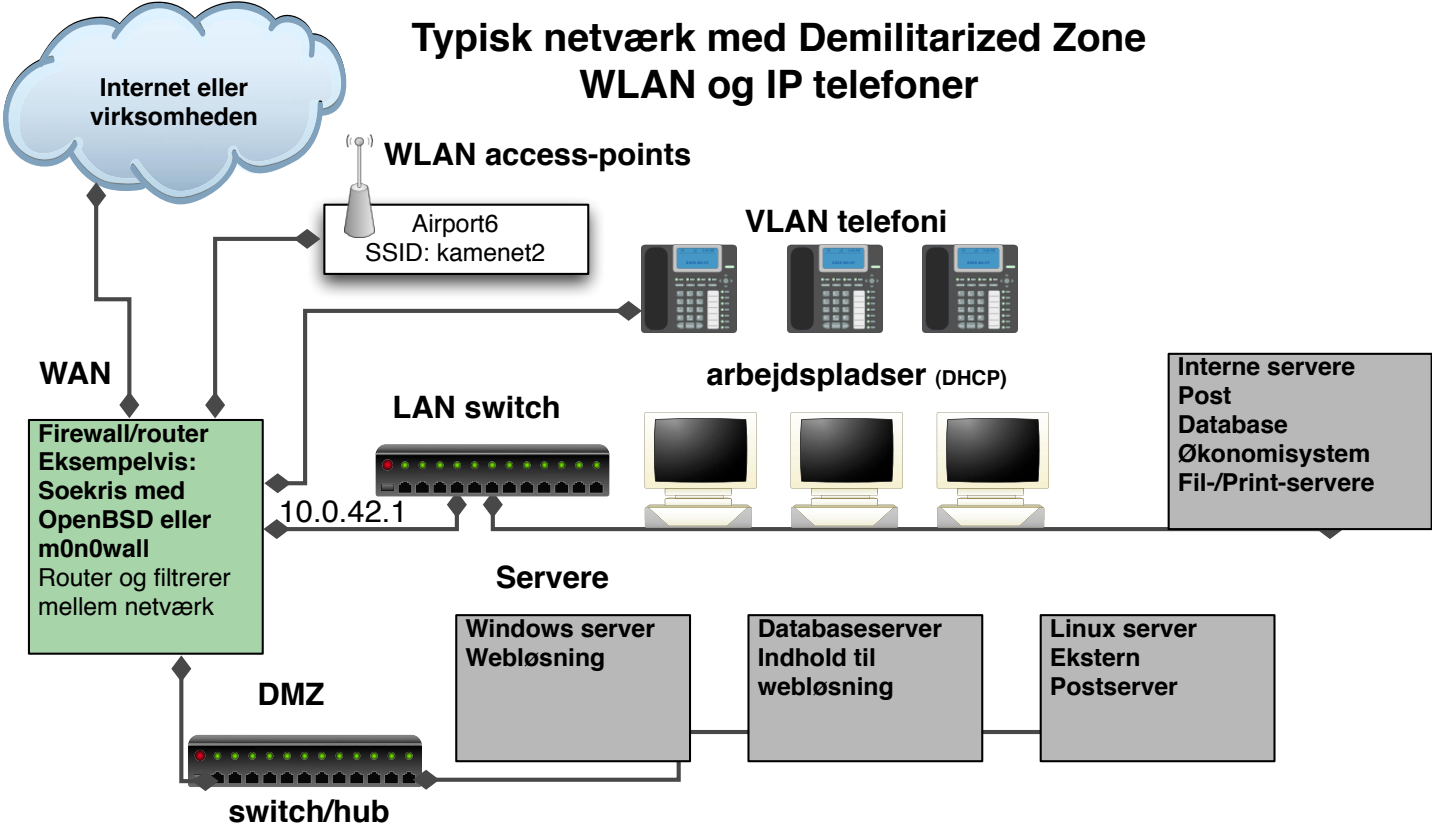


Picture originally from: <http://karenswhimsy.com/public-domain-images>

Firewall er ikke alene



Forsvaret er som altid - flere lag af sikkerhed!





