Observability for security. Deep dive into Osquery.

Artem Mishchenko

15.12.2023

SELECT * FROM speaker_info

WHERE name = ’Artem Mishchenko’;

name = Artem Mishchenko

position = Infrastructure Security TechLead, inDrive

certifications = OSCP

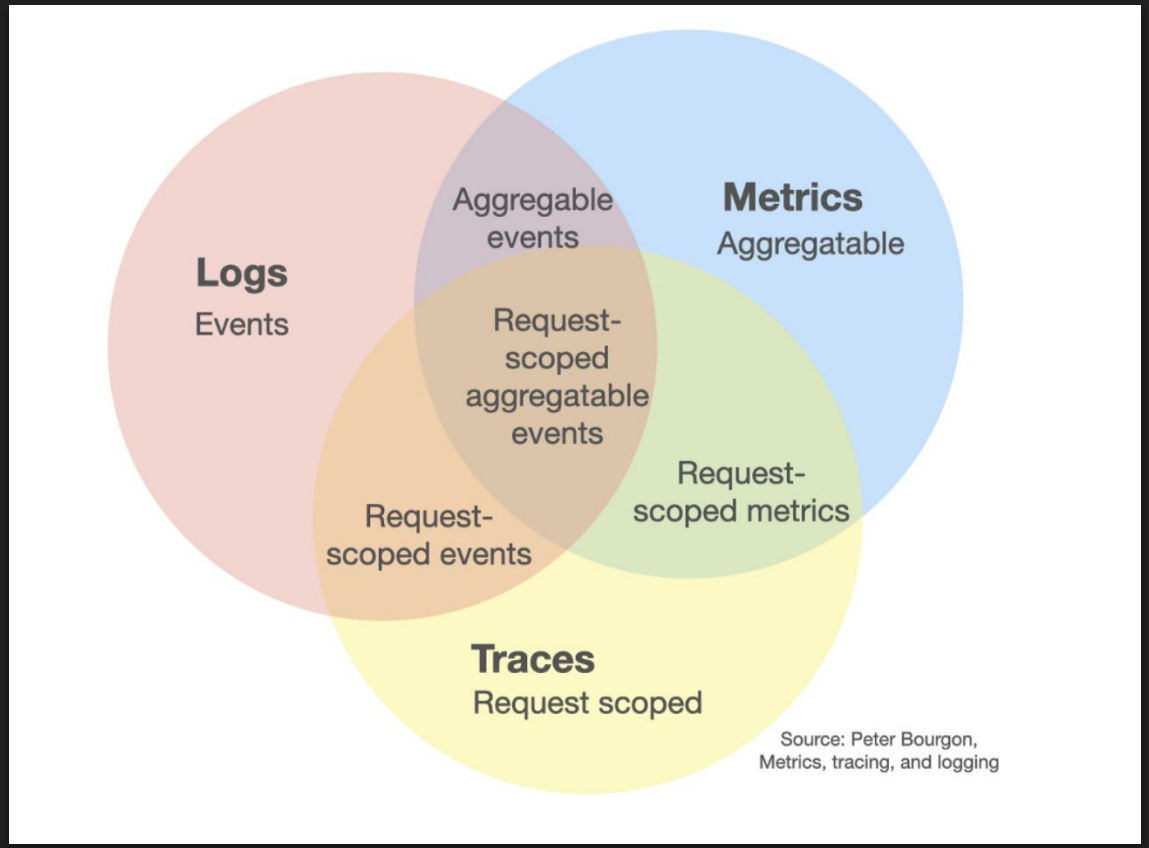
interests = SOC, Linux, K8S and Cloud Security

Agenda

1. Observability and Security
2. Osquery Basics
3. Advanced Osquery
4. Osquery Management
5. Examples and experience
6. Conclusions

1. Observability And Security

Classic Observability



Security Team Problems

- Basic logging is not enough
- No access to production with SSH
- Incident response process is slow
- Need to ask Linux admin to take file from production system
- No opportunity to make simple and fast vulnerability checks
- How to check remote system settings, line config lines?

What do we want?

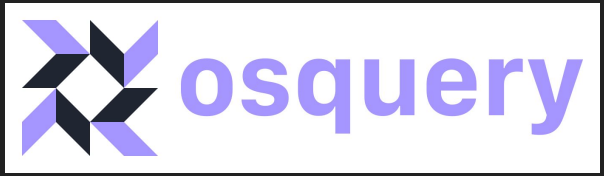
- Get current remote machine state!
- Identify security misconfigurations!
- Do lightweight Threat Hunting!
- Collect artifacts for investigations!
- Make simple vulnerability checks!
- More security alerts for SOC team!
- Save money!

Can we get all of this with Osquery?

Let’s see at the end!

2. Osquery Basics

Osquery



- Initially Facebook project, now part of Linux Foundation
- Open Source, 20k+ stars on Github
- Cross platform (Windows, MacOS, Linux, Chrome OS)
- Exposes an operating system as a high-performance relational database
- Tries to follow the concept of read-only tool without OS changes and RCE
- osqueryi is a standalone console shell for local queries
- osqueryd is a monitoring daemon that allow you schedule queries
  - osquery.conf to store queries and packs
  - osquery.flags for daemon configuration options

https://osquery.io

https://www.uptycs.com/blog/osquery-what-it-is-how-it-works-and-how-to-use-it

Just a couple of Osquery examples

```
<SQL>

SELECT pid, name, path, cmdline FROM processes;
```

This might return:

```
<TEXT>

+------+-----------+------------------+---------------------+
| pid  | name      | path             | cmdline             |
+------+-----------+------------------+---------------------+
| 1    | systemd   | /usr/lib/systemd | /usr/lib/systemd    |
| 2    | kthreadd  |                  |                     |
| 3    | kworker   |                  |                     |
...
```

https://osquery.io/

Just a couple of Osquery examples

```
<SQL>

SELECT name, version, install_date FROM programs;
```

This might return:

```
<TEXT>

+-------------+---------+--------------+
| name        | version | install_date |
+-------------+---------+--------------+
| Google Chrome | 89.0   | 20210302    |
| VLC Media Player | 3.0.11 | 20200601 |
...
```

https://osquery.io/

Why SQL is cool?

```
                    [attribute]
SELECT pid, name, username FROM processes

JOIN users ON processes.uid=users.uid
                          [join]
WHERE uid != 0
   [constraints]
```

- SQL: Structured Query Language
- Many developers and admins are familiar with SQL
- Core concepts of SQL are platform agnostic
- Core concepts have attributes

Osquery Schema

osquery

HOME | SCHEMA | BLOG | DOCS | GITHUB | DOWNLOADS

273 Tables

Osquery Version: 5.7.0 (current)

- account_policy_data
- acpi_tables
- ad_config
- alf
- alf_exceptions
- alf_explicit_auths
- app_schemes
- apparmor_events
- apparmor_profiles
- appcompat_shims
- apps
- apt_sources
- arp_cache
- asl
- atom_packages
- augeas
- authenticode
- authorization_mechanisms

Show only Tables compatible with:

Restore Default View

account_policy_data

Additional macOS user account data from the AccountPolicy section of OpenDirectory.

