Less Spooky Containers with Top Security Best Practices

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Agenda

- Container Security Model
- Why: shifting left security
- Best practices
    - Build
    - Distribute
    - Deploy
    - Run

Container security model

Containers!

Image: kees torn - MAERSK MC KINNEY MÖLLER & MARSEILLE MAERSK

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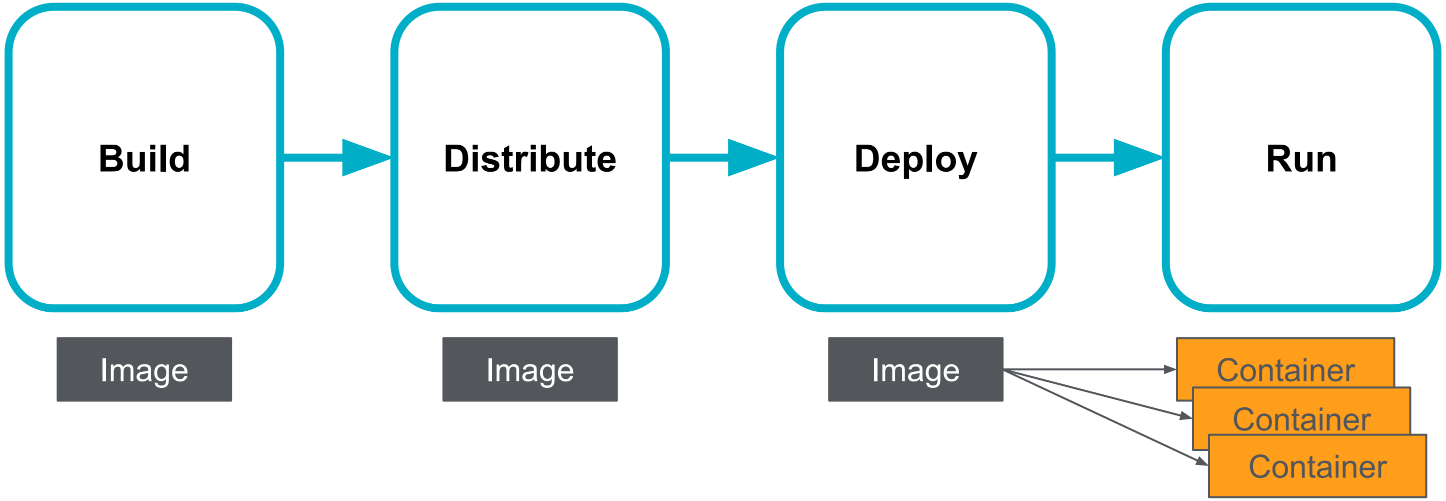
Also containers!

Images: Mr Snrub at the English-language Wikipedia ; Marc Cromme, Denmark

Container life stages



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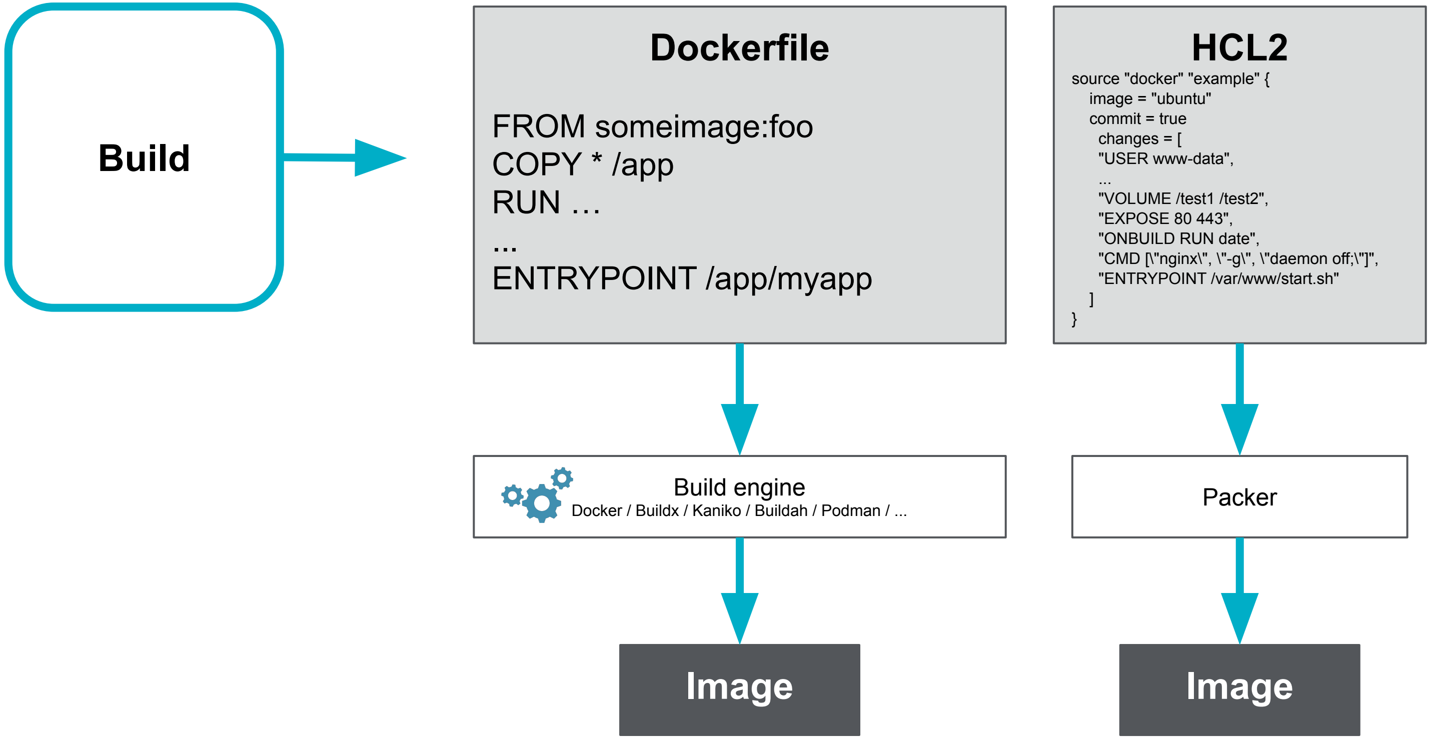
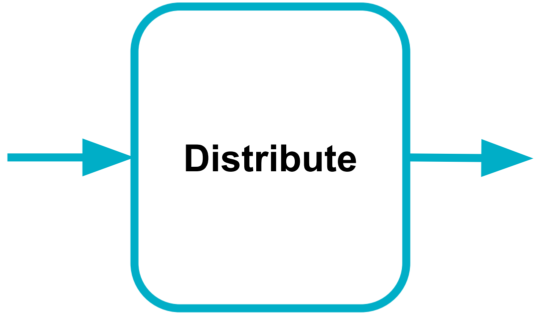
Building an image



```
FROM someimage:foo
COPY * /app
RUN …
...
ENTRYPOINT /app/myapp
```

```
source "docker" "example" {
    image = "ubuntu"
    commit = true
      changes = [
      "USER www-data",
      ...
      "VOLUME /test1 /test2",
      "EXPOSE 80 443",
      "ONBUILD RUN date",
      "CMD [\"nginx\", \"-g\", \"daemon off;\"]",
      "ENTRYPOINT /var/www/start.sh"
    ]
}
```

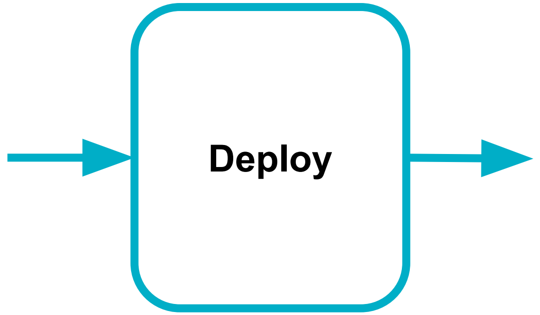
Distributing an image

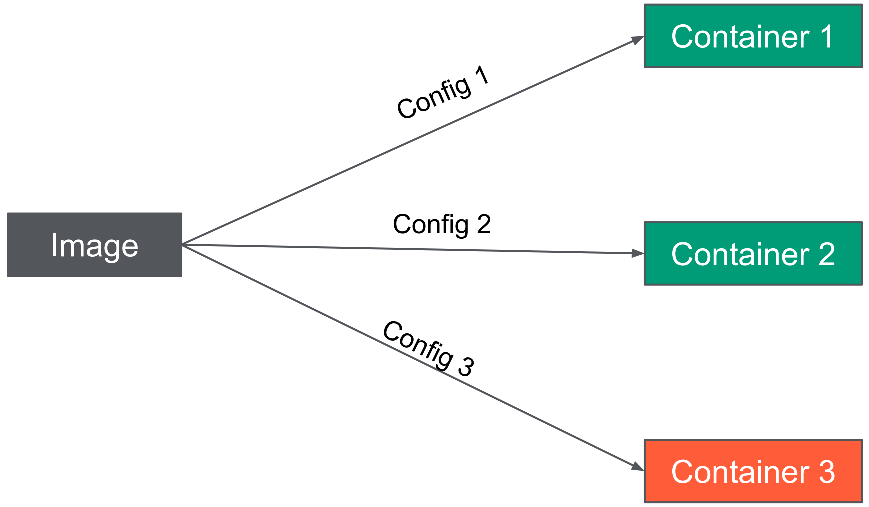


Image

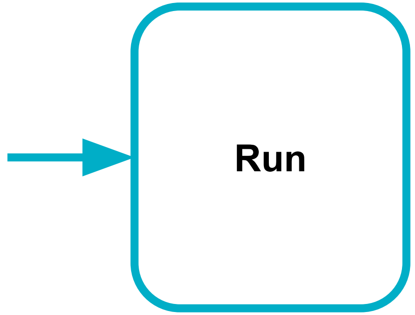
- Configuration
- Layer 1
- Layer 2
- …
- Layer N

Deploying a container





Running a container



Container

- Image root filesystem + chroot
  - Contains application(s) + dependencies
- Configuration:
  - Entrypoint and arguments
  - Environment variables
  - ...
- Isolation: namespaces (PID, IPC, MOUNTS, UTS, NET, …)
- Resource limits: CGroups
- Privilege limits: Seccomp, AppArmor, ...