Basalt set et netværksfilter - det yderste fæstningsværk

Indeholder typisk:

- Grafisk brugergrænseflade til konfiguration - er det en fordel?
- TCP/IP filtermuligheder - pakkernes afsender, modtager, retning ind/ud, porte, protokol, ...
- både IPv4 og IPv6
- foruddefinerede regler/eksempler - er det godt hvis det er nemt at tilføje/åbne en usikker protokol?
- typisk NAT funktionalitet indbygget
- typisk mulighed for nogle serverfunktioner: kan agere DHCP-server, DNS caching server og lignende

En router med Access Control Lists - kaldes ofte netværksfilter, mens en dedikeret maskine kaldes firewall

Sample rules from OpenBSD PF



```
# hosts and networks
router="217.157.20.129"
webserver="217.157.20.131"
homenet=" 192.168.1.0/24, 1.2.3.4/24 "
wlan="10.0.42.0/24"
wireless=wi0
set skip lo0
# things not used
spoofed=" 127.0.0.0/8, 172.16.0.0/12, 10.0.0.0/16, 255.255.255.255/32 "
```

block in all # default block anything

```
# egress and ingress filtering - disallow spoofing, and drop spoofed
block in quick from $spoofed to any
block out quick from any to $spoofed
```

```
pass in on $wireless proto tcp from { $wlan $homenet } to any port = 22
pass in on $wireless proto tcp from any to $webserver port = 80
```

```
pass out
```

Packet filtering



0										1										2										3													
0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1												
+-----+																																											
Version					IHL					Type of Service										Total Length																							
+-----+																																											
										Identification										Flags					Fragment Offset																		
+-----+																																											
					Time to Live										Protocol										Header Checksum																		
+-----+																																											
										Source Address																																	
+-----+																																											
										Destination Address																																	
+-----+																																											
										Options																				Padding													
+-----+																																											

Packet filtering er firewalls der filtrerer på IP niveau

Idag inkluderer de fleste stateful inspection

Kommercielle firewalls



- Checkpoint Firewall-1 <http://www.checkpoint.com>
- Cisco ASA <http://www.cisco.com>
- Clavister firewalls <http://www.clavister.com>
- Juniper SRX <http://www.juniper.net>
- Palo Alto <https://www.paloaltonetworks.com/>
- Fortinet <https://www.fortinet.com/>

Ovenstående er dem som jeg oftest ser ude hos mine kunder i Danmark

Open source baserede firewalls



- Linux firewalls IP tables, use command line tool ufw Uncomplicated Firewall!
- Firewall GUIs ovenpå Linux - mange! nogle er kommercielle produkter
- OpenBSD PF <http://www.openbsd.org>
- FreeBSD IPFW og IPFW2 <http://www.freebsd.org>
- Mac OS X benytter OpenBSD PF
- FreeBSD inkluderer også OpenBSD PF

NB: kun eksempler og dem jeg selv har brugt



Man hører indimellem begrebet *hardware firewall*

Det er dog et faktum at en firewall består af:

- Netværkskort - som er hardware
- Filtreringssoftware - som er *software*!

Det giver ikke mening at kalde en ASA 5501 en hardware firewall
og en APU2C4 med OpenBSD for en software firewall!

Man kan til gengæld godt argumentere for at en dedikeret firewall som en separat enhed kan give bedre sikkerhed

Det er også fint at tale om host-firewalls, altså at servere og laptops har firewall slået til

Linux TCP SACK PANIC - CVE-2019-11477 et al



Kernel vulnerabilities, CVE-2019-11477, CVE-2019-11478 and CVE-2019-11479

Executive Summary

Three related flaws were found in the Linux kernel's handling of TCP networking. The most severe vulnerability could allow a remote attacker to trigger a kernel panic in systems running the affected software and, as a result, impact the system's availability.

The issues have been assigned multiple CVEs: CVE-2019-11477 is considered an Important severity, whereas CVE-2019-11478 and CVE-2019-11479 are considered a Moderate severity.

The first two are related to the Selective Acknowledgement (SACK) packets combined with Maximum Segment Size (MSS), the third solely with the Maximum Segment Size (MSS).

These issues are corrected either through applying mitigations or kernel patches. Mitigation details and links to RHSA advisories can be found on the RESOLVE tab of this article.

Source: <https://access.redhat.com/security/vulnerabilities/tcpsack>

Availability and Network flooding attacks



- Our book spends some time on SYN and other flooding attacks
- SYN flood is the most basic and very common on the internet towards 80/tcp and 443/tcp
- ICMP and UDP flooding are the next targets
- Supporting literature is TCP Synfloods - an old yet current problem, and improving pf's response to it, Henning Brauer, BSDCan 2017
- All of them try to use up some resources
- Memory space in specific sections of the kernel, TCP state, firewalls state, number of concurrent sessions/connections
- interrupt processing of packets - packets per second
- CPU processing in firewalls, pps
- CPU processing in server software
- Bandwidth - megabits per second mbps

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

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

Simulating DDoS packets



A minimal introduction workshop teaching people how to produce DDoS simulation traffic - usefull for testing their own infrastructures.

We will have a server connected on a switch with multiple 1Gbit port for attackers. Attackers will be connected through 1Gbit ports using USB Ethernet - we have loaners.

Work together to produce enough to take down this server!