Improve this Description on Github

COLUMN	TYPE	DESCRIPTION
uid	BIGINT	User ID
creation_time	DOUBLE	When the account was first created
failed_login_count	BIGINT	The number of failed login attempts using an incorrect password. Count resets after a correct password is entered.
failed_login_timestamp	DOUBLE	The time of the last failed login attempt. Resets after a correct password is entered
password_last_set_time	DOUBLE	The time the password was last changed

https://osquery.io/schema

Complex query for Osquery

```
SELECT p.*, pos.*
FROM process_open_sockets AS pos
INNER JOIN processes AS p ON p.pid = pos.pid
WHERE remote_address <> "" AND remote_port != 0 AND pos.pid > 0
LIMIT 5;
```

pid	laddr	lport	raddr	rport	family	proto	path
1135	192..	56493	140..	443	2	6	..firefox
1135	192.	55620	35..	443	2	6	..firefox
1135	192.	56536	104..	443	2	6	..firefox
1135	192.	55527	34..	443	2	6	..firefox
1135	192.	56531	216..	443	2	6	..firefox

https://zercurity.medium.com/connection-network-socket-monitoring-with-osquery-8d3b28e5cce

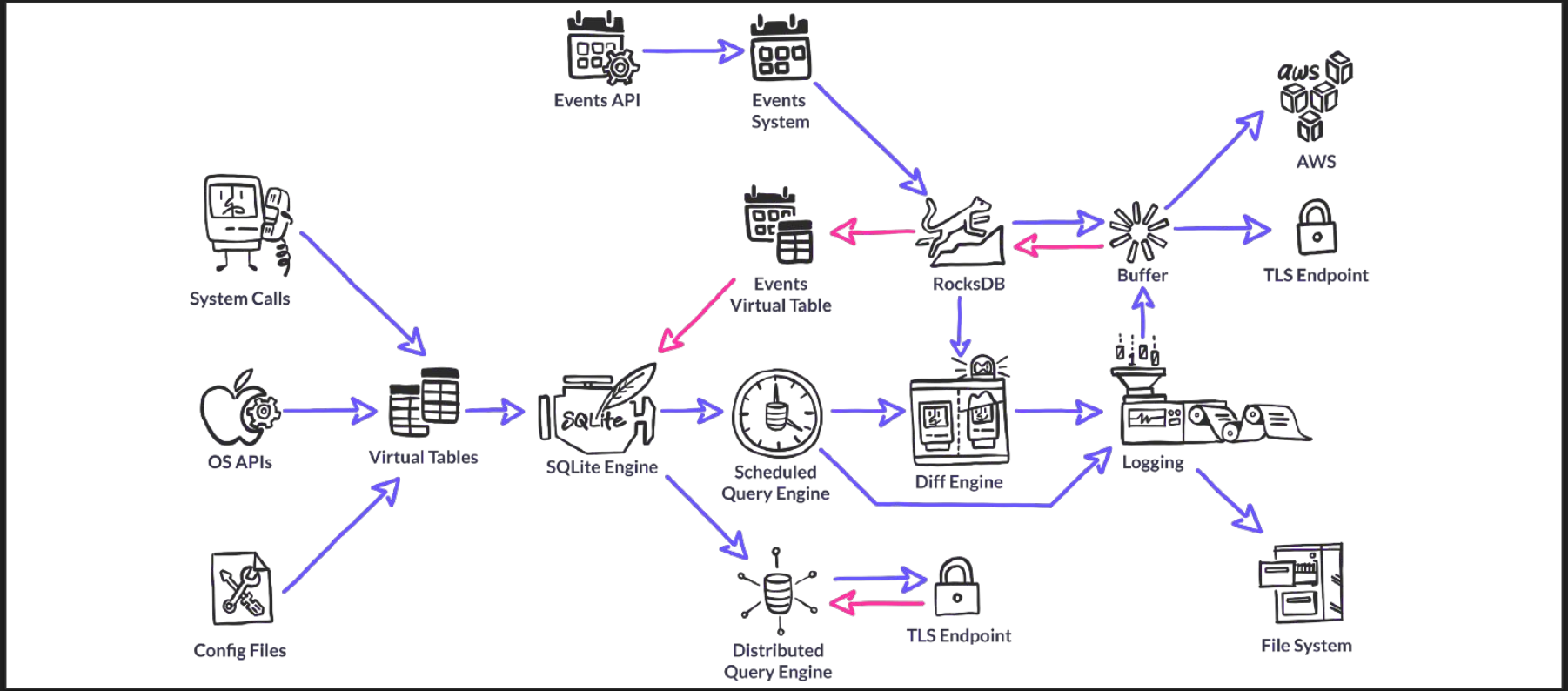
Complex query for Osquery

```
SELECT p.*, lp.*
FROM listening_ports AS lp
INNER JOIN processes AS p ON p.pid = lp.pid
WHERE address <> "" AND port != 0 AND lp.pid > 0
LIMIT 5;
```

name	addr	port	family	proto	path
SystemUIServer	0.0.0.0	57645	2	17	/System..
postgres	::1	5432	10	6	/Applic..
postgres	127.0..	5432	2	6	/Applic..
trezord	127.0..	21325	2	6	/Applic..
Chrome Helper	0.0.0.0	5353	2	17	/Applic..

https://zercurity.medium.com/connection-network-socket-monitoring-with-osquery-8d3b28e5cce

