virtual zeek week

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BSD Honeypots with Zeek - Of course it runs on BSD

A discussion on the use of Zeek with FreeBSD Jails to deploy honeypots.

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Agenda

- Introduction
- What is a Honeypot?
- Brief History of Honeypots
- Case Study of a Honeypot on FreeBSD
- Conclusion

Rant Warning

- Whenever you see beastie with a hammer, I may be ranting without any evidence.
- All information not cited in this talk is based on personal experience or opinion (marked with an asterisk *).

Introduction

- Worked in IDS/IPS since 2003 (various positions including consulting)
  - Engines: Snort, Suricata, Dragon, Zeek (formerly Bro) (also had to work with McAfee, ISS, NFR … others)
  - Signatures for Emerging Threats (since they were Bleeding Edge Snort)
  - Reverse Engineering/Exploit Development (Mostly on Windows, which is why I hate it.)
- Support Open Source Security Tools and Software
  - Maintain pulledpork for Snort/Suricata (rule updating script):
    - http://github.com/shirkdog/pulledpork
  - Active community member of open source projects:
    - Operating Systems: FreeBSD, OpenBSD, HardenedBSD
    - Security Tools: Snort, Suricata, Zeek, AIDE
  - Maintainer of several FreeBSD ports for zeek (btest,zkg)

Introduction

- Senior Consultant/Co-Owner of Daemon Security, Inc.
  - Use HardenedBSD, OpenBSD and FreeBSD daily for my work, but customers mostly use Linux.
- Assistant Professor of Cybersecurity at Harford Community College
- Founder of CharmBUG – Baltimore Area BSD User Group
  - Founded in 2016 http://www.charmbug.org

What is a Honeypot?

- Basic definition – a pot of honey that attracts things, like bears or bees.
- More useful definition for computers:

  “A honeypot is a closely monitored network decoy serving several purposes: it can distract adversaries from more valuable machines on a network, provide early warning about new attack and exploitation trends, or allow in-depth examination of adversaries during and after exploitation of a honeypot.”
  (Provos, 2003).

What is a Honeypot?

- Breaking this down:
  - Distract adversaries from more valuable machines
    - Deploy 30 systems, but only 10 are actual systems, the others are honeypots simulating your actual systems as decoys.
  - Early warning for new attacks/exploit
    - A honeypot is deployed and catches a new exploit attempt for an HTTP server vulnerability.
  - Examination of adversaries during and after exploitation
    - An attacker interacts with the honeypot after an exploit attempt and downloads additional tools, providing additional IOCs for security researchers.

What is a Honeypot?

- Honeypots provide benefits for a variety of security workflows:
  - Security Research – Deploying vulnerable systems to evaluate new attacker methods and tools
    - Citrix Application Delivery Controller Exploit CVE-2019-19781 as an example covered in my BSDCan 2020 talk.
  - Business Operations – Deploy decoys around actual systems for attackers to target
    - Requires the ability to manage the decoys and their log output
    - Normally a higher maturity level for a security organization, and not the first tool to be deployed.*

What is a Honeypot?

- Honeypots can simulate a client or a server, providing the appropriate behavior depending on the configuration of the honeypot.
  - Client send a specific request that the Server interprets correctly
    - Examples: AD Client, Web Browser.
  - Server sends a specific response that the Client interprets correctly
    - Examples: Web Server, Database.

What is a Honeypot?

- Types of Honeypots (categories):
  - Low Interaction
    - Basic Protocol/Application Support without additional interaction.
  - Medium Interaction
    - Protocol/Application Support with the ability to simulate more behavior closer to the actual Protocol/Application.
  - High Interaction
    - Similar to a real system responding with the same Protocol/Application behavior as the real system.