Why: shifting left security

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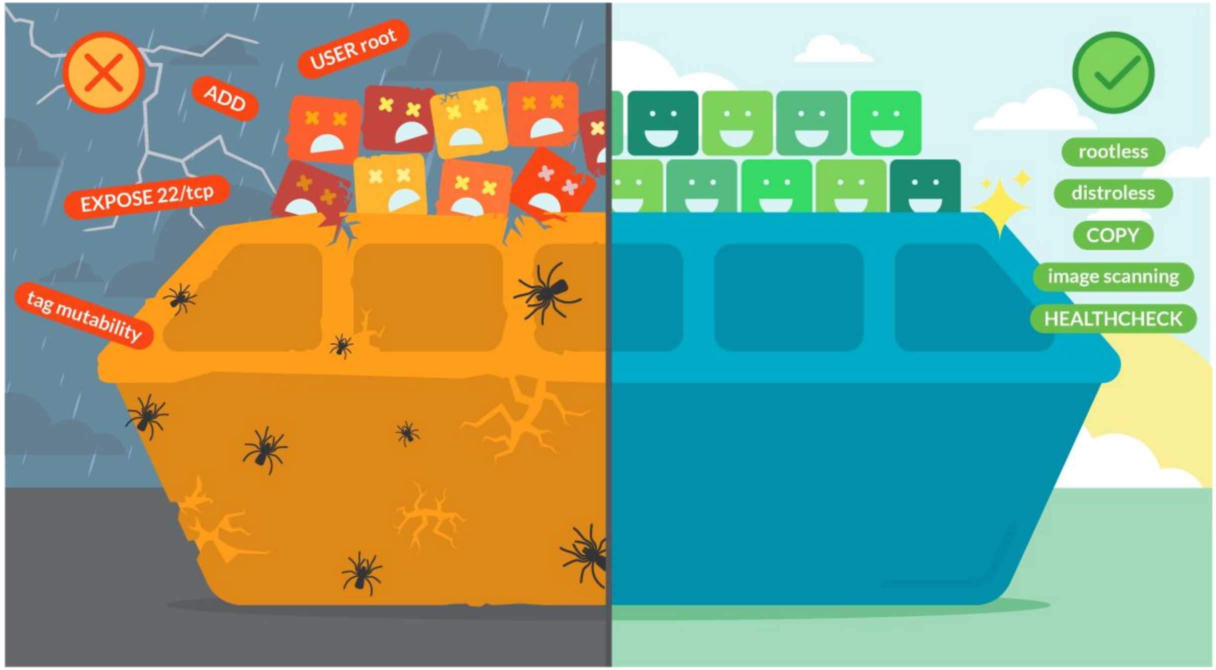
Why


USER root
ADD
EXPOSE 22/tcp
tag mutability
rootless
distroless
COPY
image scanning
HEALTHCHECK

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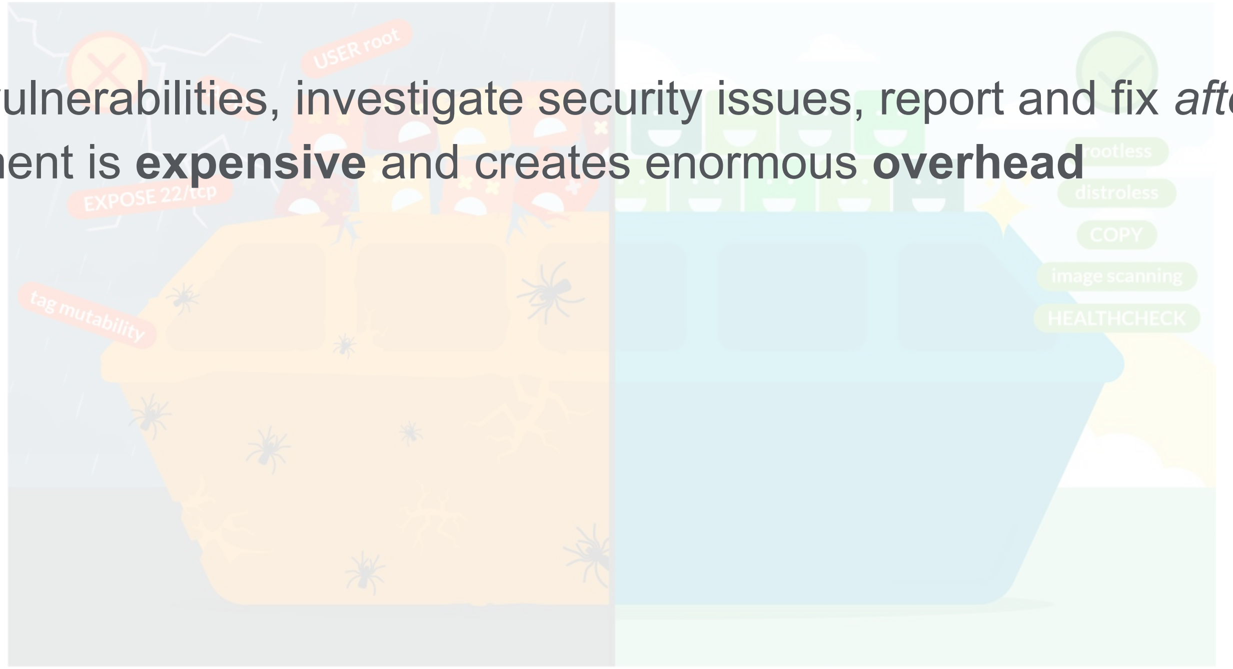
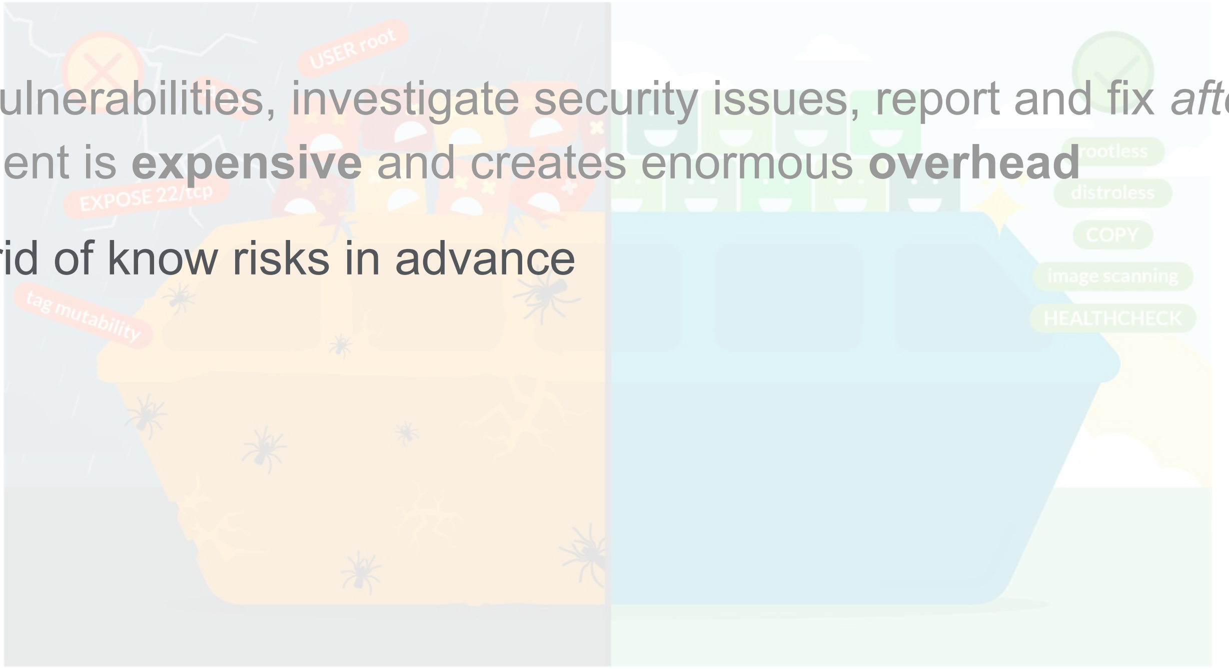
Why: shifting left security



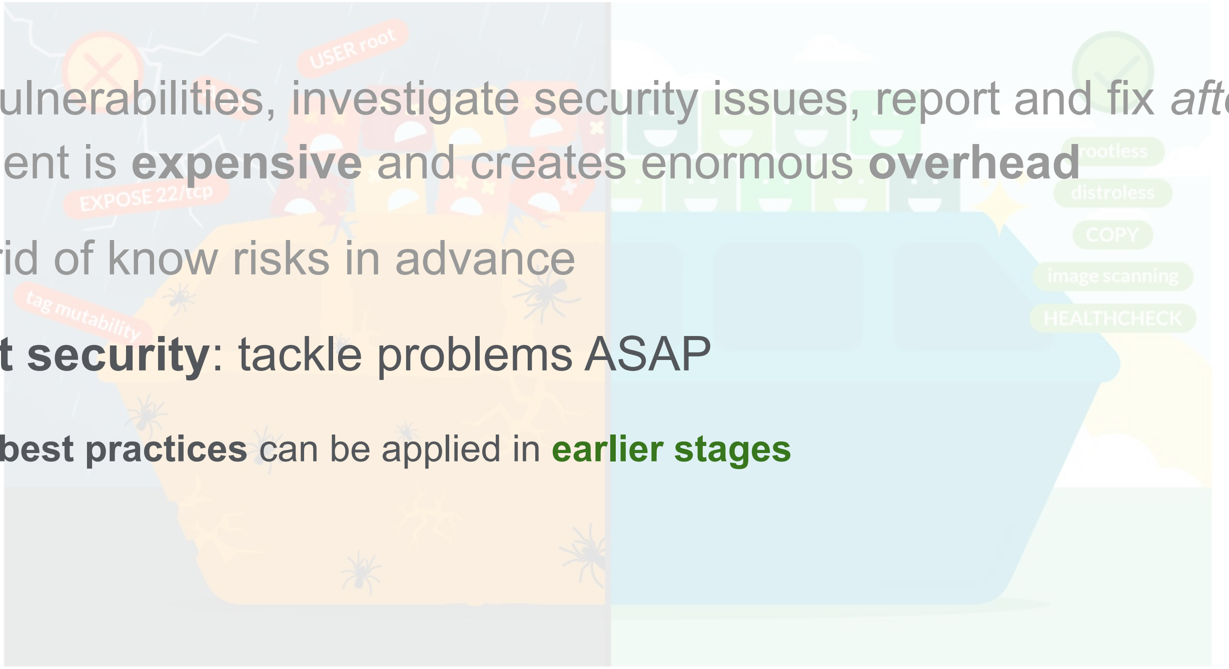
- Detect vulnerabilities, investigate security issues, report and fix *after* deployment is **expensive** and creates enormous **overhead**