Osquery: Under the Hood



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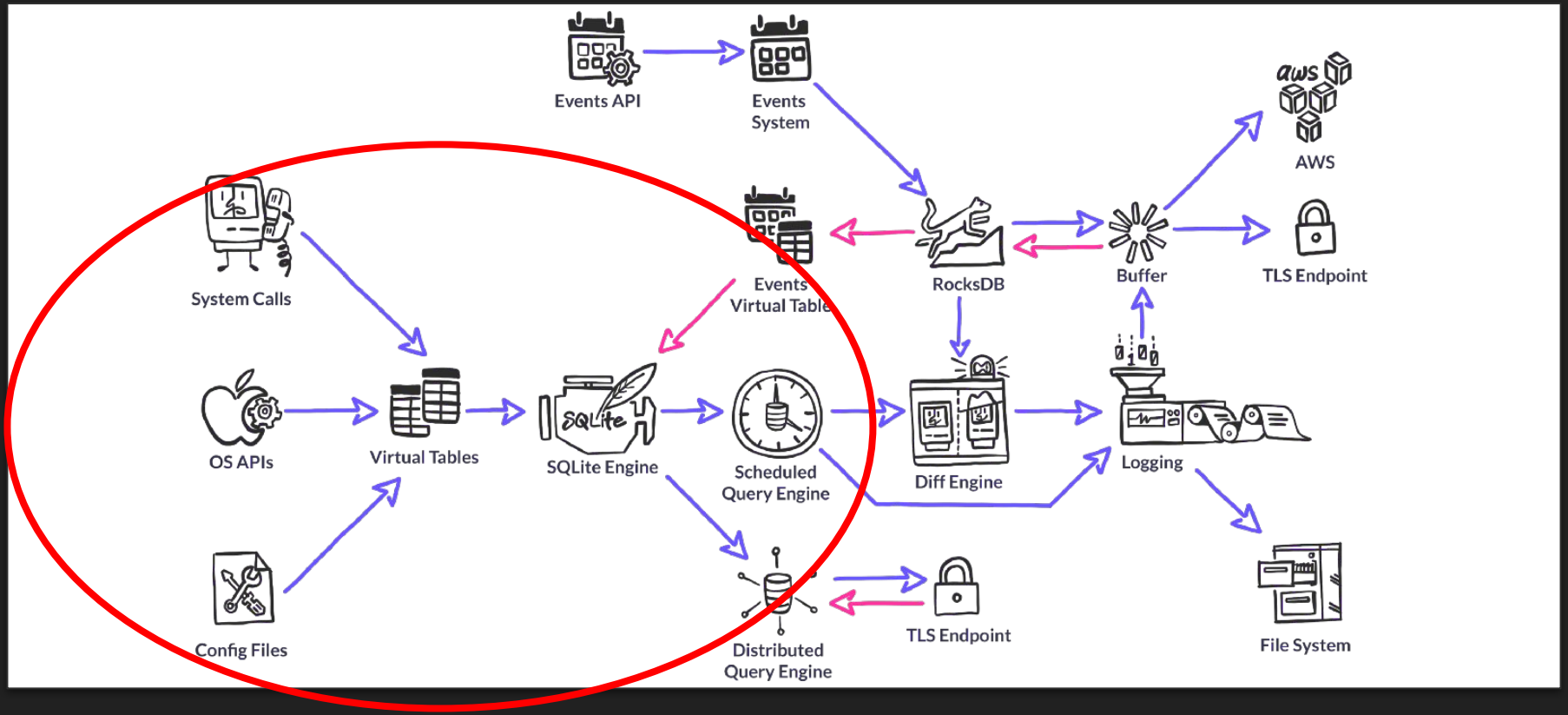
Osquery: Under the Hood



https://www.kolide.com/blog/osquery-under-the-hood

Osquery Watchdog

- When we start osqueryd, we get two processes:
  - Parent process - The “watchdog”
  - Child process - The “worker”

https://dactiv.llc/files/osquery-performance-at-scale.pdf

https://zercurity.medium.com/monitoring-and-managing-the-impact-of-query-performance-on-osquery-65d67fe7def6

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  - Child process - The “worker”
- Potentially resource-intensive operations are performed in the worker process.
  - Run queries, output logs, etc.

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Osquery Watchdog

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  - Parent process - The “watchdog”
  - Child process - The “worker”
- Potentially resource-intensive operations are performed in the worker process.
  - Run queries, output logs, etc.
- The watchdog process checks the utilization stats for the worker on an interval.
  - Resource utilization limits exceeded -> Watchdog kills/respawns worker
  - Multiple watchdog kills put the query to blacklist (denylist) for 24 hours

https://dactiv.llc/files/osquery-performance-at-scale.pdf

https://zercurity.medium.com/monitoring-and-managing-the-impact-of-query-performance-on-osquery-65d67fe7def6

Osquery Watchdog

```
I0121 08:44:48.398947 270000128 scheduler.cpp:96] Executing scheduled query expensive_query:
select 1 from users, users, users, users, users, users
W0121 08:45:13.591068 127172608 watcher.cpp:331] osqueryd worker (71861) stopping: Maximum
sustainable CPU utilization limit exceeded: 21
I0121 08:45:13.996376 127172608 watcher.cpp:583] osqueryd watcher (71860) executing worker
(71928)
I0121 08:45:14.841640 163079616 init.cpp:415] osquery worker initialized [watcher=71860]
I0121 08:45:14.842711 163079616 rocksdb.cpp:131] Opening RocksDB handle: /tmp/osquery.db
...
W0121 08:45:23.252063 163079616 config.cpp:317] Scheduled query may have failed: expensive_query
```

SELECT * FROM osquery_schedule WHERE blacklisted = 1

Configuration options:

--watchdog_level

--watchdog_utilization_limit

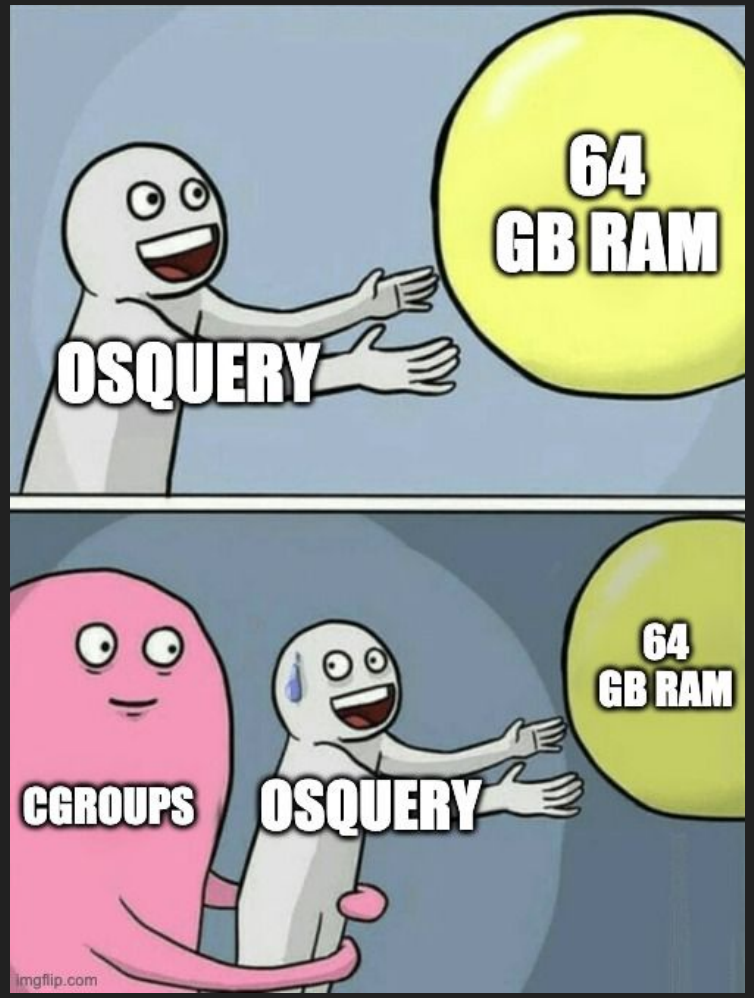
--watchdog_memory_limit

Osquery Watchdog

What should we do if we are not sure about the reliability of Watchdog?

