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Docker Image Security Best Practices

By Akshay Ithape - DevOps Engineer

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$whoami

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Passionate About & DEVOPS

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The complete portal on open source

I truly believes in Open Source so I like to share my knowledge with community in as many ways possible and helping people.

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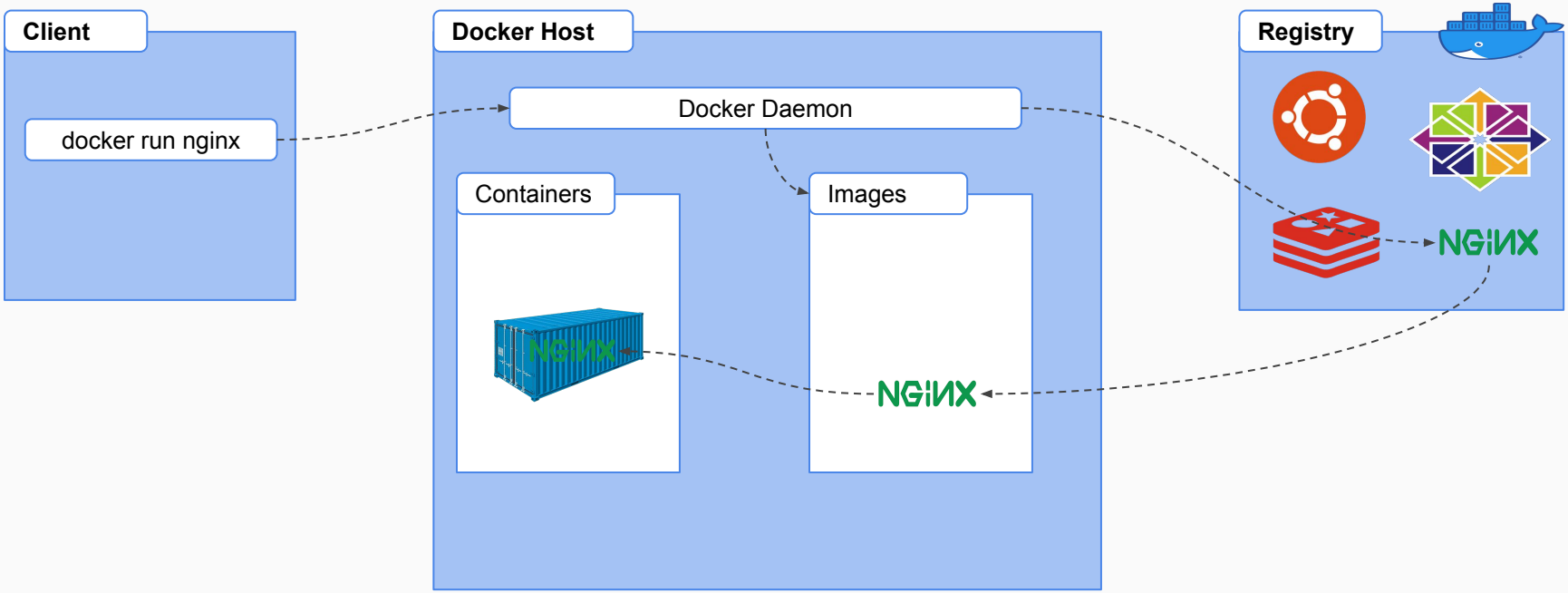
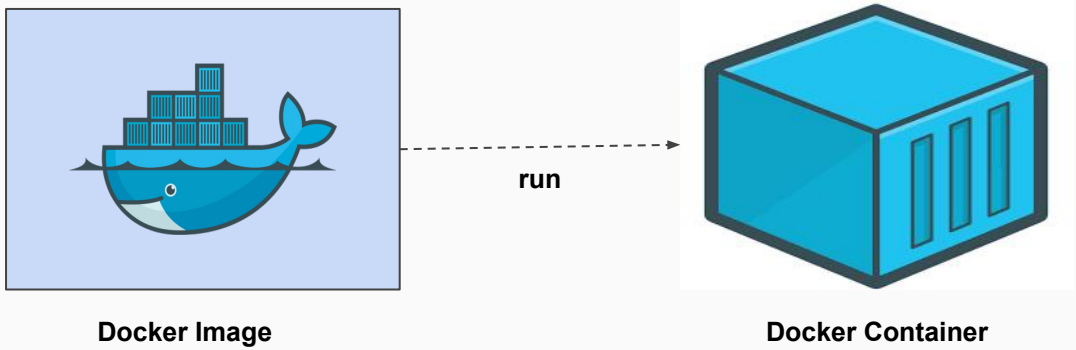
Session Agenda

