



Welcome to

10. Forensics 1: Auditing and Intrusion Detection

KEA Kompetence Computer Systems Security 2019

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Slides are available as PDF, kramse@Github
10-forensics-auditing-intrusions.tex in the repo security-courses

Plan for today



Subjects

- Auditing and logging
- Volatility and file systems
- Intrusion Detection
- Host and Networks Based Intrusion Detection (HIDS/NIDS)
- Network Security Monitoring

Exercises

- Centralized syslogging and example system
- Open a file system dump

Reading Summary



Bishop chapter 25: Auditing

Bishop chapter 26: Intrusion Detection

Download and browse the ENISA papers listed under Computer Forensics in the reading list

Because tuesday was cancelled



The following pages will be removed from the curriculum:

Bishop chapter 17: Information Flow

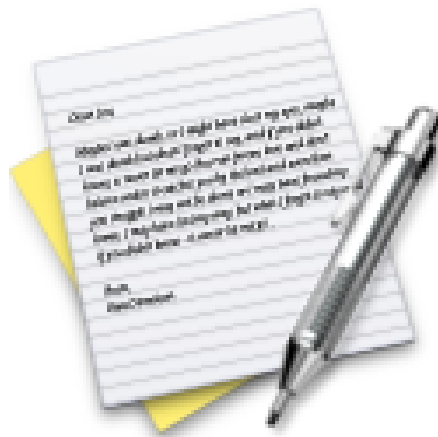
Bishop chapter 18: Confinement Problem

Capsicum: practical capabilities for UNIX

Removing ROP Gadgets from OpenBSD

but we will do the exercise Virtual Machine Escapes

Exercise



Now lets do the exercise

Virtual Machine Escapes 20min

which is number **20** in the exercise PDF.

Auditing and logging



Definition 25-1 *Logging* is the recording of events and statistics to provide information about system use and performance

Definition 25-2 *Auditing* is the analysis of records to present information about the system in a clear and understandable manner.

Goal, logs provide a mechanism for analyzing the system security state

Which information to log and which information to audit

Audit typically also comprises checking system settings, or doing a firewall audit of the rule sets in place

Anatomy of an Auditing System



Logger - collect

Analyzer - analyze it

Notifier - report results

Example systems IBM main frame RACF and Windows Event Logs service

swatchdog is an old skool, but simple tool that works

Logs should be protected and considered confidential information

Sample logs from login with Secure Shell (SSH) and performing `sudo su -`

```
Jun  5 11:53:15 pumba sshd[64505]: Accepted publickey for hlk from 79.142.233.18 port 43902  
ssh2: ED25519 SHA256:l80JMcywyBcraJiCWJ06uZ2yzHfu0VuiArqVvlVyfEI
```

```
Jun  5 11:53:19 pumba sudo:      hlk : TTY=ttyp2 ; PWD=/home/hlk ; USER=root ; COMMAND=/usr/bin/su -
```

Log Sanitization



Data sets released may be combined with others to demask users/persons

Book examples, governor medical data - health records, Netflix data

Other examples:

"New York City has released data of 173m individual taxi trips – but inadvertently made it "trivial" to find the personally identifiable information of every driver in the dataset.- but used MD5 hashing for some data with only 24 million possible inputs

<https://www.theguardian.com/technology/2014/jun/27/new-york-taxi-details-anonymised-data-researchers-warn>

"Fitness tracking app Strava gives away location of secret US army bases"

<https://www.theguardian.com/world/2018/jan/28/fitness-tracking-app-gives-away-location-of-secret-us-army-bases>

Intrusion Detection



A model of a real-time intrusion-detection expert system capable of detecting break-ins, penetrations, and other forms of computer abuse is described. The model is based on the hypothesis that security violations can be detected by monitoring a system's audit records for abnormal patterns of system usage.