Let's turn on Cgroups! (for Linux)

```
osquery_memory_limit: "{{ (
ansible_memtotal_mb | int >= 16384) |
ternary('1G', '512M') }}"
osquery_cpu_quota: "{{ (
ansible_processor_vcpus | int >= 20) |
ternary('100%', '50%') }}"
```



Osquery Possible Use Cases

- Server Infrastructure
  - Works good in Linux and Windows servers
  - Observability tool for security regression tests
  - Check something for compliance requirements
  - Lightweight threat hunting and HIDS

Osquery Possible Use Cases

- Corporate Laptops/PCs
  - Connections can be unstable
  - Security posturing and device control
  - Lightweight threat hunting & HIDS tool
  - You have to think about employees privacy
  - You have to be ready to properly explain osquery purposes to your colleagues

Osquery from the perspective of some employees - probe

3. Advanced Osquery

OWASP Limassol

Osquery Event Tables

- Helps to collect data continuously
- Uses OS features to generate events, like Linux Audit Framework
- The data is cached in internal RocksDB in Osquery
- The feature creates additional system load (not always predictable)
- Osquery Watchdog often doesn’t work as expected

--disable_events=false

--enable_file_events=true

--disable_audit=false

https://fleetdm.com/guides/osquery-evented-tables-overview

Osquery Augeas

SELECT * FROM augeas WHERE path = '<path>'

- Use concept of lenses
- Can parse different configuration formats
- Can help us to organise security checks for configs

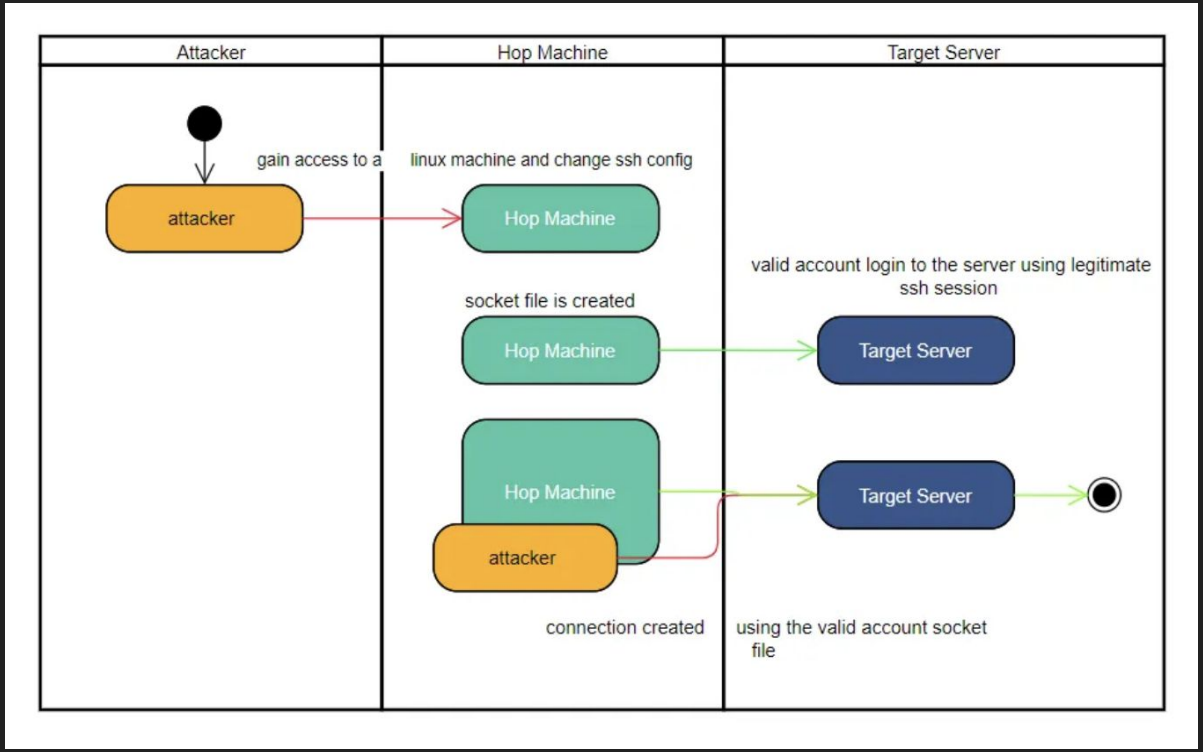
```
osquery> SELECT label,value FROM augeas
    ...> WHERE path='/etc/ssh/sshd_config' AND
    ...> (label='PermitRootLogin'
    ...> OR label='PasswordAuthentication'
    ...> OR label='AllowAgentForwarding'
    ...> OR label='PermitEmptyPasswords');
+------------------------+-------+
| label                  | value |
+------------------------+-------+
| PermitRootLogin        | no    |
| PasswordAuthentication | no    |
| PermitEmptyPasswords   | no    |
| AllowAgentForwarding   | no    |
+------------------------+-------+
```

https://medium.com/swlh/parsing-configuration-files-with-augeas-on-osquery-ec8260a9a50b

Real life scenario for Osquery: SSH Agent Hijacking

Server
/etc/ssh/sshd_config
AllowAgentForwarding yes

Client
~/.ssh/ssh_config
ForwardAgent yes



https://hx015.medium.com/ssh-session-hijack-analytic-a2c684ba410f

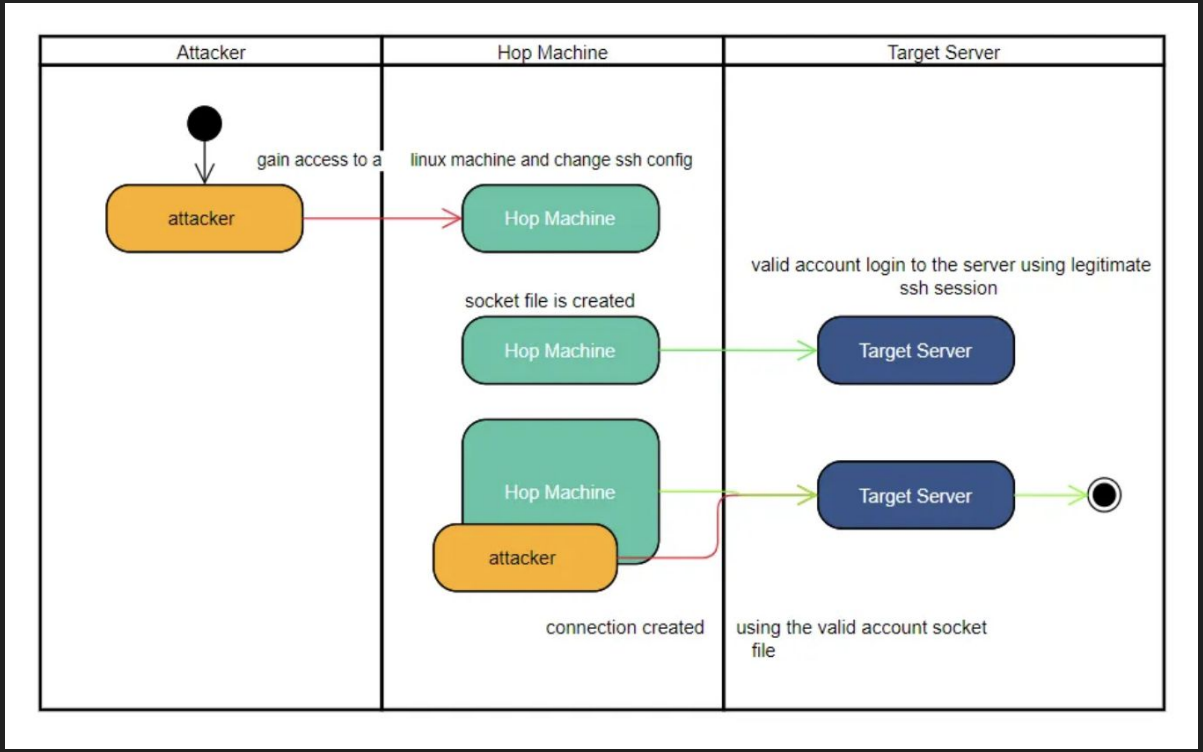
https://book.hacktricks.xyz/linux-hardening/privilege-escalation/ssh-forward-agent-exploitation