WHILE attack is ongoing there will be both the possibility to monitor traffic, monitor port, and decide on changes to prevent the attacks from working.

Common DDoS attack types



We will work through common attack types, like:

- TCP SYN flooding
- TCP other flooding
- UDP flooding NTP, etc.
- ICMP flooding
- Misc - stranger attacks and illegal combinations of flags etc.

then we will discuss which changes to environment could be implemented.

You will go away from this with tools for producing packets, hping3 and some configurations for protecting - PF rules, switch rules, server firewall rules.

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 characteristics
- 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



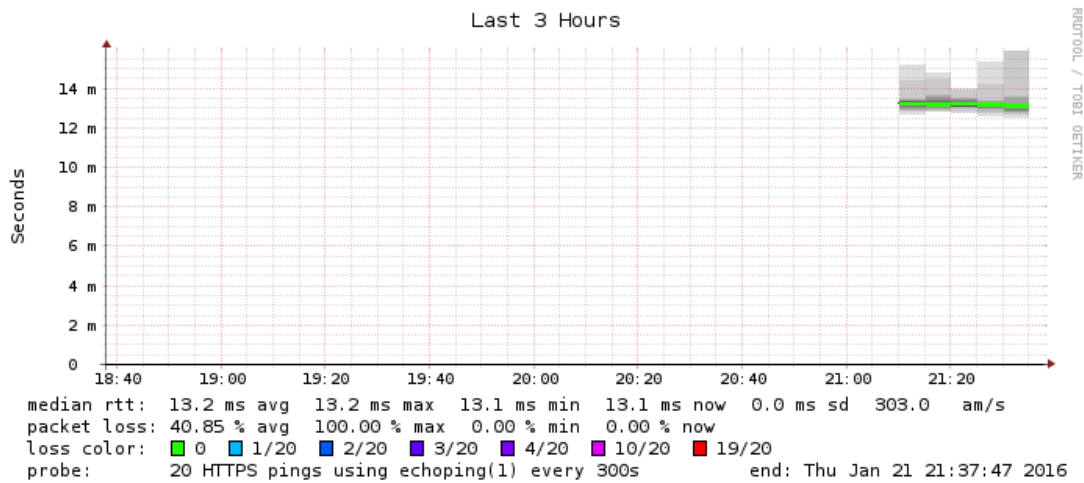
- Pre-test: Monitoring setup - from multiple points
- Pre-test: Perform full Nmap scan of network and ports
- Start small, run with delays between packets
- Turn up until it breaks, decrease delay - until using `--flood`
- Monitor speed of attack on your router interface pps/bandwidth
- Give it maximum 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