- How Docker Works ?
- Why Docker Images is Required ?
- How To Build Custom Docker Image ?
- Best Practices(Or Rules) To Choose Base Image
- Best Practices To Write Dockerfile
- Best Practices To Build & Scan Docker Image

How Docker Works ?



Why Docker Image is Required ?



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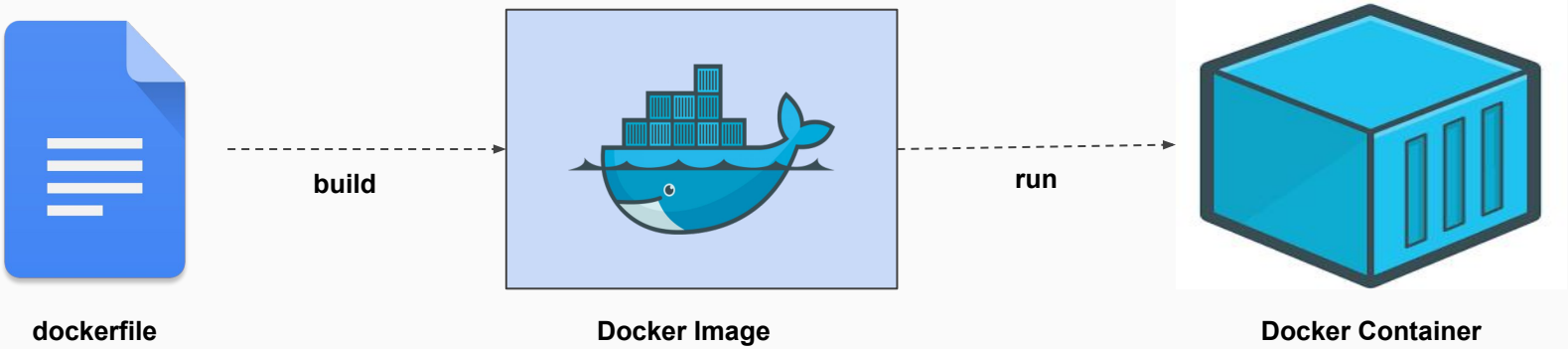
How To Build Custom Docker Image ?



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Simple Dockerfile

dockerfile-format

```
# Comment
Command arguments
```

dockerfile

```
FROM httpd:2.4

LABEL maintainer="Akshay Ithape"
LABEL desc="Apache HTTPD Image 2.4 for Demo App"

RUN apt-get update -y

WORKDIR /usr/local/apache2/htdocs/
COPY index.html .

EXPOSE 80
CMD ["httpd-foreground"]
```