Why: shifting left security



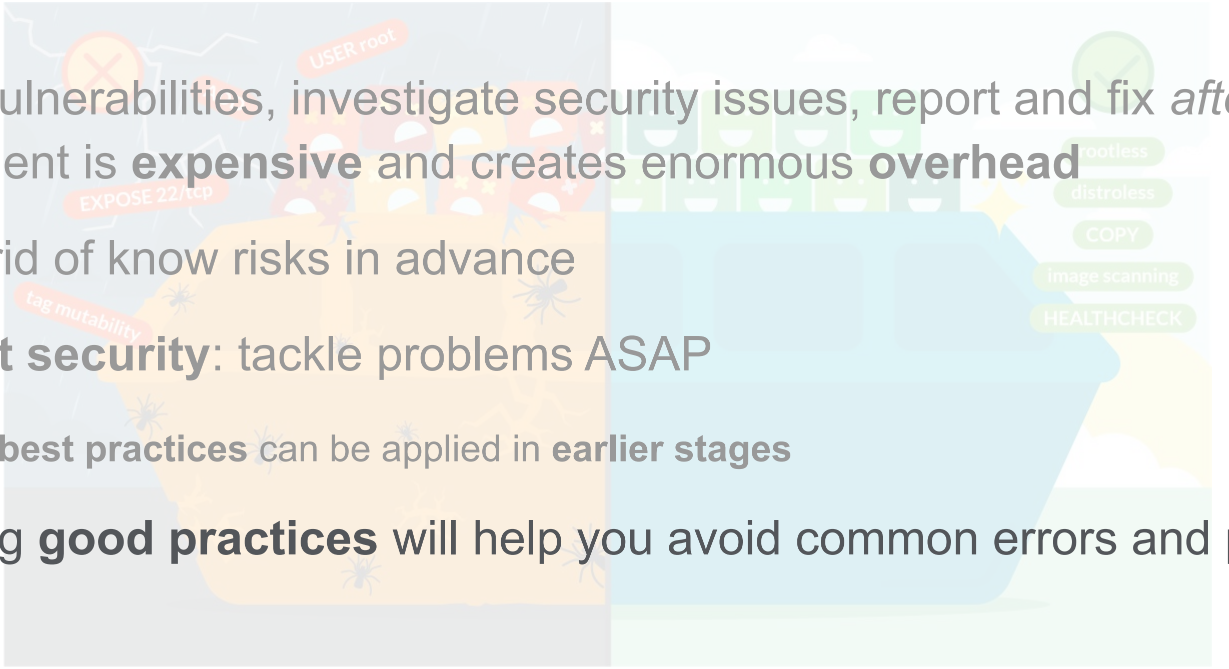
- Detect vulnerabilities, investigate security issues, report and fix *after* deployment is **expensive** and creates enormous **overhead**
- So, get rid of know risks in advance

Why: shifting left security



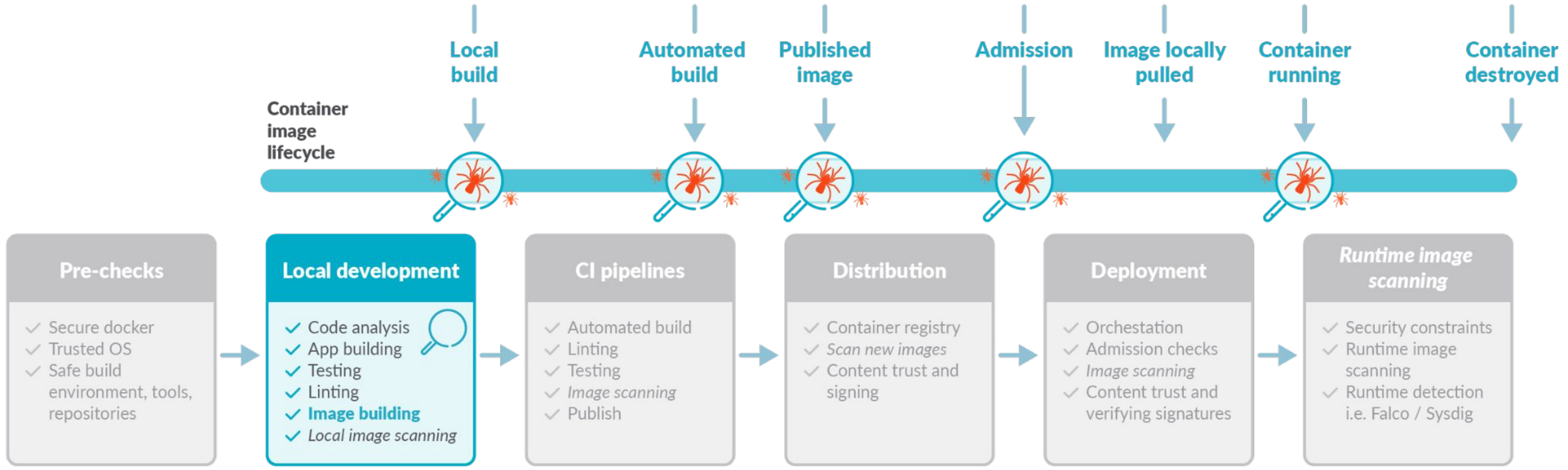
- Detect vulnerabilities, investigate security issues, report and fix *after* deployment is **expensive** and creates enormous **overhead**
- So, get rid of know risks in advance
- **Shift left security**: tackle problems ASAP
  - **Build best practices** can be applied in **earlier stages**

Why: shifting left security



- Detect vulnerabilities, investigate security issues, report and fix *after* deployment is **expensive** and creates enormous **overhead**
- So, get rid of know risks in advance
- **Shift left security**: tackle problems ASAP
  - **Build best practices** can be applied in **earlier stages**
- Following **good practices** will help you avoid common errors and pitfalls

Shifting left security

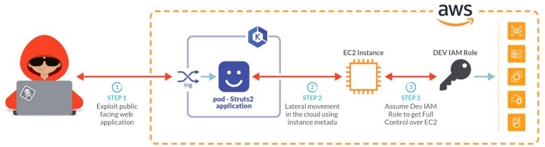


Best practices - build

Unnecessary privileges

- **Problem**: containers often *running* with more privileges than required
  - Our recent report highlighted that 58% of images are running the container entrypoint as root (UID 0)

- **Risks**:
  - Attackers can exploit vulnerabilities or bugs to gain access to other services or resources
  - https://sysdig.com/blog/lateral-movement-cloud-containers/
  - Openshift or others blocking root containers


aws
ing
pod - Struts2 application
EC2 Instance
DEV IAM Role
1 STEP 1 Exploit public facing web application
2 STEP 2 Lateral movement in the cloud using instance metada
3 STEP 3 Assume Dev IAM Role to get Full Control over EC2

Unnecessary privileges

- **Prevention**:
  - Follow the principle of **least privilege** so your service or application only has access to the resources and information necessary to perform its purpose
  - **USER directive**, run as non-root by default

Unnecessary privileges

- Step 1: Initial Dockerfile

```
FROM alpine
COPY ./src/example_app /example_app
ENTRYPOINT /example_app
```

```
> docker build -f Dockerfile1 -t test1_1 .
[+] Building 0.5s (7/7) FINISHED

> docker run --name test --rm -p 5000:5000 test1_1
Listening at :5000
```

Unnecessary privileges

- Testing the app

```
> curl "localhost:5000/?name=webinar"
Hi webinar!
> curl "localhost:5000/?name=alvaro"
Hi alvaro!
> docker exec -ti test sh
/ # ls -lh
-rw-r--r--    1 root     root         111 Apr  7 11:36 access.log
-rwxr-xr-x    1 root     root        5.9M Apr  7 11:27 example_app
...
/ # cat access.log
[2021-04-07T11:36:14Z] IP=172.17.0.1:60974 name=webinar
[2021-04-07T11:36:16Z] IP=172.17.0.1:60978 name=alvaro
/ # ps
PID   USER     TIME  COMMAND
    1 root      0:00 /example_app
```

Unnecessary privileges

- Step 2: running as non-root

```
FROM alpine
COPY ./src/example_app /app/example_app
WORKDIR /app
USER 1000
ENTRYPOINT /app/example_app
```

```
> docker build -f Dockerfile2 -t test1_2 .
[+] Building 0.5s (7/7) FINISHED
> docker run --name test --rm -p 5000:5000 test1_2
panic: open access.log: permission denied
```

Unnecessary privileges

- Step 3: fix permissions

```
FROM alpine
COPY ./src/example_app /app/example_app
WORKDIR /app
RUN chown 1000:1000 /app
USER 1000
ENTRYPOINT /app/example_app
```

```
> docker build -f Dockerfile3 -t test1_3 .
[+] Building 0.5s (7/7) FINISHED
> docker run --name test --rm -p 5000:5000 test1_3
Listening at :5000
```

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Unnecessary privileges

- Testing the **rootless** app

```
...
> docker exec -ti test sh
/app $ cat access.log
[2021-04-07T11:45:56Z] IP=172.17.0.1:60996 name=webinar
[2021-04-07T11:45:58Z] IP=172.17.0.1:61000 name=alvaro
/app $ ls -lh
total 6M
-rw-r--r--    1 1000     root           111 Apr  7 11:45 access.log
-rwxr-xr-x    1 root     root          5.9M Apr  7 11:27 example_app
/app $ ps
PID   USER     TIME  COMMAND
    1 1000      0:00 /app/example_app
```

Attack surface

- **Problem**: including unnecessary packages or exposing unused ports
- **Risks**:
  - Your system is more exposed to attacks
  - Using components not under your control
- **Prevention**:
  - Reduce attack surface
  - Protect and keep under control