Before testing: Smokeping

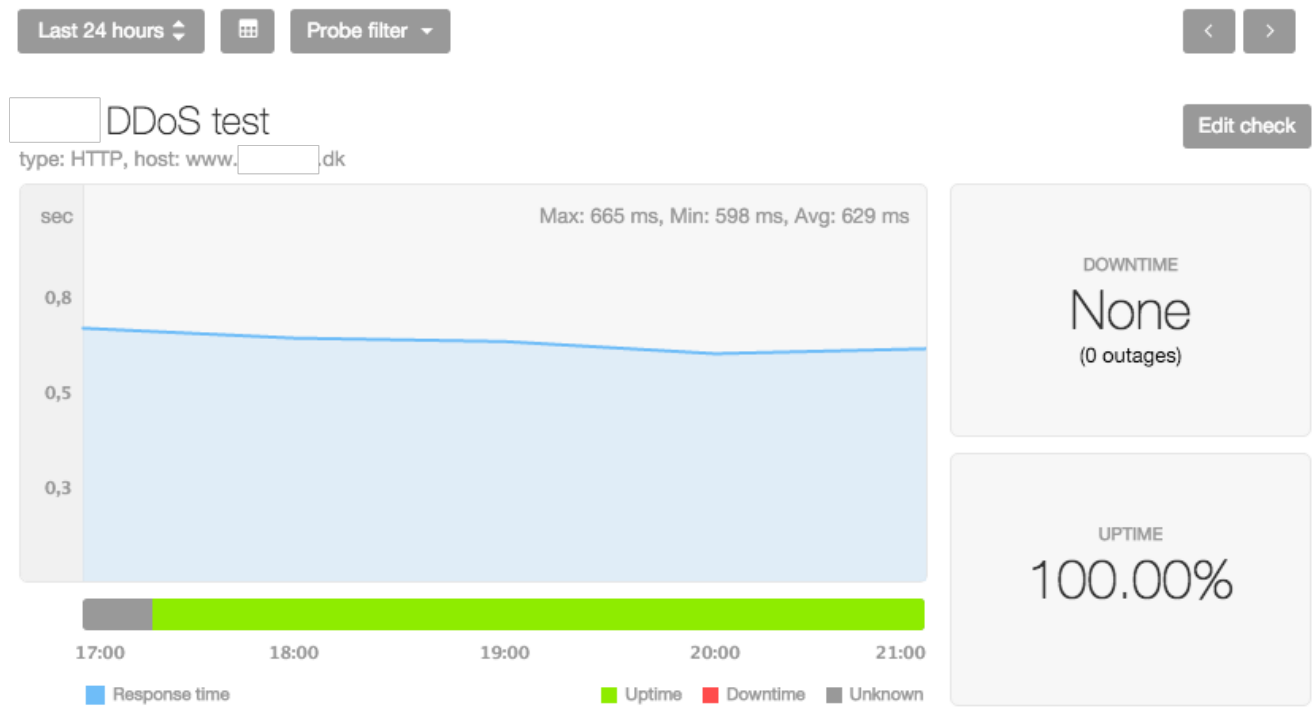


HTTPS check www. .26



Before DDoS testing use Smokeping software

Before testing: Pingdom



Another external monitoring from Pingdom.com

Running full port scan on network



```
# export CUST_NET="192.0.2.0/24"  
# nmap -p 1-65535 -A -oA full-scan $CUST_NET
```

Performs a full port scan of the network, all ports

Saves output in "all formats" normal, XML, and grepable formats

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

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

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
```

Test-cases / Scenarios, continued Spoof Source



Spoofed packets src=dst=target 😊

Flooding with spoofed packet source, within customer range

```
-a --spoof hostname
```

Use this option in order to set a fake IP source address, this option ensures that target will not gain your real address.

```
hping3 -q --flood -p 80 -S -a $CUST_IP $CUST_IP
```

Preferably using a test-case you know fails, to see effect

Still amazed how often this works

BCP38 anyone!

Test-cases / Scenarios, continued Small Fragments



Using the built-in option -f for hping

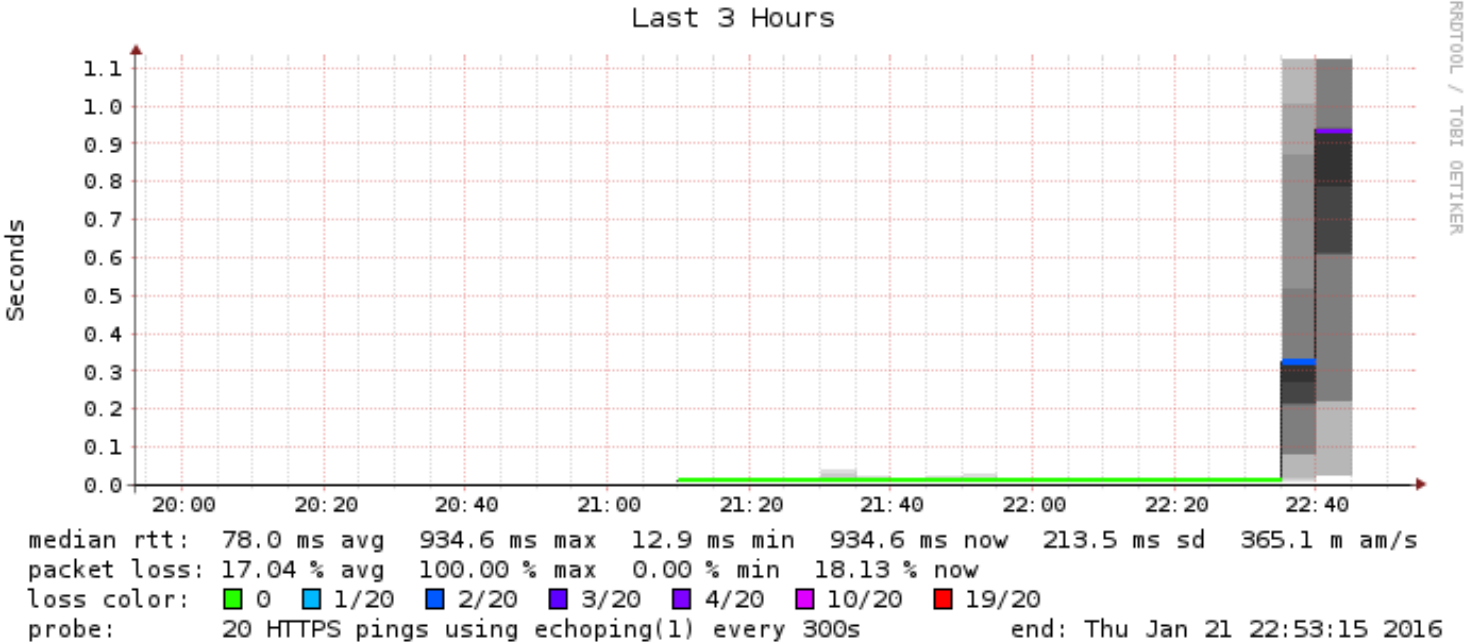
-f --frag

Split packets in more fragments, this may be useful in order to test IP stacks fragmentation performance and to test if some packet filter is so weak that can be passed using tiny fragments (anachronistic). Default **'virtual mtu' is 16 bytes**. see also --mtu option.