Brief History of Honeypots

- Concepts of a honeypot (in computing)
  - The Cuckoo's Egg – Clifford Stoll (1989)
    - First-hand account of a computer intrusion at the Lawrence Berkeley National Laboratory.
    - Stoll utilized a fake department as a honeypot to catch the attacker, who was spying for the Soviet Union.
  - The Deception Toolkit – Fred Cohen (1997)
    - http://all.net/dtk/ - includes references and studies on the use of deception.
    - Simulates network services, responds to attackers with an appropriate or deceptive response.
    - Provides a logging mechanism.

Brief History of Honeypots

- honeyd
  - Created by Niels Provos
    - Additionally worked on OpenBSD, OpenSSH, systrace and work on privilege separation
  - Version 0.5 in 2003 (originally released in 2002).
  - honeyd provides network stack behavior for each configured honeypot.
    - Scripted configuration to simulate Windows, Linux, BSD.

Brief History of Honeypots

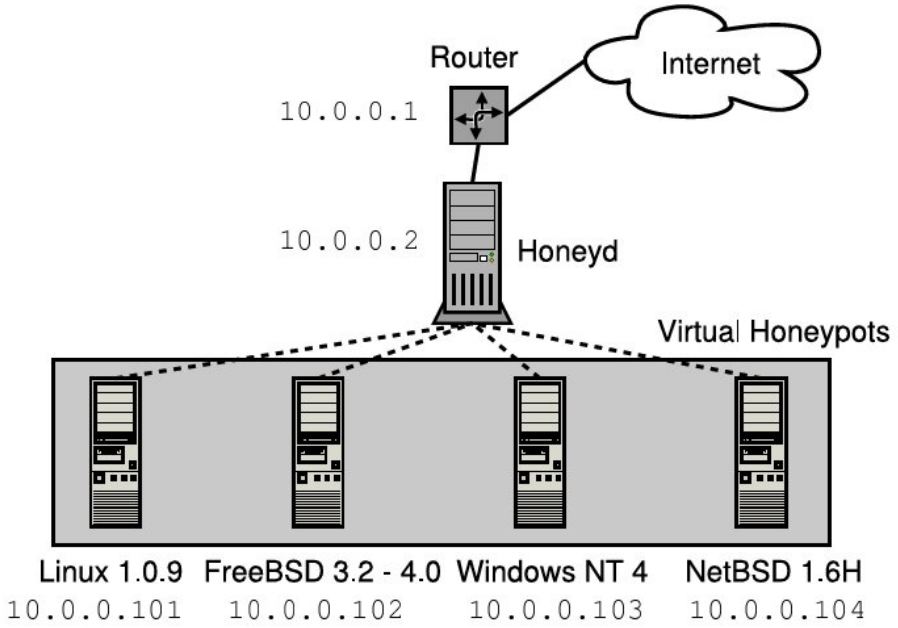


Figure 1: Honeyd receives traffic for its virtual honeypots via a router or Proxy ARP. For each honeypot, Honeyd can simulate the network stack behavior of a different operating system.

(Provos, 2003, p. 3)

Brief History of Honeypots

- Historical perspective
  - Systems in 2020 are mostly virtualized compared to requiring physical systems in the early 2000s.
  - On-Prem or Cloud based architectures make deploying honeypots or decoy systems easier than ever before.
  - Random ports being open or a number of systems sitting out on the Internet is now “the new normal”
  - Think Internet of Things (or Internet of Trash you pick) with billions of devices on the Internet.

Honeypots on BSD

- Additional details for Honeypots on BSD provided in my BSDCan 2020 talk
- Covers OpenBSD/FreeBSD and setting up honeyd, honeytrap:

  https://github.com/shirkdog/Presentations/blob/master/2020/BSDCan/BSDHoneypots.pdf

Honeypots on BSD

- From this list of available honeypots, I selected one I thought would fit my needs, as I just wanted something simple
  - Turns out, when you just jump into something, you get more involved than you originally wanted to.
  - But the solution works in the end so you are content with the result (context in my other talk, there are BETTER apps)

- Of the available applications, I selected HoneyPy

  https://github.com/foospidy/HoneyPy
- Onto the reason I started messing with honeypots.