Attack surface: reduce attack surface

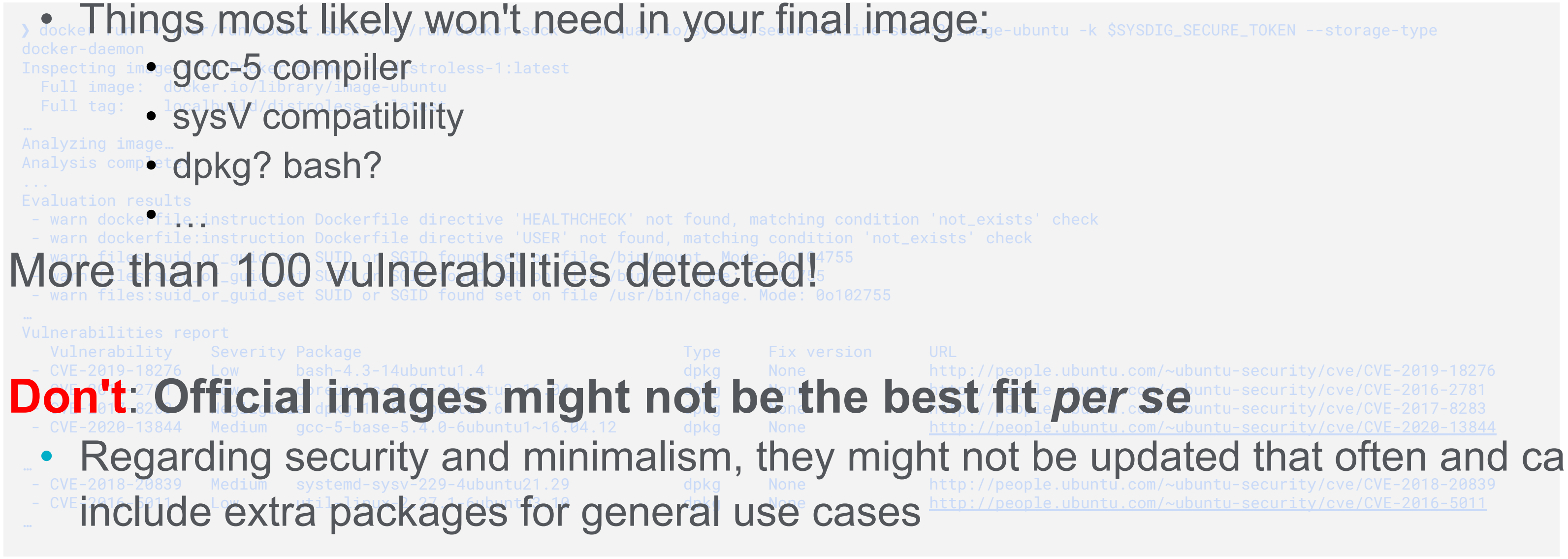
- **Don't**: Use big, generic distro images if not needed (i.e. ubuntu)

```
❯ docker run ... quay.io/sysdig/secure-inline-scan:2 image-ubuntu -k $SYSDIG_SECURE_TOKEN --storage-type docker-daemon
Inspecting image from Docker daemon -- distroless-1:latest
  Full image:  docker.io/library/image-ubuntu
  Full tag:    docker.io/library/image-ubuntu:latest
…
Analyzing image…
Analysis complete!
...
Evaluation results
 - warn dockerfile:instruction Dockerfile directive 'HEALTHCHECK' not found, matching condition 'not_exists' check
 - warn dockerfile:instruction Dockerfile directive 'USER' not found, matching condition 'not_exists' check
 - warn files:suid_or_guid_set SUID or SGID found set on file /bin/mount. Mode: 0o104755
 - warn files:suid_or_guid_set SUID or SGID found set on file /bin/su. Mode: 0o104755
 - warn files:suid_or_guid_set SUID or SGID found set on file /usr/bin/chage. Mode: 0o102755
…
Vulnerabilities report
   Vulnerability    Severity Package                           Type     Fix version      URL
 - CVE-2019-18276   Low      bash-4.3-14ubuntu1.4              dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2019-18276
 - CVE-2016-2781    Low      coreutils-8.25-2ubuntu3~16.04     dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2016-2781
 - CVE-2017-8283    Negligible dpkg-1.18.4ubuntu1.6            dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2017-8283
 - CVE-2020-13844   Medium   gcc-5-base-5.4.0-6ubuntu1~16.04.12 dpkg    None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2020-13844

…
 - CVE-2018-20839   Medium   systemd-sysv-229-4ubuntu21.29     dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2018-20839
 - CVE-2016-5011    Low      util-linux-2.27.1-6ubuntu3.10     dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2016-5011
…
```

Attack surface: reduce attack surface

- **Don't: Use big, generic distro images if not needed (i.e. ubuntu)**
  - Things most likely won't need in your final image:
    - gcc-5 compiler
    - sysV compatibility
    - dpkg? bash?
    - …
- More than 100 vulnerabilities detected!
- **Don't: Official images might not be the best fit *per se***
  - Regarding security and minimalism, they might not be updated that often and can include extra packages for general use cases



```
❯ docker run -v /var/run/docker.sock:/var/run/docker.sock --rm quay.io/sysdig/secure-inline-scan:2 image-ubuntu -k $SYSDIG_SECURE_TOKEN --storage-type
docker-daemon
Inspecting image from Docker daemon -- distroless-1:latest
  Full image:  docker.io/library/image-ubuntu
  Full tag:    localbuild/distroless-1:latest
…
Analyzing image…
Analysis complete!
...
Evaluation results
 - warn dockerfile:instruction Dockerfile directive 'HEALTHCHECK' not found, matching condition 'not_exists' check
 - warn dockerfile:instruction Dockerfile directive 'USER' not found, matching condition 'not_exists' check
 - warn files:suid_or_guid_set SUID or SGID found set on file /bin/mount. Mode: 0o104755
 - warn files:suid_or_guid_set SUID or SGID found set on file /bin/su. Mode: 0o104755
 - warn files:suid_or_guid_set SUID or SGID found set on file /usr/bin/chage. Mode: 0o102755
…
Vulnerabilities report
   Vulnerability    Severity Package                                  Type     Fix version      URL
 - CVE-2019-18276   Low      bash-4.3-14ubuntu1.4                     dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2019-18276
 - CVE-2016-2781    Low      coreutils-8.25-2ubuntu3~16.04            dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2016-2781
 - CVE-2017-8283    Negligible dpkg-1.18.4ubuntu1.6                   dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2017-8283
 - CVE-2020-13844   Medium   gcc-5-base-5.4.0-6ubuntu1~16.04.12       dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2020-13844
…
 - CVE-2018-20839   Medium   systemd-sysv-229-4ubuntu21.29            dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2018-20839
 - CVE-2016-5011    Low      util-linux-2.27.1-6ubuntu3.10            dpkg     None             http://people.ubuntu.com/~ubuntu-security/cve/CVE-2016-5011
…
```

Attack surface: reduce attack surface

- **Be minimal** in your base base
  - *alpine* versions
  - FROM scratch
  - Distroless (https://github.com/GoogleContainerTools/distroless):
    - i.e.: `FROM gcr.io/distroless/base-debian10`
      - Basic set of packages, including just required libraries like *glibc*, *libssl*, and *openssl*.
    - Slimmer: `FROM gcr.io/distroless/static-debian10`
      - For statically compiled applications like Go that don't require libc

Attack surface: reduce attack surface

- Check for **optimized** vs generic versions
  - Example: bitnami/node vs official node image
    - customized versions on top of a minideb distribution
    - frequently updated with the latest bug fixes
    - signed with Docker Content Trust
    - pass a security scan for tracking known vulnerabilities

Attack surface: build, size & reproducibility

- **Don't**:
  - **Build the application externally, copy into the container**
  - Bad reproducibility

```
FROM alpine
COPY ./src/example_app /example_app
USER 1000
WORKDIR /tmp
ENTRYPOINT /example_app
```

Attack surface: build, size & reproducibility

- **Don't**:
  - **Build directly inside the final container**
    - Big image size and multiple layers, build toolchain included in the container, other unrequired packages, remainings of the application source code, ...

```
FROM alpine
RUN apk add go
COPY ./src/ /src
WORKDIR /src
RUN go build .
ENTRYPOINT /src/example_app
```

Attack surface: build, size & reproducibility

- **Multistage builds**:

```
#This is the "builder" stage
FROM golang:1.16 as builder
WORKDIR /my-go-app
COPY src .
RUN GOOS=linux GOARCH=amd64 go build .

#This is the final stage, and we copy artifacts from "builder"
FROM alpine
COPY --from=builder /my-go-app/example_app /bin/example_app
ENTRYPOINT ["/bin/example_app"]
```

Attack surface: build, size & reproducibility

- **Multistage builds**:
  - Reproducible builds, always same build environment
  - Minimal image size, no build tools or undesired packages

```
> docker images
test2_1                                                     latest        681b9e590ae9   5 minutes ago    448MB
test2_2                                                     latest        37d02efde1e4   35 seconds ago   7.55MB
...
```

Attack surface: build, size & reproducibility

- **Example: multistage build with nodejs and typescript** (https://github.com/kevinpollet/typescript-docker-multi-stage-build):

```
FROM node:14-alpine AS builder
WORKDIR /usr/src/app
COPY typescript-docker-multi-stage-build/package*.json ./
RUN npm ci
COPY typescript-docker-multi-stage-build/tsconfig*.json ./
COPY typescript-docker-multi-stage-build/src src
RUN npm run build

FROM node:14-alpine
ENV NODE_ENV=production
WORKDIR /usr/src/app
RUN chown node:node .
USER node
COPY typescript-docker-multi-stage-build/package*.json ./
RUN npm install
COPY --from=builder /usr/src/app/lib/ lib/
EXPOSE 3000
ENTRYPOINT [ "node", "lib/server.js" ]
```

Attack surface: trusted sources

- **Don't: Use docker.io/johndoehacker/mycustom-node-image:latest**

```
FROM docker.io/johndoehacker/mycustom-node-image:latest
...
```

  - Inherit all of the problems and vulnerabilities from that image
  - Who builds and publishes that image?
  - Is it updated regularly?
  - How is it built?
  - Are we sure the published version is really from the public Dockerfile?