```
hping3 -q --flood -p 80 -S -f $CUST_IP
```

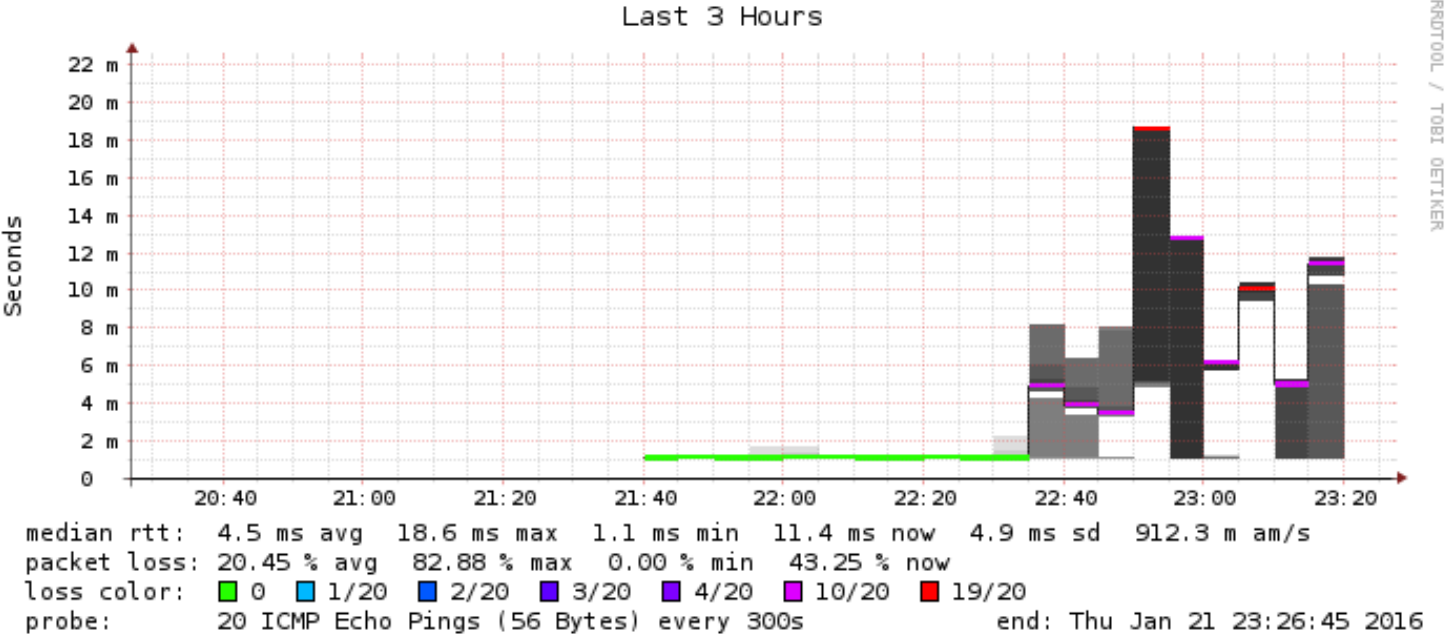
Similar process with bad checksum and Bad fragment offset

Rocky Horror Picture Show - 1



Really does it break from 50.000 pps SYN attack?

Rocky Horror Picture Show - 2

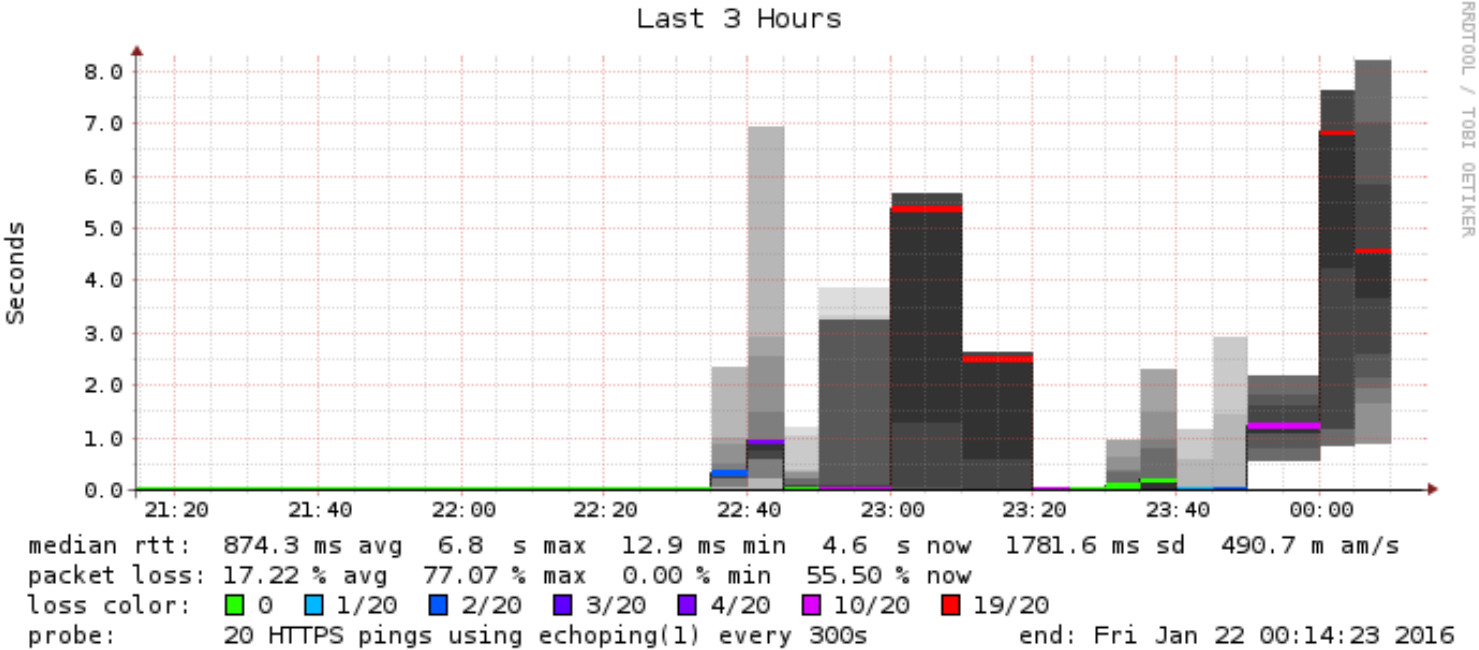


Oh no 500.000 pps UDP attacks work?

Rocky Horror Picture Show - 3



Oh no spoofing attacks work?



Exercise



Now lets do the exercise

Execute nmap TCP and UDP port scan 20 min

which is number **34** in the exercise PDF.

Exercise

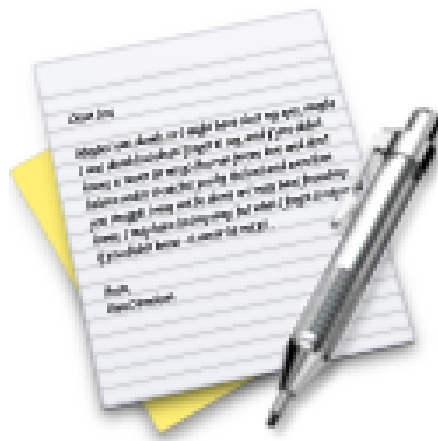


Now lets do the exercise

Discover active systems ping and port sweep 15 min

which is number **35** in the exercise PDF.