Real life scenario for Osquery: SSH Agent Hijacking

Server
/etc/ssh/sshd_config
AllowAgentForwarding yes

Client
~/.ssh/ssh_config
ForwardAgent yes

SSH_AUTH_SOCK=/tmp/ssh-haqzR16816/agent.16816



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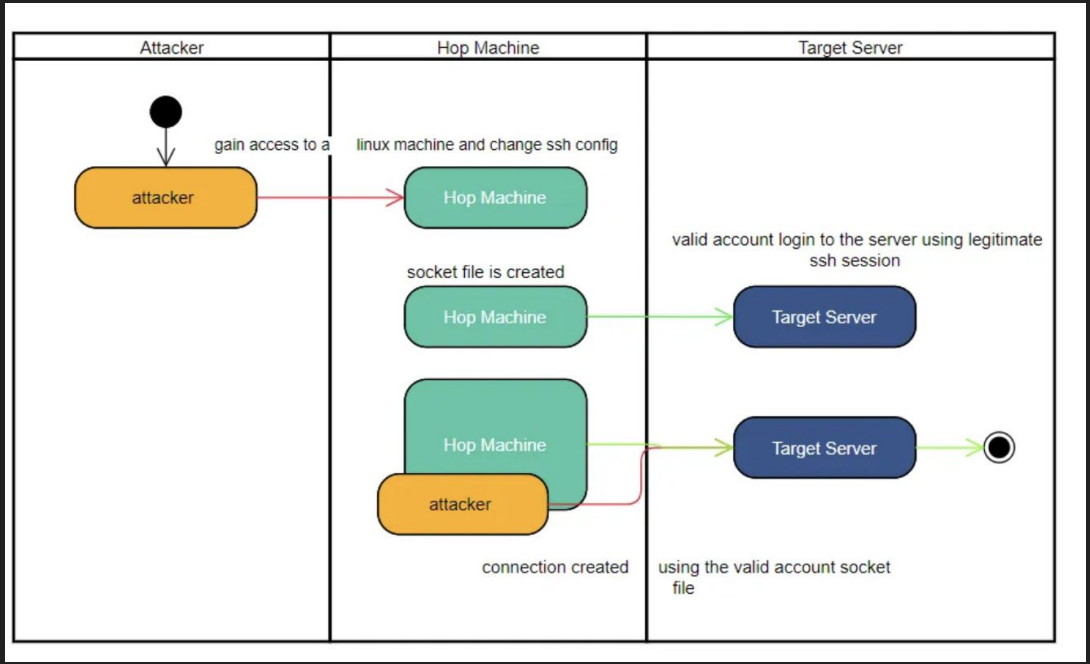


SSH_AUTH_SOCK=/tmp/ssh-haqzR16816/agent.16816 ssh bob@10.10.0.1

https://hx015.medium.com/ssh-session-hijack-analytic-a2c684ba410f

https://book.hacktricks.xyz/linux-hardening/privilege-escalation/ssh-forward-agent-exploitation

Real life scenario for Osquery: SSH Agent Hijacking

What can we do here with Osquery?

1) Find hosts with allowed AllowAgentForwarding and disable it where possible

   SELECT label, value FROM augeas WHERE path = '/etc/ssh/sshd_config' and label = "AllowAgentForwarding" and value = "yes"

2) Find users who currently use ssh agent and wean them off forwarding agents everytime, and also help fix their ssh configs

   SELECT * FROM file JOIN users using (uid) WHERE file.path LIKE '/tmp/ssh%'

3) Made better network isolation to reduce blast radius
4) Decided to use alternative tunneling methods like limited AllowTcpForwarding

File Carving

SELECT * FROM carves WHERE path LIKE '/etc/osquery/%/' and carve=1

- Take files from remote device with this feature
- Better to use it with osquery manager
- Carefully use this feature with employees' devices or disable

https://zercurity.medium.com/file-retrieval-with-osquery-using-carves-on-zercurity-9b157f7c0801
https://fleetdm.com/docs/using-fleet/fleetctl-cli#file-carving

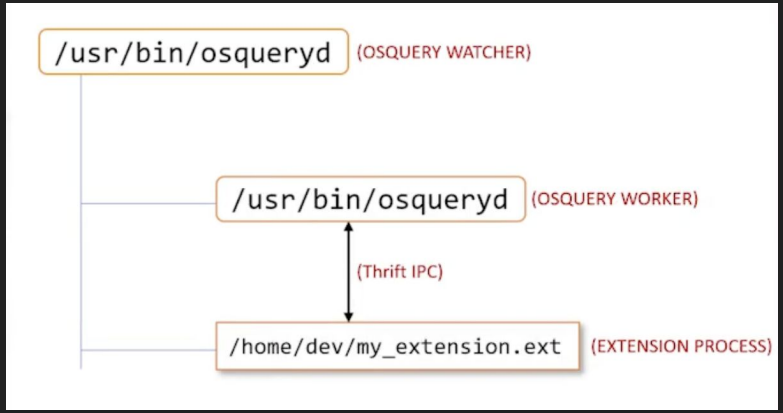
Yara Rules and Osquery

```
SELECT * FROM yara WHERE path like '/root/%%' AND sigrule IN (  'rule eicar {
  strings:
$s1="X5O!P%@AP[4\\PZX54(P^)7CC)7}$EICAR-STANDARD-ANTIVIRUS-TEST-FI
LE!$H+H*" fullword ascii
  condition:
  all of them
}'
 ) AND matches='eicar'
```

- Swiss knife to identify malware
- Whole system scan can become expensive quickly
- Can work with osquery process and FIM events
- Target smaller set of files (like current processes or specific directory)

https://www.eicar.org/download-anti-malware-testfile/
https://github.com/InQuest/awesome-yara

Osquery Extensions



- Can be written on C++, Python or Go
- For example, with help of osquery-go
  - https://github.com/osquery/osquery-go
- Acts as a separate binary
- Some interesting extensions examples
  - https://github.com/trailofbits/osquery-extensions

https://www.uptycs.com/blog/detect-java-security-vulnerabilities-at-scale-osquery

https://www.kolide.com/blog/how-to-write-a-new-osquery-table

Osquery Concerns and Lacks

- Lack of tables for container engines beyond Docker
- Lack of tables for Cloud and Kubernetes
  - Extensions from Uptycs company are deprecated and no more supported
- Works better in host operating systems

Osquery Concerns and Lacks

- We can try deploy Osquery in K8S, but implementation can be tricky (especially in dynamic/managed environment)
  - You can look a couple of examples in research of Alexander Ivanov from Wrike (https://www.youtube.com/watch?v=FvEMwVW6bBI)
- You can’t use osquery to find arbitrary file on filesystem (https://www.kolide.com/blog/the-file-table-osquery-s-secret-weapon)

4. Osquery Management

How to manage Osquery for a whole infrastructure?