Best Practices(Or Rules) To Choose Base Image

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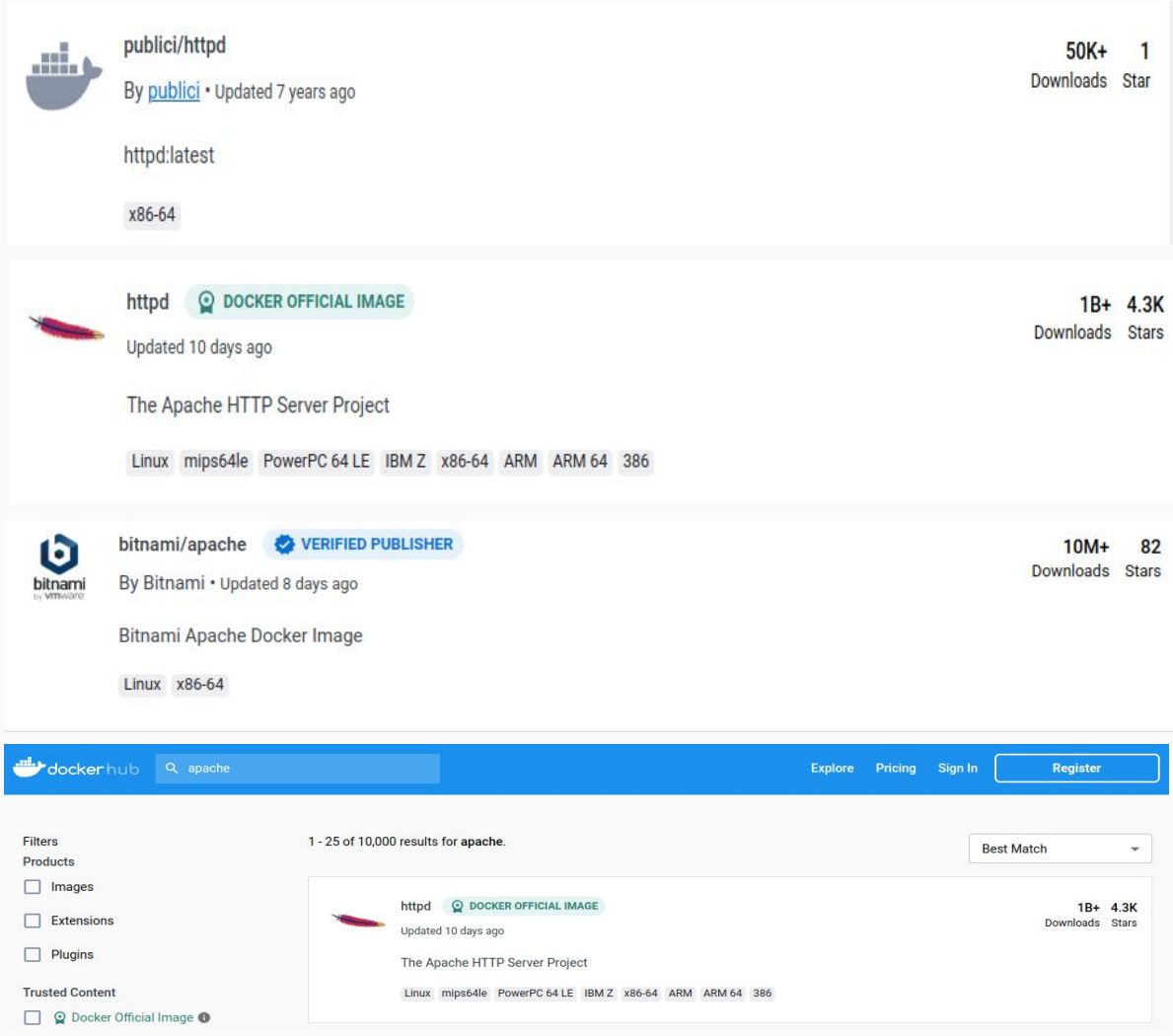
Choose Official or Verified Base Image

Always choose Official or Verified base image. If is not official or verified then vulnerability chances are very high.



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Prefer minimal base images

- Choose images with fewer OS libraries and tools lower the risk and attack surface of the containers.
- Prefer alpine-based images over full-blown system OS images.

TAG

latest

Last pushed 10 days ago by dojjanky

```
docker pull httpd:latest
```

DIGEST	OS/ARCH	COMPRESSED SIZE
6e54f6d6fc78	linux/386	54.91 MB
f2f8e87c61c7	linux/amd64	54.47 MB
699067fa2e5d	linux/arm/v5	51.26 MB

+5 more...

TAG

alpine

Last pushed 14 days ago by dojjanky

```
docker pull httpd:alpine
```

DIGEST	OS/ARCH	COMPRESSED SIZE
fef4200fbf29	linux/386	15.4 MB
ba0101687dee	linux/amd64	15.96 MB
3d3a95e80716	linux/arm/v6	15.31 MB

+4 more...