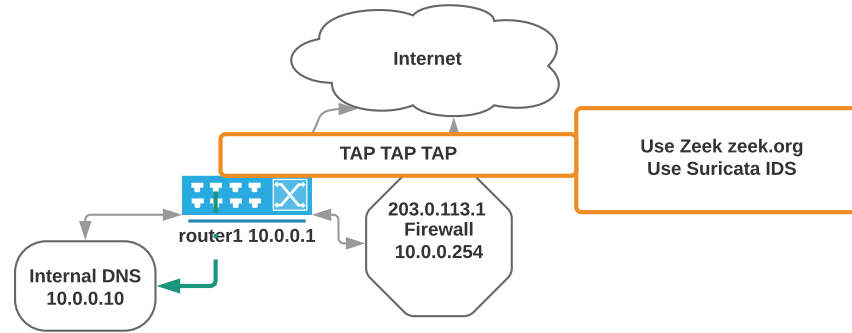
Source: *An Intrusion-Detection Model*, Dorothy E. Denning IEEE Transactions on Software Engineering (Volume: SE-13 , Issue: 2 , Feb. 1987)

Definition 26-1 *Anomaly detection* analyzes a set of characteristics of the system and compares their behavior with a set of expected values. It reports when the computed statistics do not match the expected measurements.

Uses thresholds, statistics, machine learning, artificial intelligence, neural networks, ...

Dont forget we talked about wedge, pledge, unveil recently - putting processes into prisons

Host and Networks Based Intrusion Detection (HIDS/NIDS)



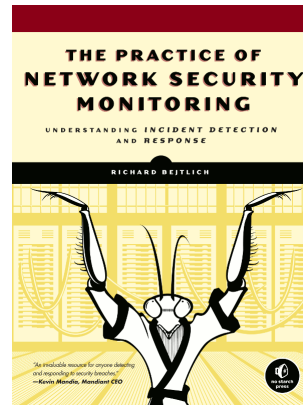
Host-based IDS (HIDS) local to system, log files etc.

Network-based (NIDS) typically uses mirrored data

Recommend Zeek <https://www.zeek.org/> and Suricata <https://suricata-ids.org/> with Emerging Threats rule sets <https://rules.emergingthreats.net/> - available as PRO (paid and recommended) or OPEN (free)

Intrusion Prevention System (IPS) - when is a firewall an IPS?

Network Security Monitoring

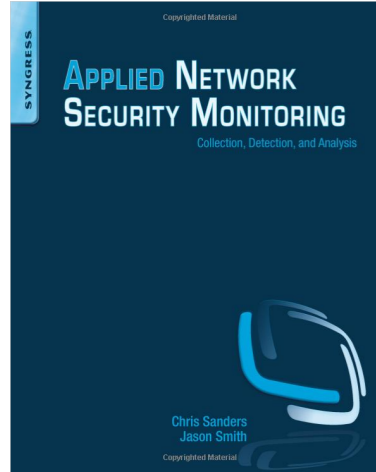


Network Security Monitoring (NSM) - monitoring networks for intrusions, and reacting to those

Recommend the book *The Practice of Network Security Monitoring Understanding Incident Detection and Response* by Richard Bejtlich July 2013

Example systems are Security Onion <https://securityonion.net/> or SELKS <https://www.stamus-networks.com/open-source/>

Book: Applied Network Security Monitoring (ANSM)

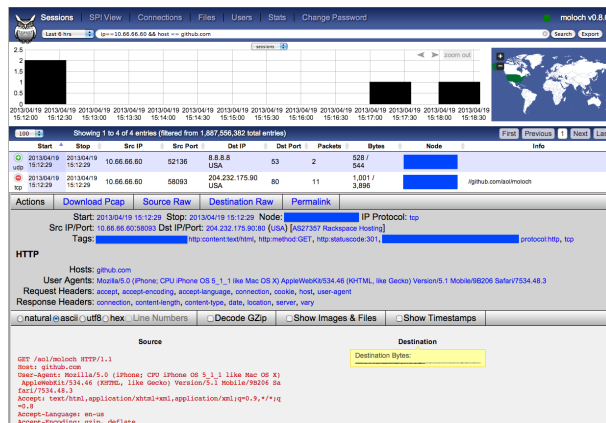


Applied Network Security Monitoring: Collection, Detection, and Analysis 1st Edition

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>

Logging today



Log analysis is required today - and we have many logs

Gather logs, parse logs, explain logs - fix stuff

Search your logs with the Elastic stack

Show sample logs from Suricata, Sudo, SSH, ... what we have

How to get started



How to get started searching for security events?