- Distribute specific queries through config
  - Can use Ansible, Puppet, Chef, SaltStack, etc
  - If you need to make changes - you need to apply them explicitly
  - Gather logs from local files on endpoints with your favorite log shipper

https://github.com/osquery/osquery?tab=readme-ov-file#osquery-fleet-managers

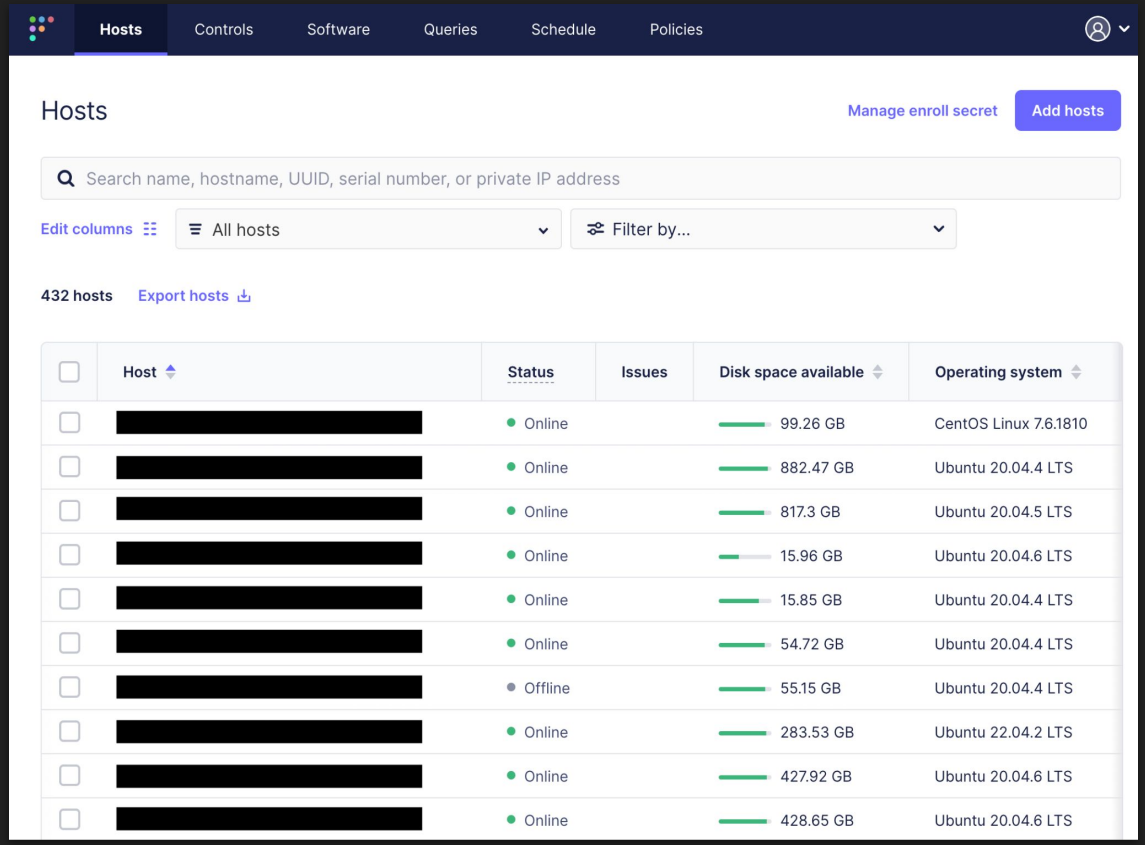
How to manage Osquery for a whole infrastructure?

- Use manager tools for Osquery
  - Fleetdm (formerly known as Kolide Fleet)
  - Kolide
  - Osctrl
  - Zentral
  - Zercurity
  - Elastic Stack Osquery Manager
  - etc

https://github.com/osquery/osquery?tab=readme-ov-file#osquery-fleet-managers

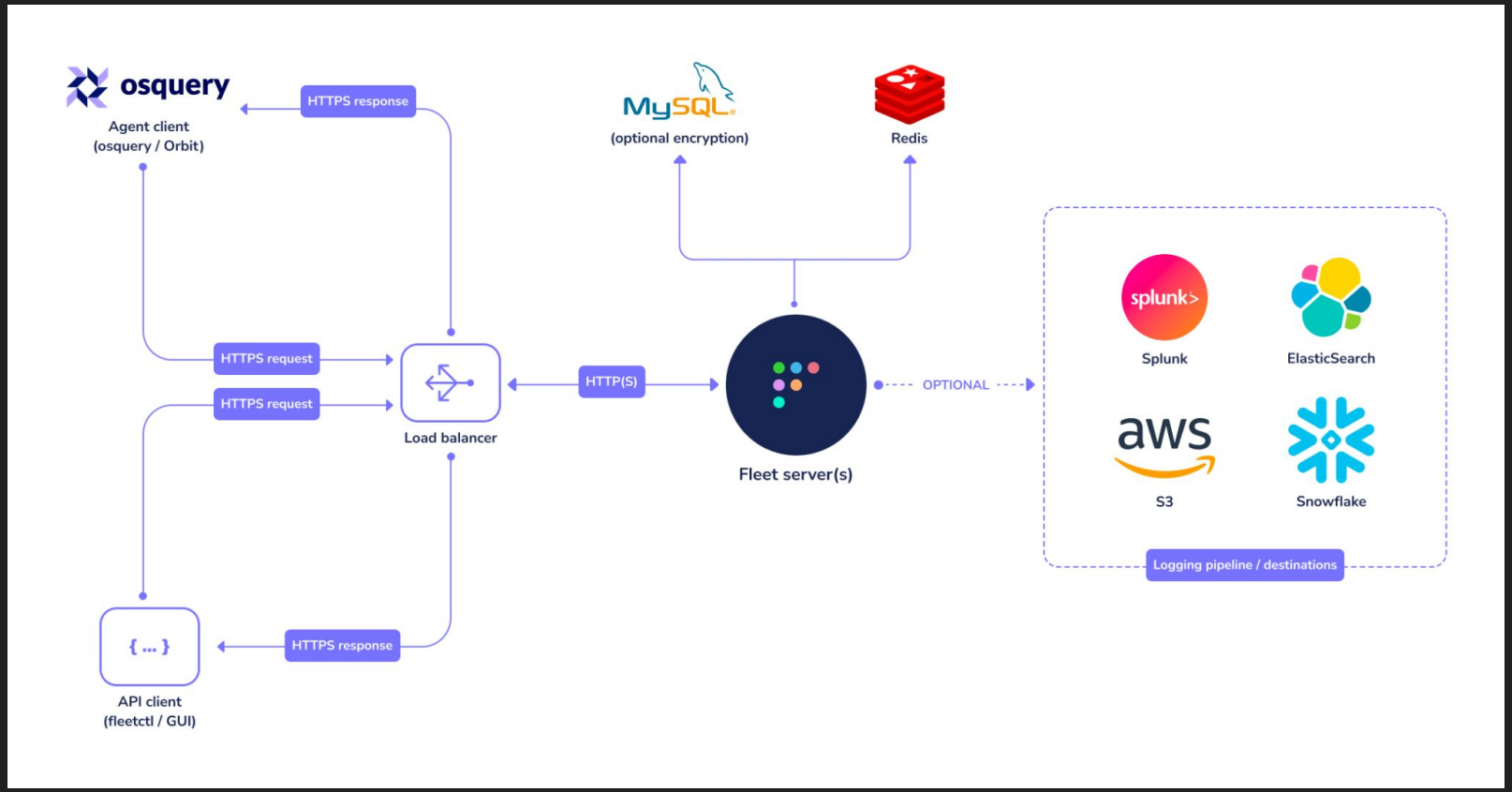
Fleetdm (formerly known as Kolide Fleet)