Exercise



Now lets do the exercise

TCP SYN flooding 30min

which is number **36** in the exercise PDF.

Exercise booklet contains some bonus exercises, feel free to try them at home

Improvements seen after testing



Turning off unneeded features - free up resources

Tuning sessions, 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.

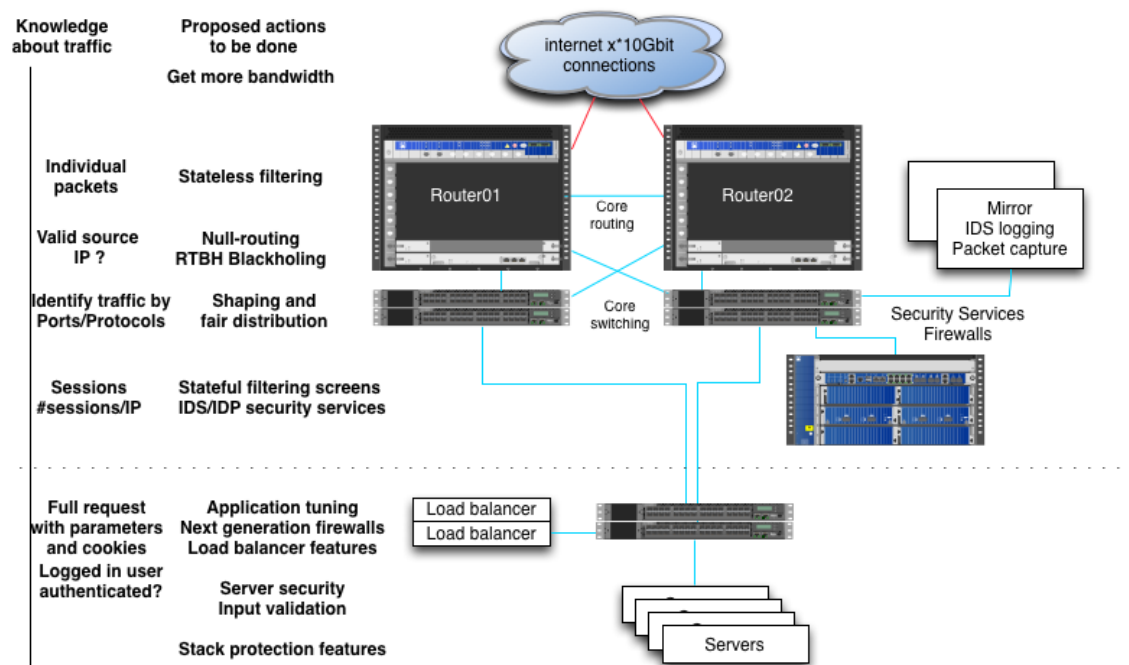
After tuning of **existing devices/network** improves results 10-100 times

Conclusion

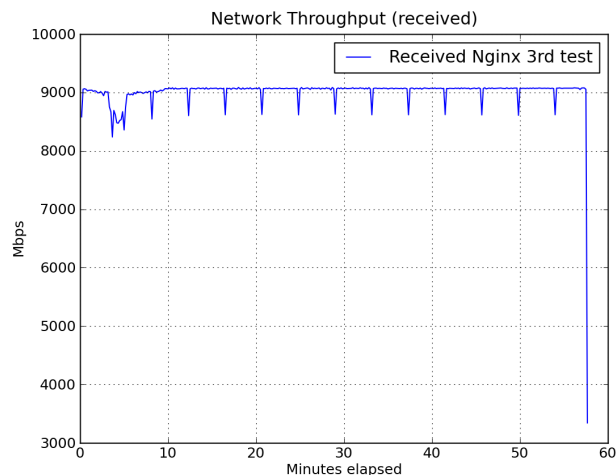


You really should try testing
Investigate your existing devices
all of them, RTFM, upgrade firmware
Choose which devices does which
part - discard early to free resources