Collect basic data from your devices and networks

- Netflow data from routers
- Session data from firewalls
- Logging from applications: email, web, proxy systems

Centralize!

Process data

- Top 10: interesting due to high frequency, occurs often, brute-force attacks
- *ignore*
- Bottom 10: least-frequent messages are interesting

Centralized syslog



Logfiler er en nødvendighed for at have et transaktionsspor

Logfiler giver mulighed for statistik

Logfiler er desuden nødvendige for at fejlfinde

Det kan være relevant at sammenholde logfiler fra:

- routere
- firewalls
- webservere
- intrusion detection systemer
- adgangskontrolsystemer
- ...

Husk - tiden er vigtig! Network Time Protocol (NTP) anbefales

Husk at logfilerne typisk kan slettes af en angriber - hvis denne får kontrol med systemet



syslog er system loggen på UNIX og den er effektiv

- man kan definere hvad man vil se og hvor man vil have det dirigeret hen
- man kan samle det i en fil eller opdele alt efter programmer og andre kriterier
- man kan ligeledes bruge named pipes - dvs filer i filsystemet som tunneller fra chroot'ed services til syslog i det centrale system!
- man kan nemt sende data til andre systemer

Man bør lave en centraliseret løsning

syslogd.conf eksempel



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

Andre syslogs syslog-ng



- der findes andre syslog systemer eksempelvis syslog-ng
- konfigureres gennem `/etc/syslog-ng/syslog-ng.conf`

```
options {  
    long_hostnames(off);  
    sync(0);  
    stats(43200);  
};  
  
source src    unix-stream("/dev/log"); internal(); pipe("/proc/kmsg"); ;  
destination messages    file("/var/log/messages"); ;  
destination console_all  file("/dev/console"); ;  
log    source(src); destination(messages); ;  
log    source(src); destination(console_all); ;
```

Kan eksempelvis TCP og garanteret aflevering af beskeder

Exercise



Now lets do the exercise

Centralized syslog 15min

which is number **21** in the exercise PDF.

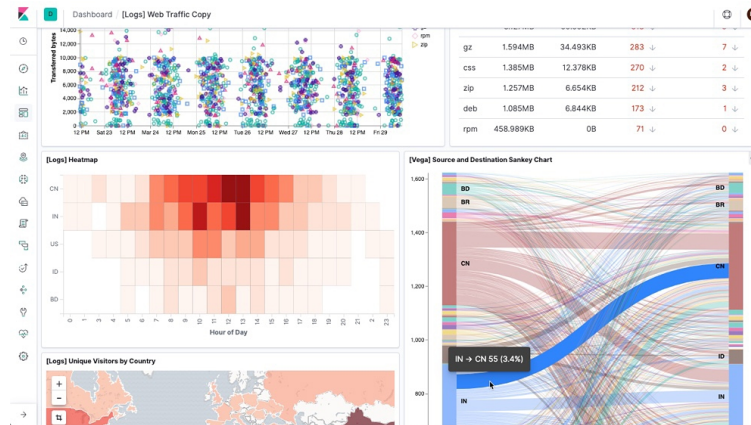
Web server access log



```
root# tail -f access_log
::1 - - [19/Feb/2004:09:05:33 +0100] "GET /images/IPv6ready.png
HTTP/1.1" 304 0
::1 - - [19/Feb/2004:09:05:33 +0100] "GET /images/valid-html401.png
HTTP/1.1" 304 0
::1 - - [19/Feb/2004:09:05:33 +0100] "GET /images/snowflake1.png
HTTP/1.1" 304 0
::1 - - [19/Feb/2004:09:05:33 +0100] "GET /~h1k/security6.net/images/logo-1.png
HTTP/1.1" 304 0
2001:1448:81:beef:20a:95ff:fef5:34df - - [19/Feb/2004:09:57:35 +0100]
"GET / HTTP/1.1" 200 1456
2001:1448:81:beef:20a:95ff:fef5:34df - - [19/Feb/2004:09:57:35 +0100]
"GET /apache_pb.gif HTTP/1.1" 200 2326
2001:1448:81:beef:20a:95ff:fef5:34df - - [19/Feb/2004:09:57:36 +0100]
"GET /favicon.ico HTTP/1.1" 404 209
2001:1448:81:beef:20a:95ff:fef5:34df - - [19/Feb/2004:09:57:36 +0100]
"GET /favicon.ico HTTP/1.1" 404 209
```

Web server logs are pretty standardized, common log format.