Case Study of a Honeypot on FreeBSD

- Story begins with a requirement to collect threat data:
  - The company I was working with required a method to produce threat data to share with its customers.
  - At the time, there was no security research of this type occurring at the company.
    - Dark nets, dirty connections, anything that was fun* was not available.
  - We needed a system to be configured to monitor for potential threats and be able to share this threat data with our customers.

Case Study of a Honeypot on FreeBSD

- Of course this will run on BSD, why not a FreeBSD Jail?
  - During the initial Mirai infections in 2016/2017, I enabled the telnetd service in a FreeBSD jail with inetd.conf to start on connections.

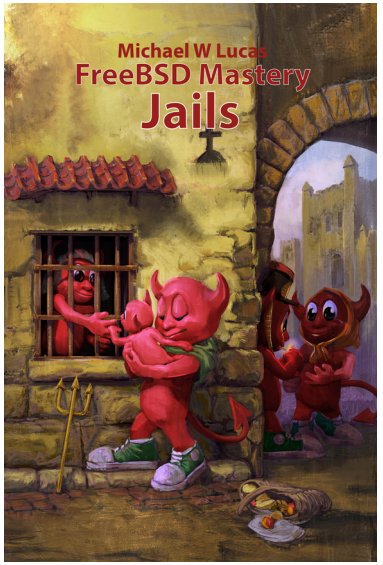
    - Technically a honeypot, but more of a deceptive service.*
    - If you do not know what inetd is, go read a UNIX book about the good ole days of preserving as much of your system resources as possible (The inetd utility appeared in 4.3BSD.)
  - Not only could I setup a jail as a honeypot, but use another jail to monitor the traffic from the honeypot
    - Using Zeek to correlate with available threat data

Case Study of a Honeypot on FreeBSD

- Design of the system - FreeBSD Host setup with an Internet connection.
  - I used Digital Ocean, but any cloud provider would do that allows console access and FreeBSD.
  - Received a single IP address, but FreeBSD jails require an IP to be configured (More on this in a second)
  - Jail management – I selected iocage, which was my first time using it and it served my needs.

Case Study of a Honeypot on FreeBSD

- Installation and setup of iocage
  - Please see Michael W. Lucas's FreeBSD Jails Mastery for complete features of iocage and other jail management tools:
    - https://www.tiltedwindmillpress.com/product/fmjail/



Case Study of a Honeypot on FreeBSD

- Example configuration for pf to redirect traffic:

```
ext_if="vtnet0"
int_if="lo0"

HELL_NET="127.6.66.0/24"

HONEYPY="127.6.66.1"
ZEEK="127.6.66.2"

set block-policy drop
set optimization aggressive
scrub in on $ext_if all fragment reassemble min-ttl 15 max-mss 1400 no-df

#jail firewall
nat pass on $ext_if from $HELL_NET to any -> ($ext_if)
rdr pass on $ext_if proto tcp from any to any port 22 -> $HONEYPY port 10022
```

Case Study of a Honeypot on FreeBSD

- In order to setup the honeypot for SSH connections, I am redirecting the traffic to the HoneyPy jail. You need a “rdr” rule for every service configured in your honeypot

  nat pass on $ext_if from $HELL_NET to any -> ($ext_if)

  rdr pass on $ext_if proto tcp from any to any port 22 -> $HONEYPY port 10022

- Ensure the following is setup for each jail on the local interface with an alias in /etc/rc.conf

  ifconfig_lo0_alias0="inet 127.6.66.1 netmask 0xffffffff"

  ifconfig_lo0_alias1="inet 127.6.66.2 netmask 0xffffffff"

Case Study of a Honeypot on FreeBSD

- Ensure ip forwarding and pf are enabled to start on boot in rc.conf, and reboot to ensure all updates are working before moving on

```
# sysrc gateway_enable=yes

# sysrc pf_enable=yes

# reboot
```