for later devices to dig deeper

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



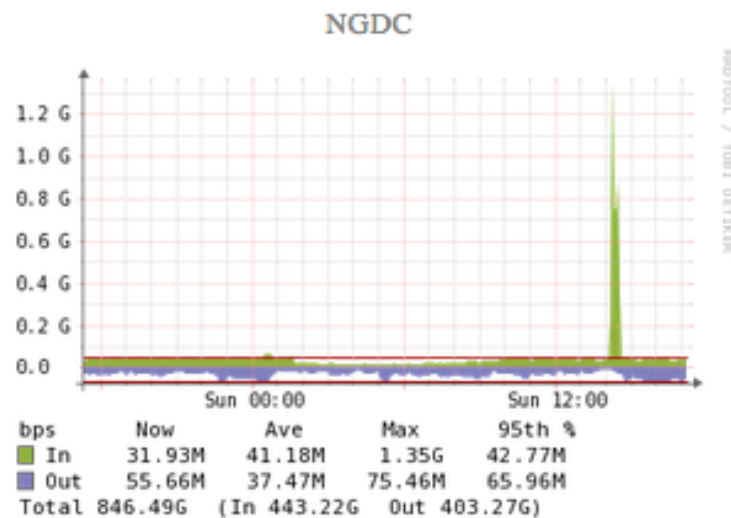
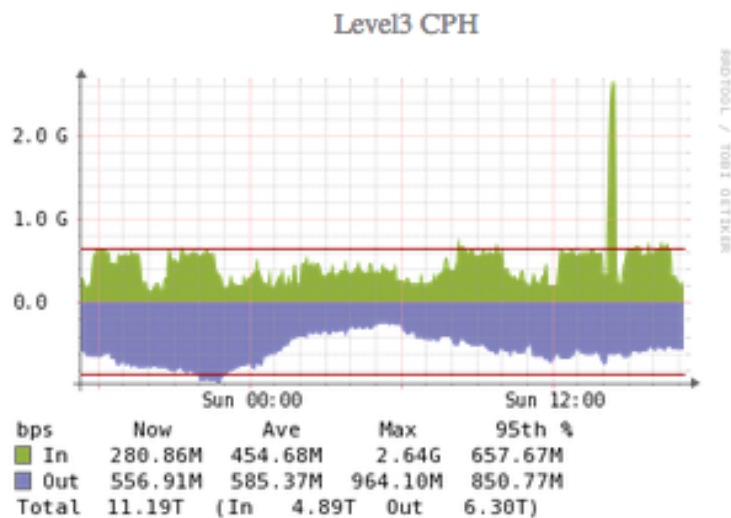
More application testing



We covered only lower layers - but helpful layer 7 testing programs exist

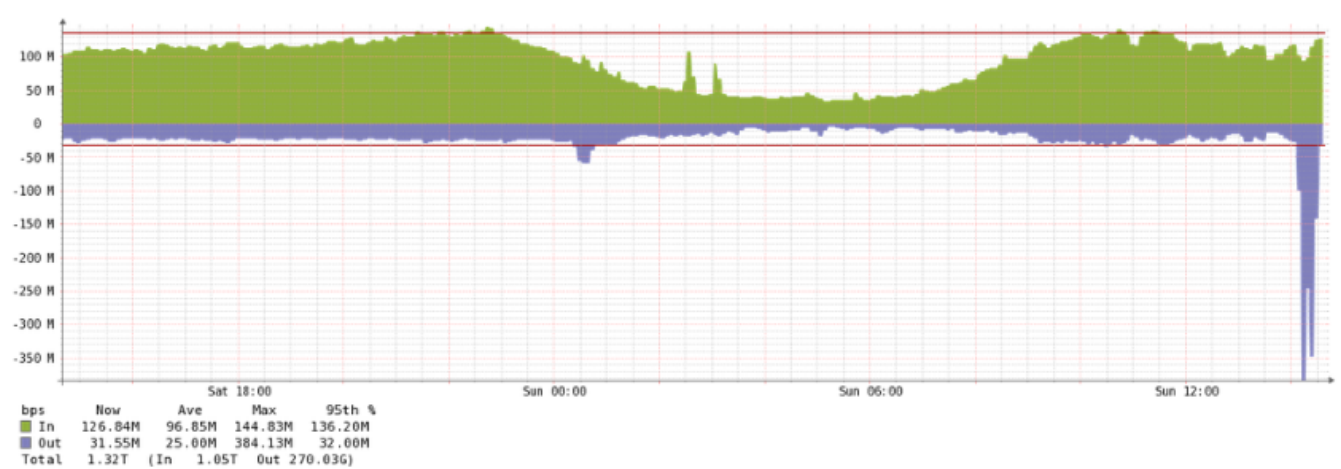
Tsung can be used to stress HTTP, WebDAV, SOAP, PostgreSQL, MySQL, LDAP and Jabber/XMPP servers <http://tsung.erlang-projects.org/>

DDoS traffic before filtering



Only two links shown, at least 3Gbit incoming for this single IP

DDoS traffic after filtering



Link toward server (next level firewall actually) about 350Mbit outgoing

Stateless firewall filter throw stuff away