Attack surface: trusted sources

- Prefer **verified** and **official** images from **trusted repositories and providers**
  - A common choice: Redhat UBI (Universal Base Images)
  - Enterprise support, upgrades or certifications vs minimalism
- When using custom images, check for the **image source** and the Dockerfile, and **build your own base image**

Credentials & Confidentiality

- **Problem**: leaking credentials or confidential information in your images
- **Risks**:
  - Attackers can use leaked credentials to access your systems
  - Exposal of confidential or sensitive information
- **Prevention**:
  - Don't include sensitive data in the image, use external stores
  - Good practices to avoid data leaks

Credentials & Confidentiality: sensitive data

- **Don't**:
  - Include hard coded credentials
  - Add credentials file or environment variables

```
FROM alpine
...
ENV SECURE_API_TOKEN=ajhda8-12312-29889234-foo
COPY aws_credentials /home/app/.aws/credentials
...
ENTRYPOINT /example_app
```

Credentials & Confidentiality: sensitive data

```
> docker inspect test3_1
[
    {
        "Id": "sha256:18440a2433ea49efa686febc6f02c21a652a498523ed42e00cf79ebf3717cc0a",
        "RepoTags": [
            "test3_1:latest"
        ],
        "RepoDigests": [],
        "Parent": "",
        "Comment": "buildkit.dockerfile.v0",
        "Created": "2021-04-07T17:01:00.8254965Z",
        "Container": "",
        "ContainerConfig": {
        ...
        },
        "DockerVersion": "",
        "Author": "",
        "Config": {
           ...
            "Env": [
                "PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin",
                "SECURE_API_TOKEN=ajhda8-12312-29889234-foo"
```

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Credentials & Confidentiality: sensitive data

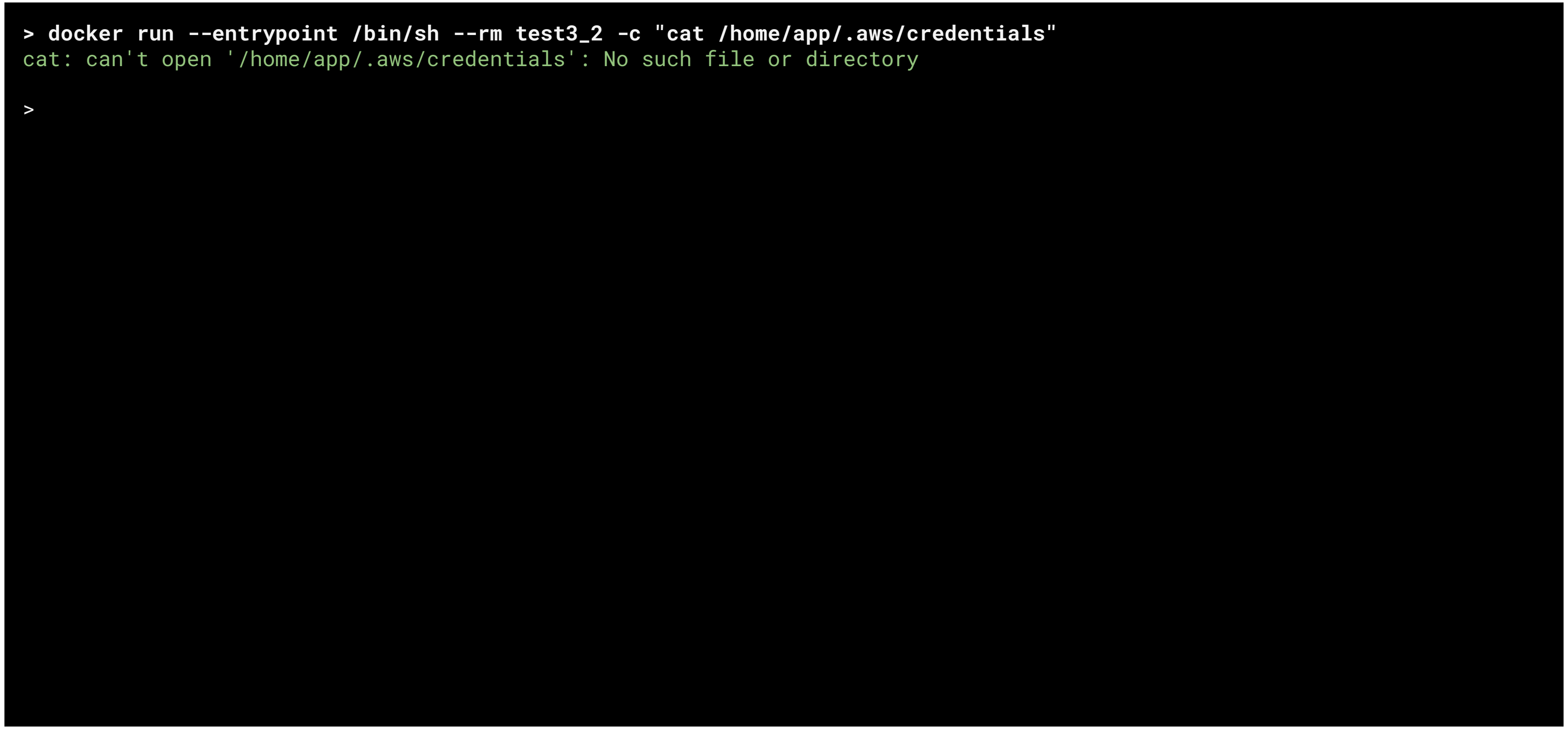
```
> docker run --entrypoint /bin/sh --rm test3_1 -c "cat /home/app/.aws/credentials"
[default]
aws_access_key_id = SOME-ACCESS-KEY
aws_secret_access_key = SOME-SECRET-KEY
```

Credentials & Confidentiality: layers

- **Even if the file is removed!! - Don't** forget the **layered** nature of images (each command creates a new layer)
  - Removing a file in a layer layer still takes space and file can be accessed

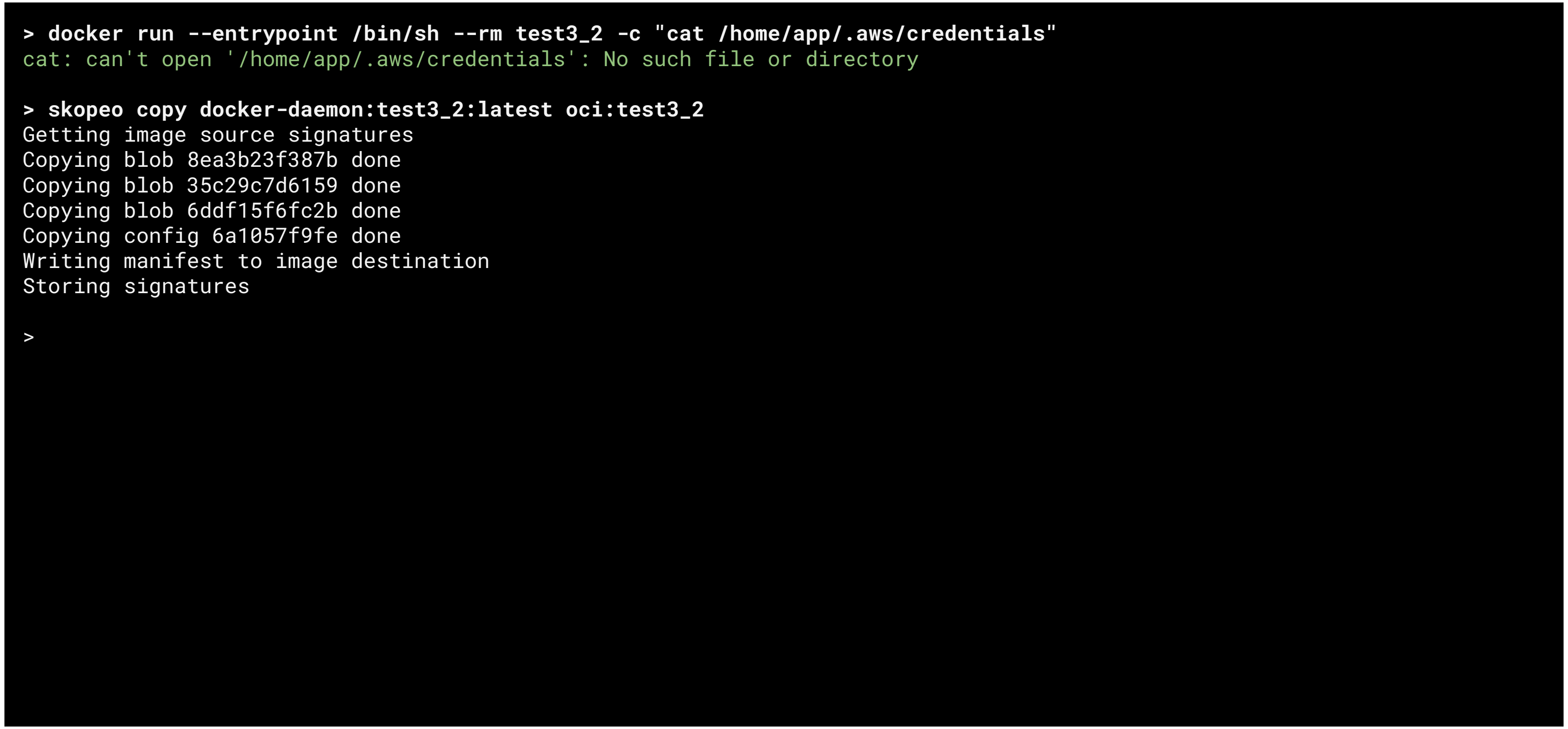
```
FROM alpine
...
COPY aws_credentials /home/app/.aws/credentials
…
RUN rm /home/app/.aws/credentials
ENTRYPOINT /example_app
```

Credentials & Confidentiality: layers



```
> docker run --entrypoint /bin/sh --rm test3_2 -c "cat /home/app/.aws/credentials"
cat: can't open '/home/app/.aws/credentials': No such file or directory

>
```

Credentials & Confidentiality: layers



```
> docker run --entrypoint /bin/sh --rm test3_2 -c "cat /home/app/.aws/credentials"
cat: can't open '/home/app/.aws/credentials': No such file or directory

> skopeo copy docker-daemon:test3_2:latest oci:test3_2
Getting image source signatures
Copying blob 8ea3b23f387b done
Copying blob 35c29c7d6159 done
Copying blob 6ddf15f6fc2b done
Copying config 6a1057f9fe done
Writing manifest to image destination
Storing signatures

>
```