Case Study of a Honeypot on FreeBSD

- Basic setup of two jails with iocage (assumes ZFS is available and zroot exists as a zpool):

```
# pkg install -y py37-iocage
# iocage activate zroot
```

(zroot is the zfs dataset on my VM, this sets up a structure for iocage to use for created jails)

```
# iocage fetch -r 12.1-RELEASE
```

(select a supported FreeBSD release, I used 12.1-FreeBSD)

```
# iocage create -n HoneyPy ip4_addr=”127.6.66.1” -r 12.1-RELEASE
# iocage create -n zeek ip4_addr=”127.6.66.2” -r 12.1-RELEASE
# iocage start HoneyPy
# iocage set boot=on HoneyPy
# iocage start zeek
# iocage set boot=on zeek
# sysrc iocage_enable=yes
```

Case Study of a Honeypot on FreeBSD

- Install the packages in the jails:

```
# iocage pkg HoneyPy update
# iocage pkg HoneyPy install -y python2 py27-twisted
# iocage pkg zeek update
# iocage pkg zeek install -y zeek
```

- Setup HoneyPy Jail:

```
# fetch https://github.com/foospidy/HoneyPy/archive/master.zip
# unzip master.zip
# mv HoneyPy-master /usr/iocage/jails/HoneyPy/root/root/
```

(or wherever your jails reside, place in the root folder)

Case Study of a Honeypot on FreeBSD

- Out-of-the-box services can be enabled in the configuration file located here

  /root/HoneyPy-master/etc/services.cfg (within the jail)

- By default, all of the output will log to the relative log directory here

  /root/HoneyPy-master/log (within the jail)

- A service can be configured with any of the available plugins, a simple low-interaction setup is to just echo back what is sent.

Case Study of a Honeypot on FreeBSD

- There is an issue with the default services running, so make a backup of that file and start fresh with the services you want.

```
cp /root/HoneyPy-master/etc/services.cfg /root/HoneyPy-master/etc/services-back
```

- The following is an example of using the Echo plugin to just echo SSH traffic back when received by the service.

```
cat << EOF > /root/HoneyPy-master/etc/services.cfg;
[SSH]
plugin      = Echo
low_port    = tcp:22
port        = tcp:10022
description = SSH/SCP on port 22
enabled     = Yes
EOF
```

Case Study of a Honeypot on FreeBSD

- Note that HoneyPy when started will listen on TCP port 10022, but expects that TCP port 22 would be used for the connection.
- pf, the packet filter firewall will handle the redirection of traffic for us as configured on the FreeBSD host.
  - All TCP port 22 traffic will be redirected to TCP port 10022. HoneyPy references ipt-kit to perform the redirection, but pf will do this for you.
- HoneyPy can be started in daemon-mode when running in production, or can be run in a console mode (next slide) providing access to stop and start the services.
  - Running the command from inside the jail

    ```
    # /usr/local/bin/python2.7 Honey.py -d
    ```

  - From outside the jail with iocage

    ```
    # iocage exec HoneyPy "/usr/local/bin/python2.7 /root/HoneyPy-master/Honey.py -d &"
    ```