Big Data tools: Elasticsearch



Elasticsearch is an open source distributed, RESTful search and analytics engine capable of solving a growing number of use cases.

<https://www.elastic.co>

We are all Devops now, even security people!

Ansible configuration management



```
- apt: name= item  state=latest
  with_items:
    - unzip
    - elasticsearch
    - logstash
    - redis-server
    - nginx
- lineinfile: "dest=/etc/elasticsearch/elasticsearch.yml state=present
  regexp='script.disable_dynamic: true' line='script.disable_dynamic: true'"
- lineinfile: "dest=/etc/elasticsearch/elasticsearch.yml state=present
  regexp='network.host: localhost' line='network.host: localhost'"
- name: Move elasticsearch data into /data
  command: creates=/data/elasticsearch mv /var/lib/elasticsearch /data/
- name: Make link to /data/elasticsearch
  file: state=link src=/data/elasticsearch path=/var/lib/elasticsearch
```

only requires SSH+python <http://www.ansible.com>

Kibana



Highly recommended for a lot of data visualisation

Non-programmers can create, save, and share dashboards

Source: <https://www.elastic.co/products/kibana>

Logstash pipeline



Logstash is an open source, server-side data processing pipeline that ingests data from a multitude of sources simultaneously, transforms it, and then sends it to your favorite “stash.” (Ours is Elasticsearch, naturally.)

<https://www.elastic.co/products/logstash>

```
input { stdin { } }  
output {  
  elasticsearch { host => localhost }  
  stdout { codec => rubydebug }  
}
```

- Logstash receives via **input**
- Processes with **filters** - grok
- Forward events with **output**

Logstash as SNMPtrap and syslog server



```
input {  
  snmptrap {  
    host => "0.0.0.0"  
    type => "snmptrap"  
    port => 1062  
    community => "xxxxxx"  }  
  tcp {  
    port => 5000  
    type => syslog  }  
  udp {  
    port => 5000  
    type => syslog  }  
}
```

- We run logstash on port 5000 - but use IPtables port forwarding
- Have you even configured SNMP traps?
- Maybe you have a device sending SNMP traps right now ...

IPtables forwarding



```
*nat
:PREROUTING ACCEPT [0:0]
# redirect all incoming requests on port 514 to port 5000
-A PREROUTING -p tcp --dport 514 -j REDIRECT --to-port 5000
-A PREROUTING -p udp --dport 514 -j REDIRECT --to-port 5000
-A PREROUTING -p udp --dport 162 -j REDIRECT --to-port 1062
COMMIT
```

Inserted near beginning of `/etc/ufw/before.rules` on Ubuntu

Remember defense in depth, dont run a privileged Java VM process as root 😊

Grok expressions



```
filter {
  if [type] == "syslog" {
    grok {
      match => { "message" => "%{SYSLOGTIMESTAMP:syslog_timestamp}
        %{SYSLOGHOST:syslog_hostname} %{DATA:syslog_program}
        (?:\[%{POSINT:syslog_pid}\])?: %{GREEDYDATA:syslog_message}" }
      add_field => [ "received_at", "%{@timestamp}" ]
      add_field => [ "received_from", "%{host}" ]
    }
    syslog_pri { }
    date {
      match => [ "syslog_timestamp", "MMM d HH:mm:ss", "MMM dd HH:mm:ss" ]
    }
  }
}
```