Vulnerabilities Scan Reports

```
httpd:latest (debian 11.5)

Total: 100 (UNKNOWN: 0, LOW: 75, MEDIUM: 12, HIGH: 11, CRITICAL: 2)
```

```
httpd:alpine (alpine 3.16.3)

Total: 0 (UNKNOWN: 0, LOW: 0, MEDIUM: 0, HIGH: 0, CRITICAL: 0)
```

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Use tags for immutability

Docker image owners can push new versions to the same tags, which may result in inconsistent images during builds, and makes it hard to track if a vulnerability has been fixed.

TAG

alpine3.16

Last pushed 14 days ago by doijanky

```
docker pull httpd:alpine3.16
```

DIGEST	OS/ARCH	COMPRESSED SIZE
fef4200fbf29	linux/386	15.4 MB
ba0101687dee	linux/amd64	15.96 MB
3d3a95e80716	linux/arm/v6	15.31 MB

+4 more...

TAG

alpine

Last pushed 14 days ago by doijanky

```
docker pull httpd:alpine
```

DIGEST	OS/ARCH	COMPRESSED SIZE
fef4200fbf29	linux/386	15.4 MB
ba0101687dee	linux/amd64	15.96 MB
3d3a95e80716	linux/arm/v6	15.31 MB

+4 more...

TAG

2.4.54-alpine3.16

Last pushed 14 days ago by doijanky

```
docker pull httpd:2.4.54-alp…
```

DIGEST	OS/ARCH	COMPRESSED SIZE
fef4200fbf29	linux/386	15.4 MB
ba0101687dee	linux/amd64	15.96 MB
3d3a95e80716	linux/arm/v6	15.31 MB

+4 more...

httpd:alpine3.16

DIGEST: sha256:ba0101687deebd67ea9a5152e9f056a480998e4f418d86d7fbb8bf613ca9a57f

dockerfile

```
dockerfile > ...
1   FROM httpd:alpine3.16@sha256:ba0101687deebd67ea9a5152e9f056a480998e4f418d86d7fbb8bf613ca9a57f
```

Best Practices To Write Dockerfile

Use labels for metadata

Labels with metadata for images provide useful information for users. Include security details as well.

dockerfile

dockerfile > ...

```dockerfile
FROM httpd:2.4

LABEL maintainer="Akshay Ithape"
LABEL desc="Apache HTTPD Image 2.4 for Demo App"

# Update the system
RUN apt-get update -y

# Set the working directory to /usr/local/apache2/htdocs/
WORKDIR /usr/local/apache2/htdocs/

# Copy project index.html file to inside docker image
COPY index.html .

# Open port number 80 for connections
EXPOSE 80

# Run entrypoint
CMD ["httpd-foreground"]
```

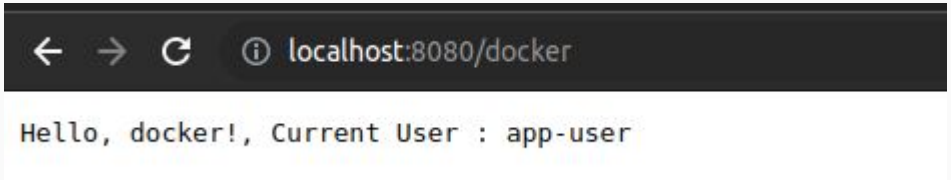
Least privileged user

Create a dedicated user and group on the image, with minimal permissions to run the application; use the same user to run this process.

```
FROM golang:alpine3.16@sha256:27a9653759f44afd08c94418

LABEL maintainer="Akshay Ithape"
LABEL desc="Golang Apline Image 3.16 for Demo App"

RUN addgroup -S myapp && adduser -S app-user -G myapp
USER app-user
RUN mkdir /home/app-user/app
WORKDIR /home/app-user/app
COPY hello.go .
RUN go build hello.go
EXPOSE 8080
CMD ["/home/app-user/app/hello"]
```



Use COPY instead of ADD

Arbitrary URLs specified for ADD could result in MITM attacks, or sources of malicious data. In addition, ADD implicitly unpacks local archives which may not be expected and result in path traversal and Zip Slip vulnerabilities.

ADD instructions is more capable the COPY.