- Core is open and free
- Live queries across all Osquery fleet
- Can schedule queries and log results
- Can save queries as policies and notify about violations
- Supports labels and packs (yet)
- Other features like MDM in paid version



https://fleetdm.com

Fleetdm Architecture



https://fleetdm.com/docs/deploy/introduction#infrastructure-dependencies

Fleetdm Security Hardening

- SAML SSO
  - Group membership based access + implicit 2FA
  - Google Workspace, Okta, etc
- Minimal RBAC
  - Only three roles in free version (**Admin, Maintainer, Observer**)
  - Add user to “Observer” role and allow only specific queries
  - Unfortunately we can’t assign users to restricted scopes in core

https://fleetdm.com/docs/deploy/single-sign-on-sso

Fleetdm Security Hardening

- Separate settings for Fleetdm and Osquery handlers in LB
  - Stronger requirements for admin panels (2FA, etc)
  - Different ACL for osquery and users
- Gather audit events from MySQL DB to SIEM
  - MySQL “activities” table

https://fleetdm.com/docs/deploy/single-sign-on-sso

Separate settings for Fleetdm on Nginx

```
    location ~ /api/(v1/)?osquery {
      proxy_pass https://fleet;
      proxy_set_header Host $host;
      proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
      proxy_buffering off;
    }
  }
```

```
    location / {
      proxy_pass https://fleet;
      proxy_read_timeout 90;
      proxy_connect_timeout 90;
      proxy_set_header Host $host;
      proxy_set_header X-Real-IP $remote_addr;
      proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
      proxy_set_header Proxy "";
      proxy_set_header Upgrade $http_upgrade;
      proxy_set_header Connection $connection_upgrade;
    }
  }
```

https://mysteryincorporated.medium.com/nginx-configuration-for-fleetdm-setups-that-want-to-catch-3m-flatties-willem-powerfish-be-proud-7f99f97fdede

Fleetdm Labels and Osquery Packs

- Packs - just a group of queries
- Labels - feature to create subgroups of hosts
- We can’t schedule query to labeled group of hosts, only pack
- There is a default global pack in Fleetdm for all hosts

Popular public packs:

https://github.com/osquery/osquery/tree/experimental/packs

https://github.com/palantir/osquery-configuration

https://github.com/teoseller/osquery-attck

https://fleetdm.com/securing/mapping-fleet-and-osquery-results-to-the-mitre-attck-framework-via-splunk

Osquery MITRE ATT&CK Pack

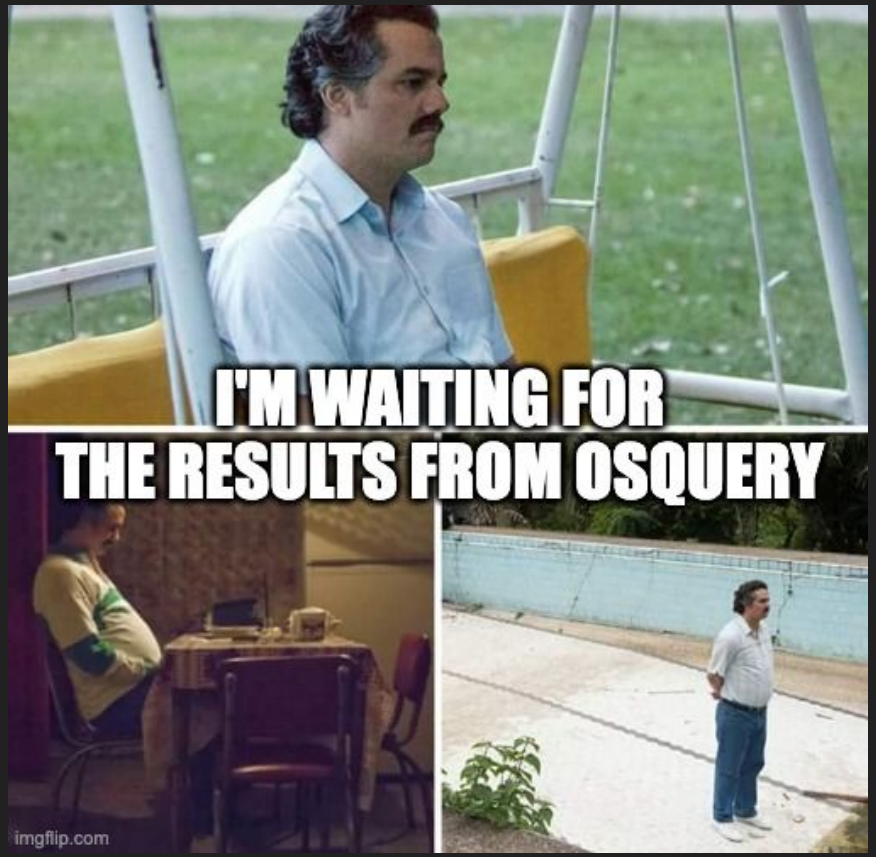
```
1   {
2     "platform": "windows",
3     "description": "ATT&CK: T1107,T1158,T1191,T1118,T1216,T1059,T1170,T1086,T1117,T1053,T1035,T1197,T1128,T1134,T1126,T1087,T1201,T1069,T1057,
4     "queries": {
5       "attrib.exe": {
6                   "query":"select * from file WHERE directory = 'C:\\Windows\\Prefetch\\' and filename like '%attrib%';",
7                   "interval": 600,
8                   "description": "Attrib Execute, usaullay used to modify file attributes - ATT&CK T1158",
9                   "platform": "windows"
10                  },
11      "schtasks.exe": {
12                  "query":"select * from file WHERE directory = 'C:\\Windows\\Prefetch\\' and filename like '%schtasks%';",
13                  "interval": 600,
14                  "description": "Schtasks Execute, usaullay used to create a scheduled task - ATT&CK T1053,S0111",
15                  "platform": "windows"
16                  },
17      "taskeng.exe": {
18                  "query":"select * from file WHERE directory = 'C:\\Windows\\Prefetch\\' and filename like '%taskeng%';",
19                  "interval": 600,
20                  "description": "taskeng Execute, usaullay used to create a scheduled task - ATT&CK T1053",
21                  "platform": "windows"
22          },
```

https://fleetdm.com/securing/mapping-fleet-and-osquery-results-to-the-mitre-attck-framework-via-splunk