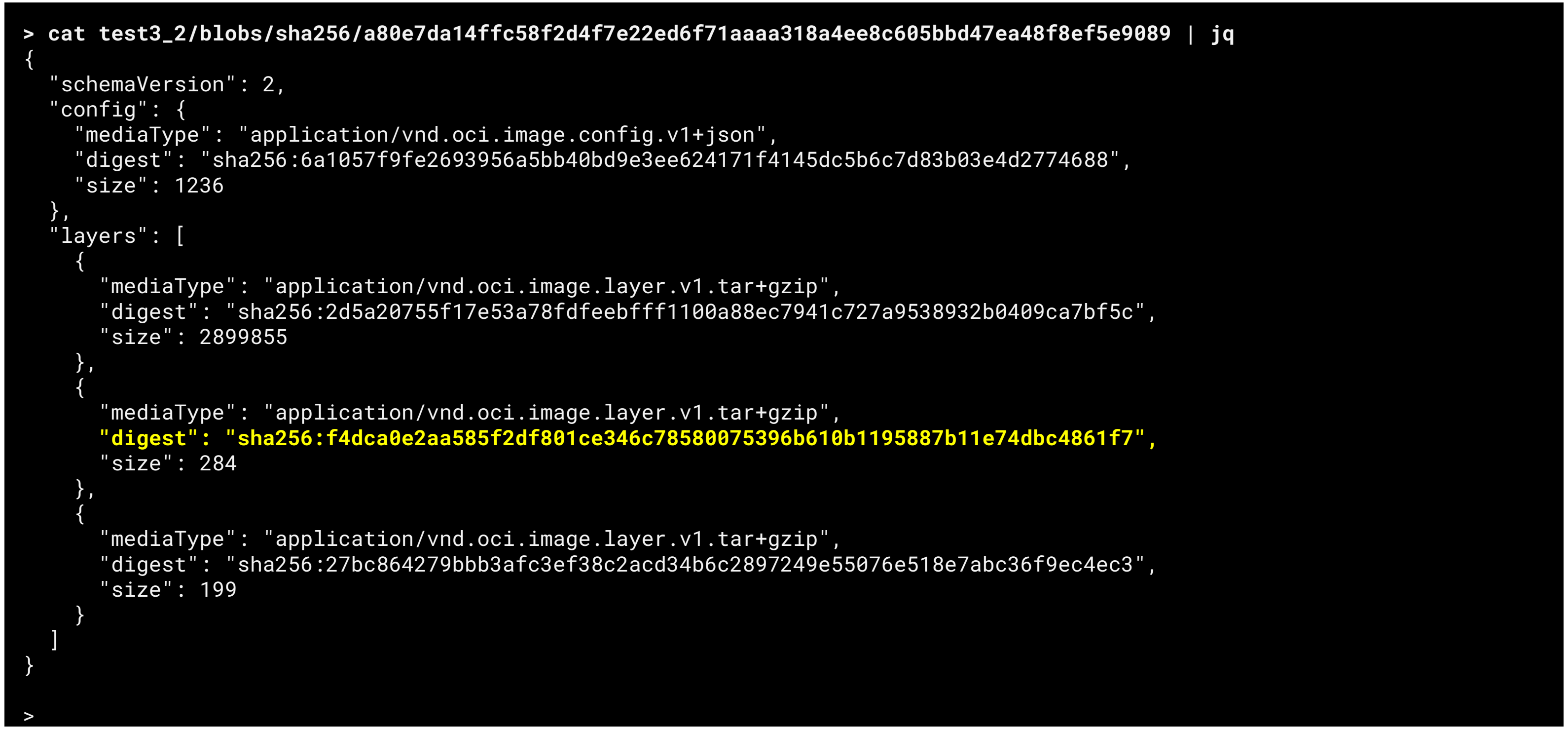
Credentials & Confidentiality: layers

```
> docker run --entrypoint /bin/sh --rm test3_2 -c "cat /home/app/.aws/credentials"
cat: can't open '/home/app/.aws/credentials': No such file or directory

> skopeo copy docker-daemon:test3_2:latest oci:test3_2
Getting image source signatures
Copying blob 8ea3b23f387b done
Copying blob 35c29c7d6159 done
Copying blob 6ddf15f6fc2b done
Copying config 6a1057f9fe done
Writing manifest to image destination
Storing signatures

> cat test3_2/index.json
{"schemaVersion":2,"manifests":[{"mediaType":"application/vnd.oci.image.manifest.v1+json","digest":"sha256:a80e7da14ffc5
8f2d4f7e22ed6f71aaaa318a4ee8c605bbd47ea48f8ef5e9089","size":657}]}
```

Credentials & Confidentiality: layers

```
> docker run --entrypoint /bin/sh --rm test3_2 -c "cat /home/app/.aws/credentials"
cat: can't open '/home/app/.aws/credentials': No such file or directory

> skopeo copy docker-daemon:test3_2:latest oci:test3_2
Getting image source signatures
Copying blob 8ea3b23f387b done
Copying blob 35c29c7d6159 done
Copying blob 6ddf15f6fc2b done
Copying config 6a1057f9fe done
Writing manifest to image destination
Storing signatures

> cat test3_2/index.json
{"schemaVersion":2,"manifests":[{"mediaType":"application/vnd.oci.image.manifest.v1+json","digest":"sha256:a80e7da14ffc5
8f2d4f7e22ed6f71aaaa318a4ee8c605bbd47ea48f8ef5e9089","size":657}]}

> cat test3_2/blobs/sha256/a80e7da14ffc58f2d4f7e22ed6f71aaaa318a4ee8c605bbd47ea48f8ef5e9089 | jq
{
  "schemaVersion": 2,
  "config": {
    "mediaType": "application/vnd.oci.image.config.v1+json",
    "digest": "sha256:6a1057f9fe2693956a5bb40bd9e3ee624171f4145dc5b6c7d83b03e4d2774688",
    "size": 1236
  },
  "layers": [
    {
      "mediaType": "application/vnd.oci.image.layer.v1.tar+gzip",
      "digest": "sha256:2d5a20755f17e53a78fdfeebfff1100a88ec7941c727a9538932b0409ca7bf5c",
      "size": 2899855
    },
    {
      "mediaType": "application/vnd.oci.image.layer.v1.tar+gzip",
      "digest": "sha256:f4dca0e2aa585f2df801ce346c78580075396b610b1195887b11e74dbc4861f7",
```

Credentials & Confidentiality: layers

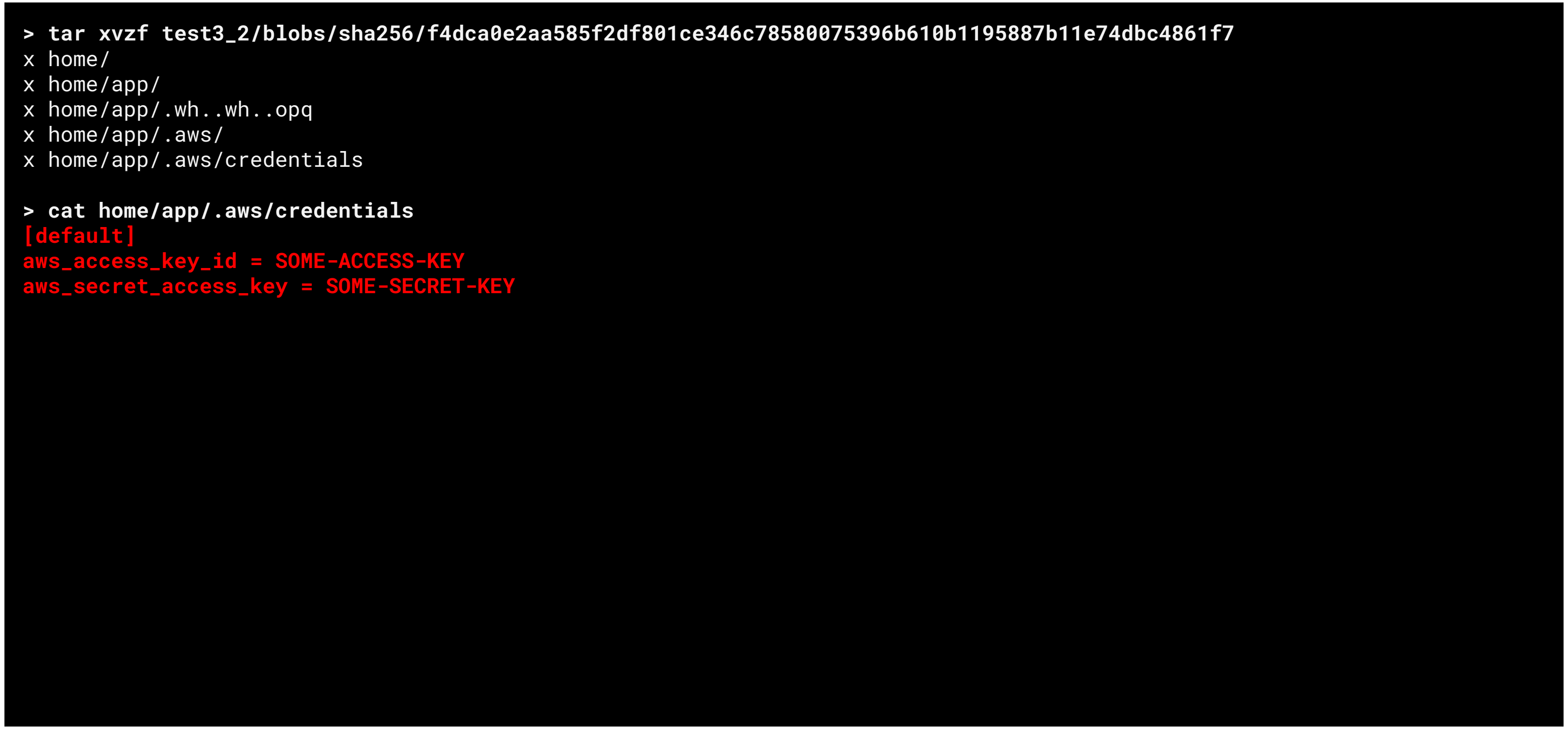


```
> cat test3_2/blobs/sha256/a80e7da14ffc58f2d4f7e22ed6f71aaaa318a4ee8c605bbd47ea48f8ef5e9089 | jq
{
  "schemaVersion": 2,
  "config": {
    "mediaType": "application/vnd.oci.image.config.v1+json",
    "digest": "sha256:6a1057f9fe2693956a5bb40bd9e3ee624171f4145dc5b6c7d83b03e4d2774688",
    "size": 1236
  },
  "layers": [
    {
      "mediaType": "application/vnd.oci.image.layer.v1.tar+gzip",
      "digest": "sha256:2d5a20755f17e53a78fdfeebfff1100a88ec7941c727a9538932b0409ca7bf5c",
      "size": 2899855
    },
    {
      "mediaType": "application/vnd.oci.image.layer.v1.tar+gzip",
      "digest": "sha256:f4dca0e2aa585f2df801ce346c78580075396b610b1195887b11e74dbc4861f7",
      "size": 284
    },
    {
      "mediaType": "application/vnd.oci.image.layer.v1.tar+gzip",
      "digest": "sha256:27bc864279bbb3afc3ef38c2acd34b6c2897249e55076e518e7abc36f9ec4ec3",
      "size": 199
    }
  ]
}

>
```

Credentials & Confidentiality: layers

```
> tar xvzf test3_2/blobs/sha256/f4dca0e2aa585f2df801ce346c78580075396b610b1195887b11e74dbc4861f7
x home/
x home/app/
x home/app/.wh..wh..opq
x home/app/.aws/
x home/app/.aws/credentials

>
```

Credentials & Confidentiality: layers



```
> tar xvzf test3_2/blobs/sha256/f4dca0e2aa585f2df801ce346c78580075396b610b1195887b11e74dbc4861f7
x home/
x home/app/
x home/app/.wh..wh..opq
x home/app/.aws/
x home/app/.aws/credentials

> cat home/app/.aws/credentials
[default]
aws_access_key_id = SOME-ACCESS-KEY
aws_secret_access_key = SOME-SECRET-KEY
```

Credentials & Confidentiality: leaks

- **Don't**: Leak files from the build context

```
docker build -t myimage .
```

  - The "." parameter is the build context
  - All the files in the build context are sent to the docker daemon
    - You can copy confidential or unnecessary files into the container, like configuration files, credentials, backups, lock files, temporary files, sources, subfolders, dotfiles, etc.
  - COPY and ADD commands work from the build context

Credentials & Confidentiality: leaks

- **Example**

```
docker build -f Dockerfile -t myimage .
```

```
...
COPY . /my-app
```

This would copy everything inside the build context, which for the "." example, includes the Dockerfile itself.