Case Study of a Honeypot on FreeBSD

```
/usr/local/bin/python2.7 Honey.py
Your service configuration suggests that you want to run on at least one low port!
To enable port redirection run the following ipt-kit (https://github.com/foospidy/ipt-kit) commands as root:

                        ___
  /\  /\___  _ __   ___ _   _  / _ \_   _
 / /_/ / _ \| '_ \ / _ \ | | |/ /_)/ | | |
/ __  / (_) | | | |  __/ |_| / ___/| |_| |
\/ /_/ \___/|_| |_|\___|\__, \/     \__, |
                        |___/       |___/
[HoneyPy Copyright (c) 2013-2017. foospidy]
HoneyPy Console. For help type 'help'.
HoneyPy> start
16 service(s) started!
HoneyPy> list
FTP     <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 10021>
SSH     <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 10022>
Telnet  <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 10023>
SMTP    <<class 'twisted.internet.tcp.Port'> of plugins.SmtpExim.SmtpExim.pluginFactory on 10025>
DNS     <plugins.DnsUdp.DnsUdp.pluginMain on 10053>
HTTP    <<class 'twisted.internet.tcp.Port'> of plugins.Web.Web.pluginFactory on 10080>
HTTPS   <<class 'twisted.internet.tcp.Port'> of plugins.Web.Web.pluginFactory on 10443>
DCERPC  <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 10135>
DCERPC2 <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 10137>
DCERPC3 <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 10139>
CIFS    <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 10445>
CIFS.udp        <plugins.Echo_udp.Echo.pluginMain on 10445>
MSSQL   <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 1434>
RDP     <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 3389>
MySQL   <<class 'twisted.internet.tcp.Port'> of plugins.Echo.Echo.pluginFactory on 3306>
Elasticsearch   <<class 'twisted.internet.tcp.Port'> of plugins.Elasticsearch.elasticsearch.pluginFactory on 9200>
HoneyPy>
```

Case Study of a Honeypot on FreeBSD

- Example log event
- 2020-05-15 00:02:36,467784,+0000 [Echo,97469,XX.XX.XX.XX] 620669b0-963f-11ea-af87-2a017b7d7b0b TCP RX 127.6.66.1 10022 SSH XX.XX.XX.XX 33962 5353482d322e302d50555454590d0a
- Hex string == SSH-2.0-PUTTY

Case Study of a Honeypot on FreeBSD

- HoneyPy jail will have services started for all of the emulated services, while the Zeek jail will monitor all of the traffic.
- In order for the jail to monitor the host interface, a devfs rule must be configured.
- Create the following in /etc/devfs.rules on the FreeBSD host

```
[devfsrules_jail_bpf=7]

add include $devfsrules_jail

add path 'bpf*' unhide
```

Case Study of a Honeypot on FreeBSD

- Add the following to the /etc/rc.conf on the FreeBSD host:

```
devfs_system_ruleset="devfsrules_jail_bpf"
```

- Using the iocage “set” command, ensure the zeek jail loads this devfs ruleset, which gives access to sniff packets from within the jail, then restart devfs and the jail:

```
# iocage set devfs_ruleset=7 zeek
# service devfs restart
# iocage restart zeek
```

- Now we can configure the Zeek jail.

Case Study of a Honeypot on FreeBSD

- Zeek NSM for Intel Monitoring and Traffic recording – https://www.zeek.org
  - Zeek provides a simple way to ingest threat data and generate notice logs when a specific IOC is observed.
  - Anything else captured that was protocol specific would be logged by Zeek.
  - Suricata can also be used with IP/URL/HASH signatures, but I am more used to having Zeek just work with the intel data*

Case Study of a Honeypot on FreeBSD

- The goal was to combine various OS INT threat sources to create a threat feed for Zeek
- A script automatically downloads the CSV threat data and puts it into an intel.dat file Zeek can read in
  - There are steps to setup MISP on FreeBSD, and I am hoping to be able to get a port setup which would allow the aggregation of multiple threat sources and provide this intel output, instead of perl/python scripts*.