Osquery Data Pulling Model

Available intervals options:

- distributed_interval: 60
  - Can be changed directly in Osquery flags and in Fleetdm
- logger_tls_period: 10
  - Can be changed directly in Osquery flags and in Fleetdm
- config_refresh: 60
  - Only in Osquery flags



https://osquery.readthedocs.io/en/stable/installation/cli-flags

5. Examples and experience

Osquery for Security: sshd config

config-auth-ssh | allowed PermitRootLogin

Author
SIEM Admin User

We should have only PermitRootLogin=no in production

Query:

```
SELECT label, value FROM augeas WHERE path = '/etc/ssh/sshd_config' and label =
    "PermitRootLogin" and value != 'no';
```

Compatible with: ✓ macOS ✗ Windows ✓ Linux

☐ **Observers can run**

Users with the Observer role will be able to run this query on hosts where they have access.

config-auth-ssh | allowed PasswordAuthentication

Author
SIEM Admin User

We should have only PasswordAuthentication=no in production

Query:

```
SELECT label, value, path FROM augeas WHERE path = '/etc/ssh/sshd_config' and label =
    "PasswordAuthentication" and value = "yes";
```

Compatible with: ✓ macOS ✗ Windows ✓ Linux

☐ **Observers can run**

Users with the Observer role will be able to run this query on hosts where they have access.

Osquery for Security: SSH Private Keys

users-leaks | ssh users private keys

Author
You

Add

Query

```
SELECT path, mode, username, datetime(mtime, 'unixepoch', 'localtime') AS mtime, datetime(atime, 'unixepoch', 'localtime') AS atime, inode, file.uid,
    file.gid
FROM users
JOIN user_ssh_keys USING (uid), file USING (path);
```

Compatible with: ✓ macOS ✓ Windows ✓ Linux ✕ ChromeOS

☐ **Observers can run**

Users with the observer role will be able to run this query on hosts where they have access.

Osquery for Security: Privileged Docker Containers

Find Containers Running As Privileged

https://community.carbonblack.com/t5/Query-Exchange/Find-Containers-Running-As-Privileged/idi-p/75266

Query

```
SELECT id, name, image, state, started_at
  FROM docker_containers
  WHERE privileged=1;
```

Compatible with: ✓ macOS ✗ Windows ✓ Linux ✗ ChromeOS

☐ **Observers can run**

Users with the observer role will be able to run this query on hosts where they have access.

Osquery for Security: Software Packages

vulners | rpm packages

Author
SIEM Admin User

Get software packages from RHEL based servers for Vulners API requests

Query:

```
SELECT (SELECT REPLACE(value, '"','') FROM augeas where path='/etc/os-release' and label='ID') as osname, (SELECT REPLACE(value, '"','') FROM augeas
    where path='/etc/os-release' and label='VERSION_ID') as osversion, name || '-' || version || '-' || release || '-' || arch as package FROM
    rpm_packages
```

Compatible with: ✗ macOS ✗ Windows ✓ Linux

☐ **Observers can run**

Users with the Observer role will be able to run this query on hosts where they have access.

vulners | deb packages

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Get software packages from Debian based servers for Vulners API requests

Query:

```
SELECT (SELECT REPLACE(value, '"','') FROM augeas where path='/etc/os-release' and label='ID') as osname, (SELECT REPLACE(value, '"','') FROM augeas
    where path='/etc/os-release' and label='VERSION_ID') as osversion, name || ' ' || version || ' ' || arch as package FROM deb_packages
```

Compatible with: ✗ macOS ✗ Windows ✓ Linux

☐ **Observers can run**

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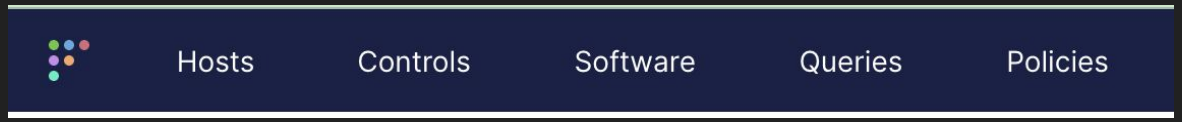
Osquery for Security: Software Packages

Host	osname	osversion	package
[redacted]	ubuntu	22.04	zstd 1.4.8+dfsg-3build1 amd64
[redacted]	ubuntu	22.04	zlib1g 1:1.2.11.dfsg-2ubuntu9.2 amd64
[redacted]	ubuntu	22.04	zabbix-agent2 1:6.2.9-1+ubuntu22.04 amd64
[redacted]	ubuntu	22.04	xz-utils 5.2.5-2ubuntu1 amd64
[redacted]	ubuntu	22.04	xxd 2:8.2.3995-1ubuntu2.12 amd64
[redacted]	ubuntu	22.04	xkb-data 2.33-1 all
[redacted]	ubuntu	22.04	xfsprogs 5.13.0-1ubuntu2 amd64
[redacted]	ubuntu	22.04	xdg-user-dirs 0.17-2ubuntu4 amd64
[redacted]	ubuntu	22.04	wireless-regdb 2022.06.06-0ubuntu1~22.04.1 all
[redacted]	ubuntu	22.04	whiptail 0.52.21-5ubuntu2 amd64
[redacted]	ubuntu	22.04	wget 1.21.2-2ubuntu1 amd64
[redacted]	ubuntu	22.04	vim-tiny 2:8.2.3995-1ubuntu2.12 amd64
[redacted]	ubuntu	22.04	vim-runtime 2:8.2.3995-1ubuntu2.12 all

https://vulners.com/

Concerns for the future of Fleetdm



- There is no Packs button in Fleetdm anymore
- This page is available only by direct link /packs/manage
- Fleetdm developers focus on paid version and “Teams” feature
- “Teams” feature can provide great experience for scope restriction
- But Fleetdm wants to use Teams as replacement for Packs and Labels
- Fleet will support Packs until the next major version release

https://osquery.slack.com/archives/C01DXJL16D8/p1683537869964549

Concerns for the future of Fleetdm

How to live further?

We still didn’t decide, but we can

- Try another osquery manager
- Fork specific Fleetdm version, support and develop it ourselves
- Just live with old version until it breaks
- Live without Packs and Label and query all hosts anytime
- Maybe something else

https://osquery.slack.com/archives/C01DXJL16D8/p1683537869964549

6. Conclusions

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What did we get as result?

- Get current remote machine state! => Different Osquery tables, can write new with extensions
- Identify security misconfigurations! => Augeas and other tables
- Do lightweight Threat Hunting! => Different Osquery tables
- Collect artifacts for investigations! => Carving table
- Make simple vulnerability checks! => Yara rules and packages gathering with Osquery (for checks with a third-party API)
- More security alerts for SOC team! => Different Osquery tables
- Save money! => Osquery is free, Fleetdm also has free core version

Thank you for the attention!

Q&A

OWASP Limassol

My LinkedIn