- Logstash filter expressions grok can normalize and split data into fields

Source: Config snippet from recommended link

<http://logstash.net/docs/1.4.1/tutorials/getting-started-with-logstash>

Grok expressions, sample from my archive



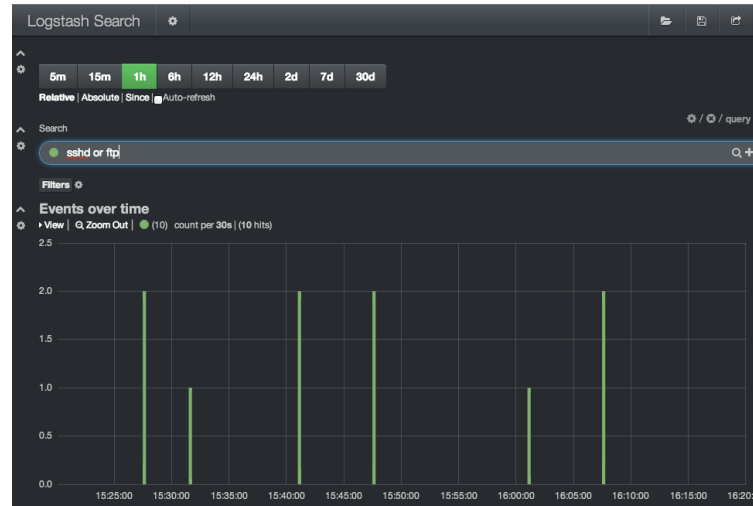
```
filter {
# decode some SSHD
if [syslog_program] == "sshd" {
  grok {
# May 20 10:27:08 odn1-nsm-01 sshd[4554]: Accepted publickey for hlk from
10.50.11.17 port 50365 ssh2: DSA 9e:fd:3b:3d:fc:11:0e:b9:bd:22:71:a9:36:d8:06:c7

match => { "message" => "%{SYSLOGTIMESTAMP:timestamp} %{HOSTNAME:host_target}
sshd\[ %{BASE10NUM}\]: Accepted publickey for %{USERNAME:username} from
  %{IP:src_ip} port %{BASE10NUM:port} ssh2" }

# "May 20 10:27:08 odn1-nsm-01 sshd[4554]: pam_unix(sshd:session):
session opened for user hlk by (uid=0)"
match => { "message" => "%{SYSLOGTIMESTAMP:timestamp} %{HOSTNAME:host_target}
sshd\[ %{BASE10NUM}\]: pam_unix\(sshd:session\): session opened for user
%{USERNAME:username}" }
```

- Logstash filter expressions grok can normalize and split data into fields

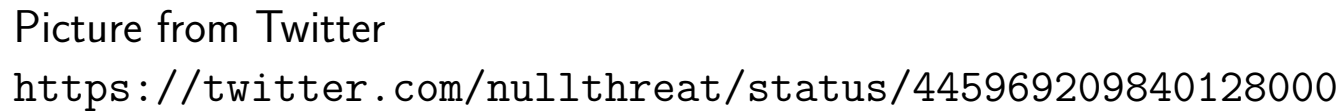
View data efficiently



View data by digging into it easily - must be fast

Logstash and Kibana are just examples, but use indexing to make it fast!

Other popular examples include Graylog and Grafana



30

IP reputation



Zeek documentation Intel framework

<https://docs.zeek.org/en/stable/frameworks/intel.html>

Suricata reputation support

<https://suricata.readthedocs.io/en/suricata-4.0.5/reputation/index.html>

Exercise



Now lets do the exercise

Create Kibana Dashboard 15min

which is number **22** in the exercise PDF.

Collect Network Evidence from the network



Network Flows

Cisco standard NetFlow version 5 defines a flow as a unidirectional sequence of packets that all share the following 7 values:

- Ingress interface (SNMP ifIndex)
- Source IP address
- Destination IP address
- IP protocol
- Source port for UDP or TCP, 0 for other protocols
- Destination port for UDP or TCP, type and code for ICMP, or 0 for other protocols
- IP Type of Service

Source: <https://en.wikipedia.org/wiki/NetFlow>

Netflow



Netflow is getting more important, more data share the same links

Accounting is important

Detecting DoS/DDoS and problems is essential

Netflow sampling is vital information - 123Mbit, but what kind of traffic

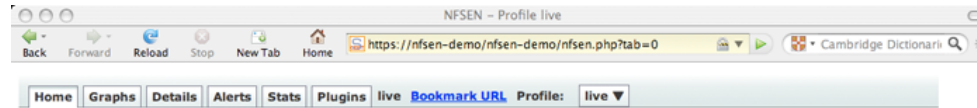
NFSen is an old but free application <http://nfsen.sourceforge.net/>