Case Study of a Honeypot on FreeBSD

- Zeek intel configuration example (Note: this is only two lines in the file, made larger for this slide, and all space is **TABS** separating fields):

```
#fields indicator	indicator_type	meta.source	meta.url	meta.do_notice

006b18b6fbea18750367f1753d9a418d23983823a01bea3ffdbc551eeced97fd	Intel::FILE_HASH	AlienVault OTXv2 - Signed Executable Potentially Related to TrickBot and Lazarus Group Activity ID: 5df94019452f666b340101d7 Author: AlienVault https://twitter.com/VK_Intel/status/1206497909858078720 T
```

Case Study of a Honeypot on FreeBSD

- Zeek indicator types (from Zeek 3.0.6):

```
## Enum type to represent various types of intelligence data.
type Type: enum {
## An IP address.
ADDR,
## A subnet in CIDR notation.
SUBNET,
## A complete URL without the prefix ``"http://"``.
URL,
## Software name.
SOFTWARE,
## Email address.
EMAIL,
## DNS domain name.
DOMAIN,
## A user name.
USER_NAME,
## Certificate SHA-1 hash.
CERT_HASH,
## Public key MD5 hash. (SSH server host keys are a good example.)
PUBKEY_HASH,        };
```

Case Study of a Honeypot on FreeBSD

- Zeek config updates to load a formatted intel file (add to /usr/local/share/zeek/site/local.zeek or create your own file and load it with local.zeek and load it within the zeek jail):

```
@load policy/frameworks/intel/seen

@load policy/frameworks/intel/do_notice

@load policy/frameworks/files/hash-all-files

redef Intel::read_files += {

   "/nsm/intel/intel.dat",

};
```

Case Study of a Honeypot on FreeBSD

- Ensure a properly formatted intel file exists at /nsm/intel/intel.dat (within the jail)
- Run the following to enable zeek to start on jail startup

```
# iocage exec zeek  “sysrc zeek_enable=yes”
```

Case Study of a Honeypot on FreeBSD

- Now run the zeek deploy command from within the jail
  - There are numerous other configurations for Zeek, I am only covering the basic items to get things running.

```
# iocage exec zeek "sed -i '' -e 's/localhost/127\.6\.66\.2/g' /usr/local/etc/node.cfg"

# iocage exec zeek "sed -i '' -e 's/eth0/vtnet0/g' /usr/local/etc/node.cfg"

# iocage exec zeek zeekctl deploy
```

Case Study of a Honeypot on FreeBSD

- Now with HoneyPy running fake services, and a list of IOCs to monitor for, we can correlate honeypot hits to intel hits to provide a fidelity that the IOCs are actually actively scanning hosts.
- Knowing this can reduce the time on incident response for scanners compared to real attackers.

Case Study of a Honeypot on FreeBSD

- Correlation of logs from Zeek and HoneyPy showing this IOC is still scanning and active.

conn.log:1590637759.244217 **Czwhu743bo5qkWgBd4** XX.XX.XX.XX **52080** XX.XX.XX.30 22 tcp - 33.907172 968 968 RSTO F T 0 ShADdR 9 1340 4 1140 -

intel.log:1590637759.244276 **Czwhu743bo5qkWgBd4** XX.XX.XX.XX **52080** XX.XX.XX.30 22 XX.XX.XX.XX Intel::ADDR Conn::IN_ORIG zeek Intel::ADDR Emerging_Threats_Compromised_IPs - - -

ssh.log:1590637760.196914 **Czwhu743bo5qkWgBd4** XX.XX.XX.XX **52080** XX.XX.XX.30 22 2 - 0 INBOUND SSH-2.0-paramiko_1.7.5 **SSH-2.0-paramiko_1.7.5** aes128-ctr hmac-sha2-256 none diffie-hellman-group-exchange-sha256 ssh-rsa