Credentials & Confidentiality: leaks

Good practices:

- Use a **clean build context**

```
docker build -f Dockerfile -t myimage files/
```

- Use **.dockerignore** file
- Prefer **COPY over ADD**, and **avoid wildcards**
  - COPY is more explicit, more predictable and less error prone
  - ADD can add files from a URL or from a .tar file

sysdig

Linting

- Tools like Haskell Dockerfile Linter (hadolint) can detect bad practices in your Dockerfile, and even expose issues inside the shell commands executed by the RUN instruction.

- Image scanners (like Sysdig's) are also capable of detecting bad practices via customizable rules

- **Automate**: Consider incorporating such a tool in your CI pipelines.

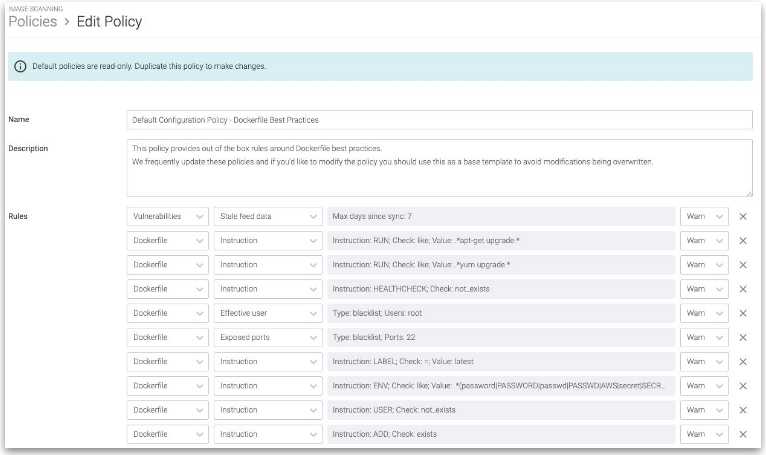


IMAGE SCANNING
Policies › Edit Policy

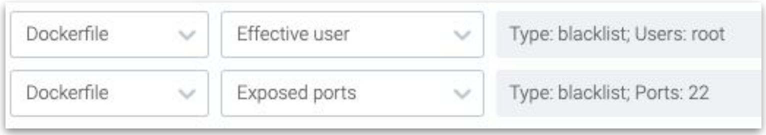
Default policies are read-only. Duplicate this policy to make changes.

Name: Default Configuration Policy - Dockerfile Best Practices

Description: This policy provides out of the box rules around Dockerfile best practices.
We frequently update these policies and if you'd like to modify the policy you should use this as a base template to avoid modifications being overwritten.

Rules

Vulnerabilities	Stale feed data	Max days since sync: 7	Warn
Dockerfile	Instruction	Instruction: RUN; Check: like; Value: .*apt-get upgrade.*	Warn
Dockerfile	Instruction	Instruction: RUN; Check: like; Value: .*yum upgrade.*	Warn
Dockerfile	Instruction	Instruction: HEALTHCHECK; Check: not_exists	Warn
Dockerfile	Effective user	Type: blacklist; Users: root	Warn
Dockerfile	Exposed ports	Type: blacklist; Ports: 22	Warn
Dockerfile	Instruction	Instruction: LABEL; Check: =; Value: latest	Warn
Dockerfile	Instruction	Instruction: ENV; Check: like; Value: .*(password|PASSWORD|passwd|PASSWD|AWS|secret|SECR...	Warn
Dockerfile	Instruction	Instruction: USER; Check: not_exists	Warn
Dockerfile	Instruction	Instruction: ADD; Check: exists	Warn



Dockerfile	Effective user	Type: blacklist; Users: root
Dockerfile	Exposed ports	Type: blacklist; Ports: 22

Image Scanning

- **Image scanning** can be implemented at different stages
  - Detect bad practices and known vulnerabilities
  - The earlier the scan is performed, the better

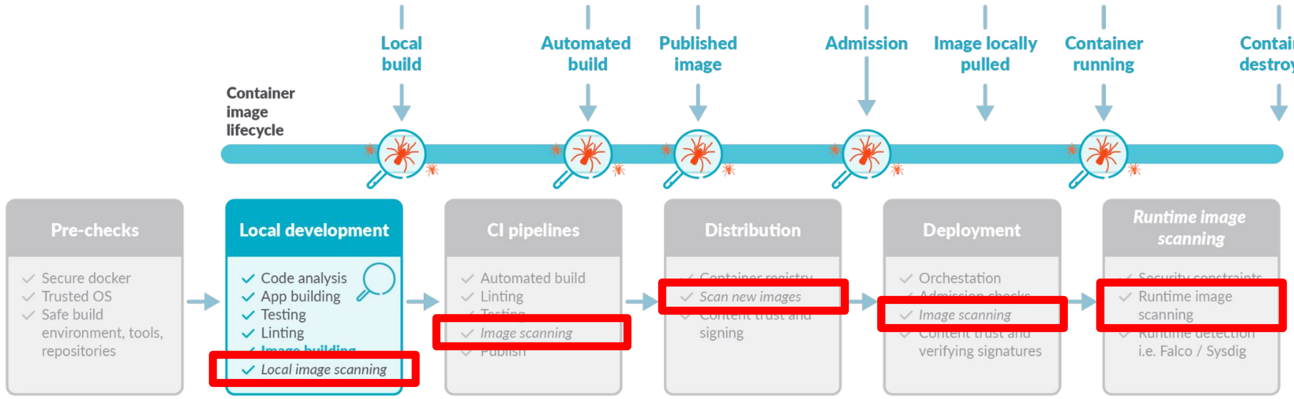
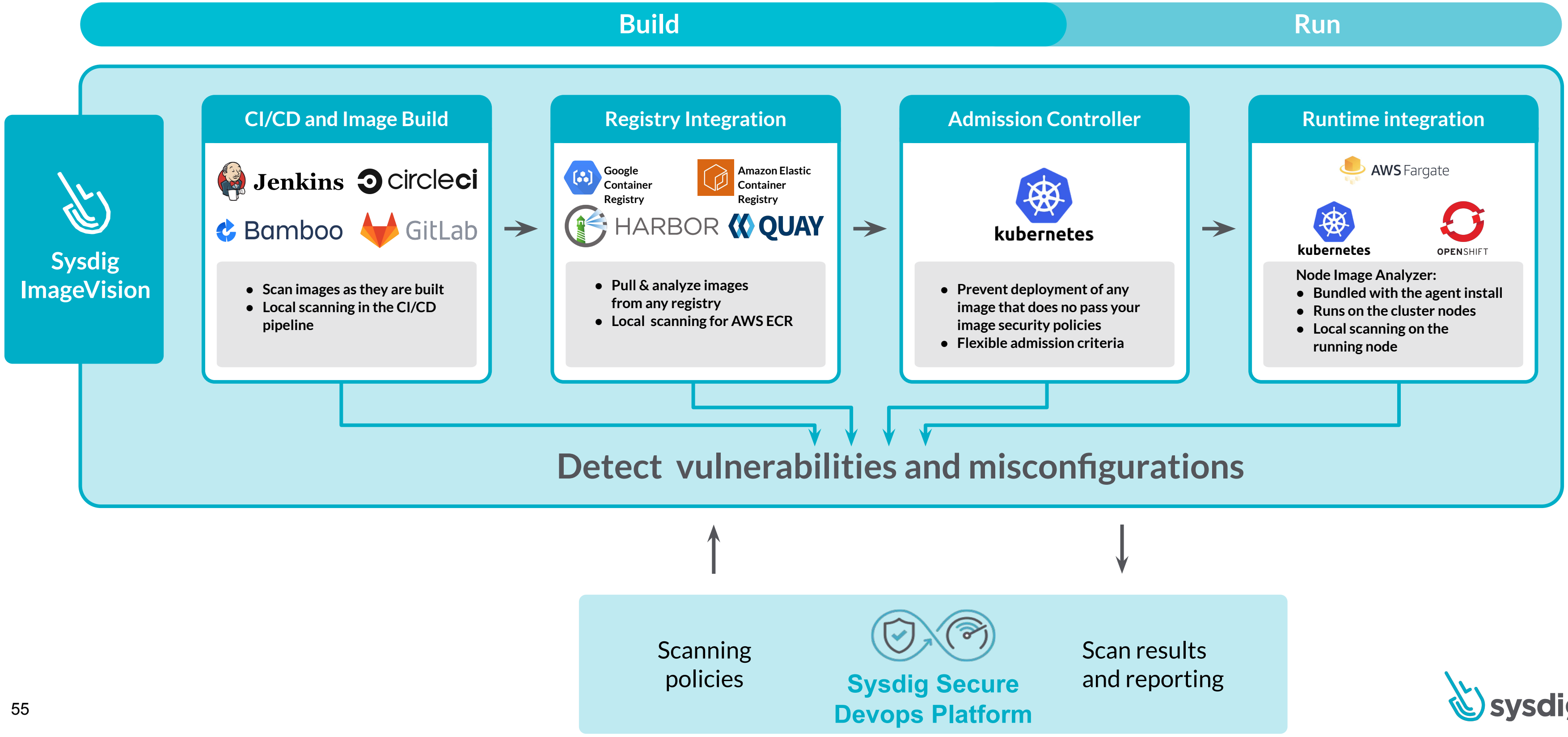


Image Scanning



CI/CD and Image Build
- Scan images as they are built
- Local scanning in the CI/CD pipeline

Registry Integration
- Pull & analyze images from any registry
- Local scanning for AWS ECR

Admission Controller
- Prevent deployment of any image that does no pass your image security policies
- Flexible admission criteria

Runtime integration

Node Image Analyzer:
- Bundled with the agent install
- Runs on the cluster nodes
- Local scanning on the running node

Best practices - distribute

sysdig

Image distribution

- **Problems**:
  - Images pushed to the registry from untrusted sources
  - Images bypassing security scans or best practices at build
  - Images replaced or tampered
- **Risks**:
  - Unsecure images deployed and running in your environment

Image distribution: protect registry

- Protect registry access
  - Proper credentials and permissions
  - Internal registry (don't expose to the Internet)