```
hlk@MX-CPH-02> show configuration firewall filter all | no-more
/* This is a static sample, perhaps better to use BGP flowspec and RTBH */
term edgeblocker {
    from {
        source-address {
            84.180.xxx.173/32;
...
            87.245.xxx.171/32;
        }
        destination-address {
            91.102.91.16/28;
        }
        protocol [ tcp udp icmp ];
    }
    then {
        count edge-block;
        discard;
    }
}
```

Hint: can also leave out protocol and then it will match all protocols

Stateless firewall filter limit protocols



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

Routers have extensive Class-of-Service (CoS) tools today

Strict filtering for some servers, still stateless!



```
term some-server-allow {  
    from {  
        destination-address {  
            109.238.xx.0/xx;  
        }  
        protocol tcp;  
        destination-port [ 80 443 ];  
    }  
    then accept;  
}  
term some-server-block-unneeded {  
    from {  
        destination-address {  
            109.238.xx.0/xx;  
        }  
        protocol-except icmp;  
    }  
    then discard;  
}
```

Wut - no UDP, yes UDP service is not used on these servers

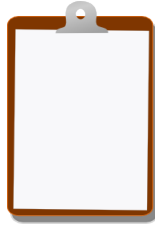
Firewalls - screens, IDS like features



When you know regular traffic you can decide *normal settings*:

```
hlk@srx-kas-05# show security screen ids-option untrust-screen
icmp {
    ping-death;
}
ip {
    source-route-option;
    tear-drop;
}
tcp {    Note: UDP flood setting also exist
    syn-flood {
        alarm-threshold 10024;
        attack-threshold 200;
        source-threshold 10024;
        destination-threshold 2048;
        timeout 20;
    }
    land;
}
```

For Next Time



Think about the subjects from this time, write down questions

Check the plan for chapters to read in the books

Visit web sites and download papers if needed

Retry the exercises to get more confident using the tools