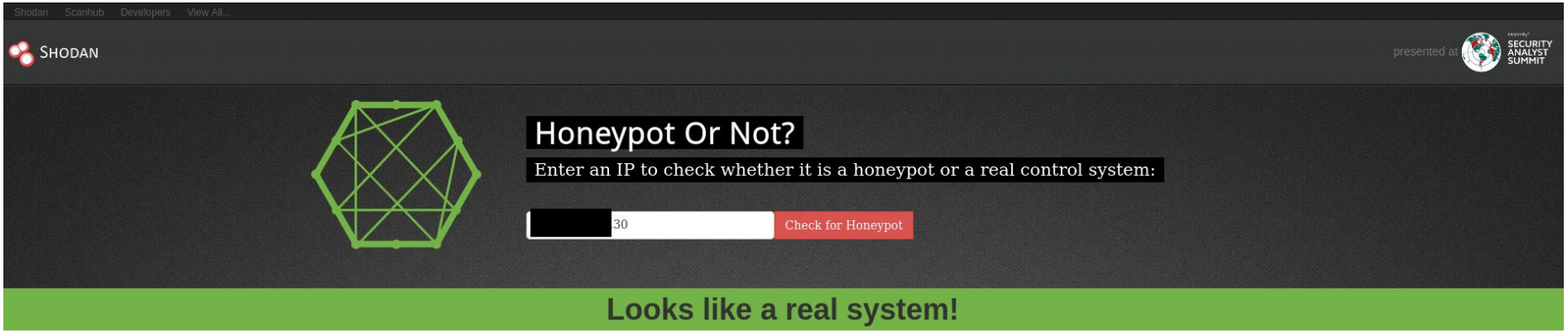
HoneyPy.log:2020-05-28 03:49:20,197160,+0000 [Echo,29,XX.XX.XX.XX] 35a664b0-a096-11ea-9769-2a017b7d7b0b TCP RX 127.6.66.1 10022 SSH XX.XX.XX.XX **52080 5353482d322e302d706172616d696b6f5f312e372e350d0a**

Case Study of a Honeypot on FreeBSD

- I have scripts I created to correlate and provide this information to the customers.
- My case study ends with this initial setup, but there are other directions to take this build-out.
- The good news is Shodan has an API to evaluate whether a system is real or looks like a honeypot.

Case Study of a Honeypot on FreeBSD

- So far, my system appears to be legitimate, not a honeypot
- Without additional analysis, it looks like a FreeBSD firewall redirecting traffic, not a cloud instance hosting a honeypot jail.