Currently also investigating sFlow - hopefully more fine grained

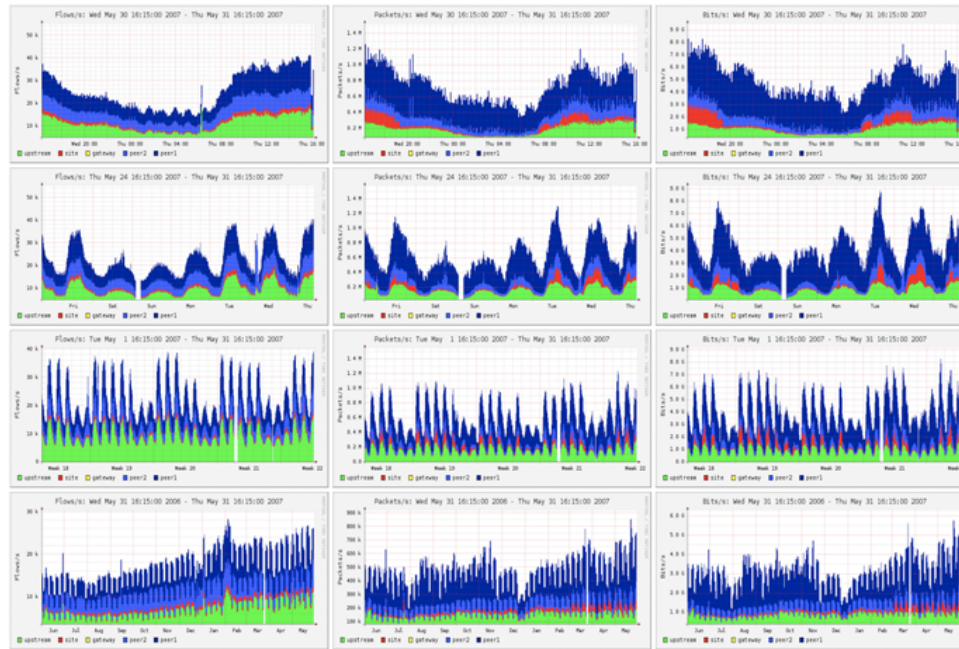
sFlow, short for "sampled flow", is an industry standard for packet export at Layer 2 of the OSI model,

<https://en.wikipedia.org/wiki/SFlow>

Netflow using NFSen



Overview Profile: live, Group: (nogroup)

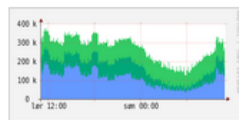


nfsen 1.3

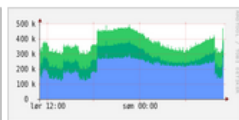


Profile: live

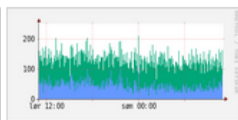
TCP



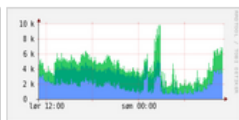
any



ICMP

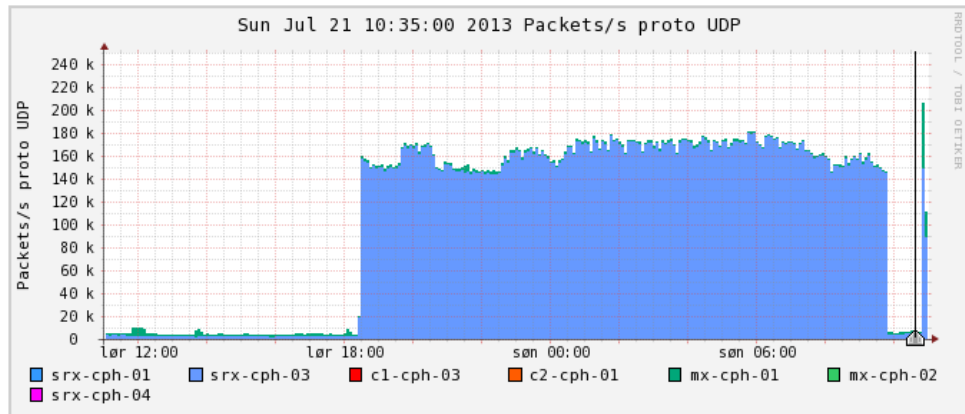


other



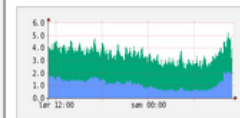
Profileinfo:

Type: live
Max: unlimited
Exp: never
Start: Jun 23 2011 - 13:10 CEST
End: Jul 21 2013 - 11:00 CEST

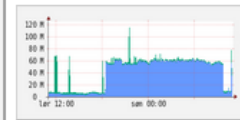


t_{start} 2013-07-21-10-35
t_{end} 2013-07-21-10-35

Flows



Traffic



Select Display: << < | ^ > >> >|

☒ Lin Scale ☒ Stacked Graph
☐ Log Scale ☐ Line Graph

An extra 100k packets per second from this netflow source (source is a router)

Netflow processing from the web interface



Netflow Processing

Source: peer1 peer2 gateway site upstream
Filter: and <none>

Options:
☐ List Flows ☒ Stat TopN
Top: 10
Stat: Flow Records order by flows
☒ proto
Aggregate: ☒ srcPort ☒ dstPort
Limit: ☐ Packets ☐ / IPv6 long
Output: line ☐ / IPv6 long
Clear Form process

```
** nfdump -M /netflow0/nfsen-demo/profile-data/live/peer1:peer2:gateway:site:upstream -T -r 2007/05/31/04/nfcapd.200705310440
nfdump filter:
any
Aggregated flows 2797250
Top 10 flows ordered by flows:
Date flow start      Duration Proto      Src IP Addr:Port      Dst IP Addr:Port      Packets  Bytes  Flows
2007-05-31 04:39:54.045 299.034 UDP      116.147.95.88:1110    188.142.64.162:27014  68      5508   68
2007-05-31 04:39:56.282 298.174 UDP      116.147.249.27:1478   188.142.64.163:27014  67      5427   67
2007-05-31 04:39:57.530 298.206 UDP      117.196.44.62:1031    188.142.64.166:27014  67      5427   67
2007-05-31 04:39:57.819 298.112 UDP      117.196.75.134:1146   188.142.64.167:27014  67      5427   67
2007-05-31 04:39:53.787 297.216 UDP      61.191.235.132:4121   60.9.138.37:2121     62      3720   62
2007-05-31 04:39:55.354 300.833 UDP      60.9.138.37:2121     118.25.93.95:2121    61      3660   61
2007-05-31 04:39:58.936 298.977 UDP      60.9.138.36:2121     119.182.123.166:2121  61      3660   61
2007-05-31 04:39:54.329 303.585 UDP      120.150.194.76:2121   60.9.138.37:2121    61      3660   61
2007-05-31 04:39:53.916 300.734 UDP      60.9.138.37:2121     125.167.25.128:2121  61      3660   61
2007-05-31 04:39:57.946 300.353 UDP      60.9.138.36:2121     121.135.4.186:2121   61      3660   61

IP addresses anonymized
Summary: total flows: 4616424, total bytes: 156.6 G, total packets: 172.6 M, avg bps: 644.8 M, avg pps: 90946, avg bpp: 929
Time window: 2007-05-31 04:11:49 - 2007-05-31 04:44:58
Total flows processed: 4616424, skipped: 0, Bytes read: 240064932
Sys: 6.184s flows/second: 746464.4 Wall: 6.185s flows/second: 746361.3
```

Bringing the power of the command line forward

Next steps



Always improving things:

Suricata IDS <http://www.openinfosecfoundation.org/>

More graphs, with **automatic identification** of IPs under attack

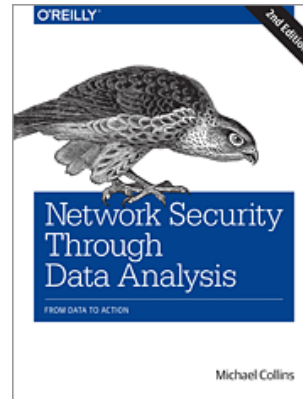
Identification of **short sessions without data** - spoofed addresses

Alerting from **existing** devices

Dashboards with key measurements

Conclusion: Combine tools!