- Protect communications
  - HTTPS / TLS
  - Valid certificates

Image distribution: enforce good practices

- Image scanning when a new image is **pushed** to the registry
  - Report vulnerabilities and bad practices
  - Integrated image scanning (i.e. Harbor, ECR, …)
  - Connect with external tools (Sysdig)
- Harbor and others can block vulnerable images - no pull allowed
- Full registry scan: security posture

Image distribution: protect content

- Use tools to ensure images are not tampered via digital signatures:
  - Docker content trust + Docker notary or Harbor notary
  - Sigstore + cosign - https://www.sigstore.dev/

- Verify image signatures at deployment time
  - i.e. Connaisseur admission controller in Kubernetes
  - Trust configuration for podman, cri-o, etc:

    /etc/containers/policy.json

Best practices - deploy

sysdig

Unnecessary privileges: UID

- Remember **unnecessary privileges**?
  - The **orchestrator** or **runtime** environment (i.e., docker run, kubernetes, etc.) has the last word on who is the running container effective user.
- **Prevention**
  - Avoid **running your containers as root**. Allow running as **any UID**
    - Openshift and some Kubernetes clusters will apply **restrictive policies by default**, **preventing root** containers from running or using a **random UID**
    - Simplifies permissions with host mounts: match container and host UIDs

Unnecessary privileges: UID

- Try to un as UID "1001" instead of the default "1000"

```
> docker run -u 1001 --name test --rm -p 5000:5000 test1_3
panic: open access.log: permission denied
```

```
FROM alpine
COPY ./src/example_app /app/example_app
USER 1000
WORKDIR /tmp
ENTRYPOINT /app/example_app
```

```
> docker run -u 1001 --name test --rm -p 5000:5000 test1_4
Listening at :5000
```

sysdig

Unnecessary privileges: UID

- Verifying the container is running with UID 1001

```
...
> docker exec -ti test sh
/tmp $ ls -lh
total 4K
-rw-r--r--    1 1001     root         111 Apr  7 11:53 access.log
/tmp $ ps
PID   USER     TIME  COMMAND
    1 1001      0:00 /app/example_app
/tmp $ ls -lh /app
total 5.9M
-rwxr-xr-x    1 root     root        5.9M Apr  7 11:27 example_app
```

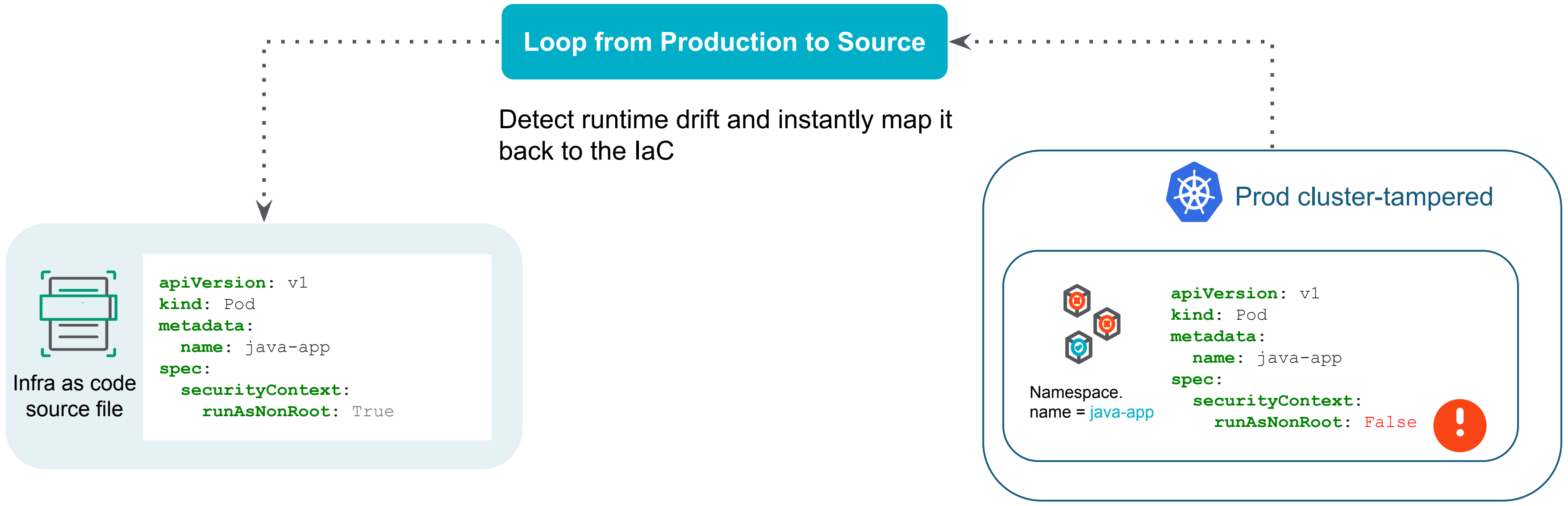
Unnecessary privileges: perms. & capab.

- **Restrict application permissions and capabilities** on runtime
  - In case your container is compromised, the range of action available to an attacker is limited
  - --cap-drop flag in Docker
  - securityContext.capabilities.drop in Kubernetes
  - AppArmor in Docker or Kubernetes
  - Seccomp in Docker or Kubernetes.

Unnecessary privileges: kubernetes

```
apiVersion: v1
kind: Pod
...
metadata:
  ...
  annotations:
    container.apparmor.security.beta.kubernetes.io/hello: localhost/k8s-apparmor-example-deny-write

spec:
  securityContext:
    runAsUser: 1001
    runAsGroup: 1001
    fsGroup: 2000
  ...
  containers:
  - name: foo
    image: my-nice-app:2.0.3
    ...
    securityContext:
      runAsUser: 1002
      capabilities:
        drop:
         - all
        add: ["SYS_TIME"]
      seccompProfile:
        type: Localhost
        localhostProfile: my-profiles/profile-allow.json
```

Unnecessary privileges: IaC



Detect runtime drift and instantly map it back to the IaC

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: java-app
spec:
  securityContext:
    runAsNonRoot: True
```

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: java-app
spec:
  securityContext:
    runAsNonRoot: False
```

https://apolicy.io/

Unnecessary privileges: rootless containers

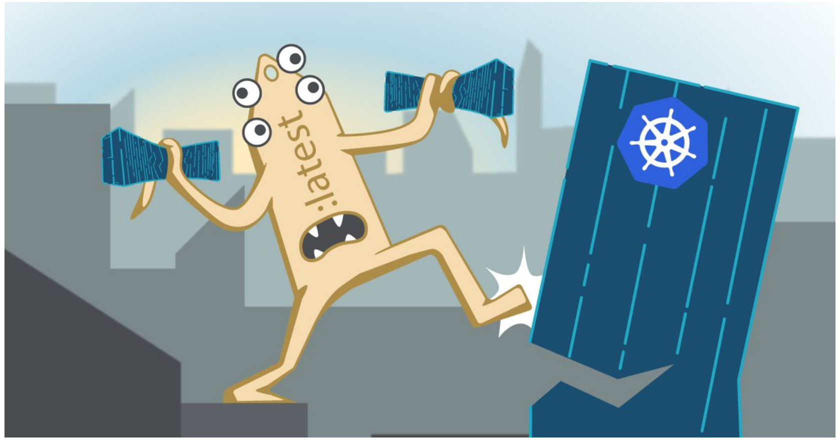
https://rootlesscontaine.rs/

- **Container runtime** (i.e. Docker daemon) with non-root user
  - Run inside a new user namespace
    - UID 0 *inside* the container is standard user *outside* the container
    - UID / GID mapping (via /etc/subuid and /etc/subgid)
  - Docker - https://docs.docker.com/engine/security/rootless/
  - Podman - https://github.com/containers/podman#rootless
  - Kubernetes - https://kubernetes.io/docs/tasks/administer-cluster/kubelet-in-userns/
  - Some shortcomings - due to limited privileges

sysdig

Mutant tags

- **Beware!** *Attack of the mutant tags*



https://sysdig.com/blog/toctou-tag-mutability/

https://www.youtube.com/watch?v=j8K6EjOPhxs

Best practices - run

Vulnerability management

- **New vulnerabilities are discovered daily**

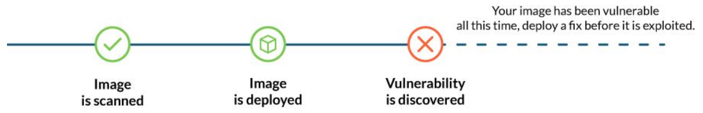
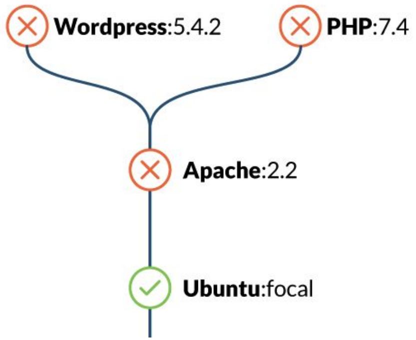


Image is scanned
Image is deployed
Vulnerability is discovered
Your image has been vulnerable all this time, deploy a fix before it is exploited.

- **Don't: Use outdated images**
  - Stick to the latest security patches
  - No need to always go with the latest version (breaking changes)



Vulnerability management

- Runtime vulnerability assessment is key
  - **Re-evaluate** scanned images to detect new applying vulnerabilities
- **Update often +** define a **versioning strategy**
  - Stick to stable or long-term support versions
  - Rebuild periodically
    - To get the latest packages from the base distro
    - npm, go mod offer ways to specify version ranges (keep up with latest security updates)
  - Plan in advance.
    - Be ready to drop old versions
    - Migrate before base image reaches the end of its life and stops receiving updates

Vulnerability management

- Fixing every single vulnerability might my mission impossible
- **Evaluate risk**: severity + exploitability + environment metrics
    - Is the environment critical (i.e. production)?
    - Does an exploit exist?
    - Is the exploit remote or local? Privileged or standard user? ...
    - Is the application exposed to the internet?
- Improve management and focus: use **alerting** and **ticketing** systems
- Upgrade or patch vs protect (i.e. firewall, configuration, ...)

Runtime detection

- **Runtime threat detection** is critical. Falco can help.
- Create **specific** rules to detect exploitation of known vulnerabilities
- Generic rules to detect suspicious activity
  - i.e. unexpected processes, network connections, filesystem read/write, etc.
- Monitor & alert unexpected patterns
  - i.e. high CPU usage caused by cryptomining activities
- **Respond** to suspicious activity. i.e. stop or pause container + **forensics**

Q & A

sysdig