Case Study of a Honeypot on FreeBSD

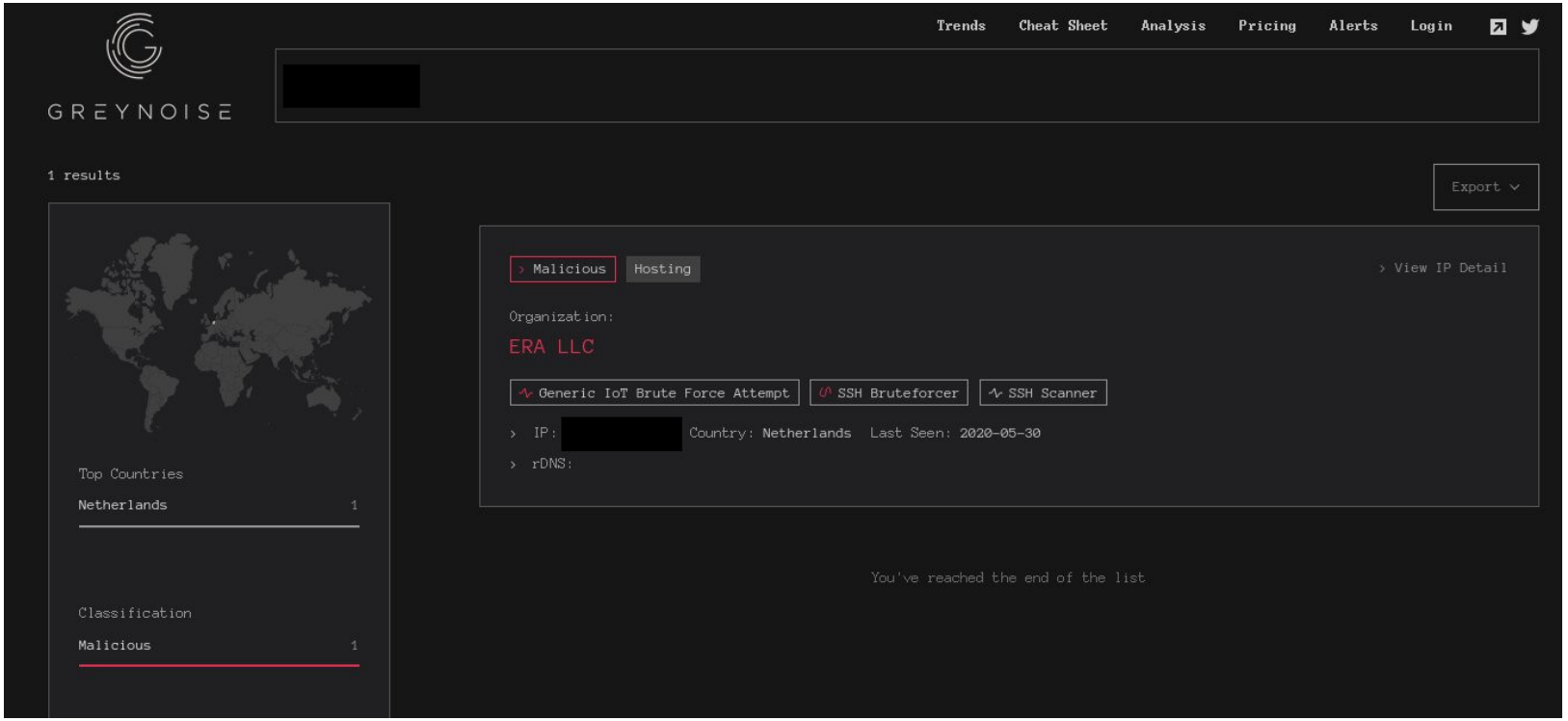
- Getting more from this data:
  - Validate against the customer log data
    - Are they seeing any of the correlated honeypot/zeek IOCs in their own logs? Are the IOCs still valid?
    - MISP provides a mechanism to aggregate this data and mark specific IOCs as being too old, or aging out, and automating the update of the threat data.
    - Zeek supports updates to the intel files and continues to run.
      - This is part of the way the input framework works within Zeek.
      - Also J-Gras has a Zeek package to expire intel items.

Case Study of a Honeypot on FreeBSD

- Getting more from this data:
  - Configuring API integration to validate if the traffic is a known scanner or more of a potential threat.
  - GreyNoise provides this service to identify known scanners or potentially malicious traffic: https://greynoise.io
    - If a system has been observed by GreyNoise's sensors, they will add additional context to the alerts.

Case Study of a Honeypot on FreeBSD

- GreyNoise lookup for the IP in this alert



Case Study of a Honeypot on FreeBSD

- This case study shows but one example of setting up a Honeypot on BSD operating systems.
- Outside of this collected data in simple log formats, aggregating this log data and looking for trends can provide further insight into potential new attacker behavior.
- Taking this a step further is to ingest this data into a Security Incident and Event Management (SIEM) system to evaluate threat data to actual traffic in your environment.
  - The ability to ask “I saw this attack hit the honeypot, from this specific source host, did this source host access anything else?”

Conclusion

- BSD Operating System are well suited for honeypots
  - And are a part of the history of honeypots
- BSD-NSM – Coming soon to FreeBSD.
  - Will include the ability to deploy honeypots in addition to Zeek, Suricata or Snort in jails (looking at honeytrap covered in my BSDCan talk)
- If anything from this talk, hopefully more honeypots will start using BSD operating systems over docker images.

Thank you

References

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Questions?

Stay Connected

Website - Zeek.org

Mailing List - zeek@lists.zeek.org

Slack - http://bit.ly/ZeekOrgSlackInvite

Find out more ways to connect at: https://zeek.org/community/

virtual
ZeekWeek 2020
13-15 October