Network Security Through Data Analysis



Low page count, but high value! Recommended.

Network Security through Data Analysis, 2nd Edition By Michael S Collins Publisher: O'Reilly Media 2015-05-01:
Second release, 348 Pages

New Release Date: August 2017

Network tools - more examples



Using PacketQ

Let's have a practical look at how PacketQ works by trying to figure out what kind of DNS ANY queries are being sent towards our name-server.

DNS ANY traffic is currently commonly abused for DNS amplification attacks (See Blog post “DDoS-Angriffe durch Reflektierende DNS-Amplifikation vermeiden” in German). The first thing I want to know is what are the IP addresses of the victims of this potential DNS amplification attack:

```
packetq -t -s "select src_addr,count(*) as count from dns where qtype=255 group
by src_addr order by count desc limit 3" lol0.20130118.070000.000179
"src_addr" ,"count"
"216.245.221.243",933825
"85.126.233.70" ,16802
"80.74.130.55" ,91
```

- DNS: DSC and PacketQ <https://github.com/DNS-OARC/PacketQ>
- Packetbeat <https://www.elastic.co/products/beats/packetbeat>
- <http://securityblog.switch.ch/2013/01/22/using-packetq/>
- <http://jpmens.net/2013/05/27/server-agnostic-logging-of-dns-queries-responses/>

Volatility and file systems



Table 1.2 *The expected life span of data*

Type of Data	Life Span
Registers, peripheral memory, caches, etc.	Nanoseconds
Main memory	Ten nanoseconds
Network state	Milliseconds
Running processes	Seconds
Disk	Minutes
Floppies, backup media, etc.	Years
CD-ROMs, printouts, etc.	Tens of years

Order of volatility (OOV) of evidence *Forensic Discovery* Dan Farmer, Wietse Venema, Addison-Wesley Professional, 2005

<http://fish2.com/security/wf-book.pdf> - full book available!

Network Forensics ENISA



The European Union Agency for Network and Information Security (ENISA) is a centre of expertise for cyber security in Europe.

ENISA is contributing to a high level of network and information security (NIS) within the European Union, by developing and promoting a culture of NIS in society to assist in the proper functioning of the internal market.

<https://www.enisa.europa.eu/>

ENISA has published a number of network forensics documents which are free to use, so these are our basics.

Forensic analysis



Network forensics is a sub-branch of digital forensics relating to the monitoring and analysis of computer network traffic for the purposes of information gathering, legal evidence, or intrusion detection 5 .

Systems used to collect network data for forensics use usually come in three forms:

- Packet capture: All packets passing through a certain traffic point are captured and written to storage
- Intrusion detection systems
- Network flow sensors

The acronym OSCAR 8 stands for: Obtain information, Strategize, Collect evidence, Analyse, Report

Source: Forensic analysis Network Incident Response Handbook, Document for teachers 1.0 DECEMBER 2016, ENISA
EXE2_Forensic_analysis_II-Handbook.pdf



- We will use these as examples:
- ENISA Presenting, correlating and filtering various feeds Handbook, Document for teachers
<https://www.enisa.europa.eu/topics/trainings-for-cybersecurity-specialists/online-training-materials/documents/presenting-correlating-and-filtering-various-feeds-handbook>
- ENISA Forensic analysis, Network Incident Response
https://www.enisa.europa.eu/topics/trainings-for-cybersecurity-specialists/online-training-materials/documents/2016-resources/exe2_forensic_analysis_ii-handbook
- ENISA Network Forensics, Handbook, Document for teachers
<https://www.enisa.europa.eu/topics/trainings-for-cybersecurity-specialists/online-training-materials/documents/network-forensics-handbook>

Exercise

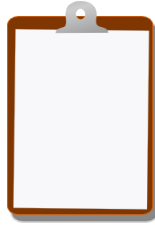


Now lets do the exercise

File System Forensics

which is number **23** in the exercise PDF.

For Next Time



Think about the subjects from this time, write down questions

Check the plan for chapters to read in the books

Most days have less than 100 pages, but some days may have more!

Visit web sites and download papers if needed

Retry the exercises to get more confident using the tools