- It can handle remote URLs.
- It can auto-extract tar files.

As we using remote URls so chances are high for MITM attacks or malicious data.

Space and image layer considerations

When local archives are used, ADD automatically extracts them to the destination directory. While this may be acceptable, it adds the risk of zip bombs and Zip Slip vulnerabilities that could then be triggered automatically.

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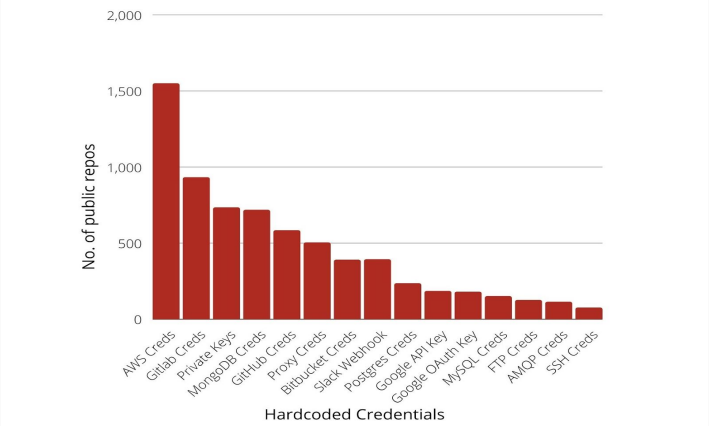
Don’t leak sensitive information to docker images

It’s easy to accidentally leak secrets, tokens, and keys into images when building them.



46076
Docker Containers

Leaked at least one Hardcoded Secret or Config file

Top 5 Exposures in Docker Images

- **Hardcoded secrets**
- **Sensitive config files**
- **Adding the entire git repo**
- **Paid software licenses**
- **Default credentials**

Exposures in Docker Containers

15,541
Hardcoded Secrets were identified across 10,181 Repositories

57,589
Potentially Sensitive Config files copied to Docker Images across 36,176 Repos

https://redhuntlabs.com/blog/scanning-millions-of-publicly-exposed-docker-containers-thousands-of-secrets-leaked.html

How to proactively stop exposures in docker images?

- Don’t hardcode tokens/API keys in docker images
- Do not clone/download the required files using credentials. Instead copy them to the image.
- Used .dockerignore file
- Multi-Stage build
- Used container private registry.

File Edit Selection View Go Run Terminal Help

EXPLORER

DOCKER-TEST

- .dockerignore
- .env
- dev1.pub
- dockerfile
- index.js
- package.json
- private.key

OUTLINE

dockerfile

```
FROM node:alpine

RUN mkdir /app
WORKDIR /app
COPY package.json .
RUN npm install
COPY . .
EXPOSE 3000
USER node
CMD ["node", "index.js"]
```

.dockerignore

```
.env
private.key
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

~/docker-test at 09:10:11 am

```
❯ docker build -f dockerfile -t node-test:v3 .
Sending build context to Docker daemon  6.144kB
Step 1/9 : FROM node:alpine
 ---> 15c6163d954c
Step 2/9 : RUN mkdir /app
 ---> Using cache
 ---> 2366349bdb11
Step 3/9 : WORKDIR /app
 ---> Using cache
 ---> 4118da81c329
Step 4/9 : COPY package.json .
 ---> Using cache
 ---> 81c8480f487b
Step 5/9 : RUN npm install
 ---> Using cache
 ---> b4290cd49163
Step 6/9 : COPY . .
 ---> Using cache
 ---> 14e1829510c4
Step 7/9 : EXPOSE 3000
 ---> Using cache
 ---> 6887a76f2bda
Step 8/9 : USER node
 ---> Using cache
 ---> c4952af36f6e
Step 9/9 : CMD ["node", "index.js"]
 ---> Using cache
 ---> d8561ad14f9c
Successfully built d8561ad14f9c
Successfully tagged node-test:v3
```

~/docker-test at 09:10:14 am

```
❯ ./setup-run.sh
```

~/docker-test at 09:10:43 am

```
❯ docker run -it node-test:v3 /bin/sh
/app $ ls -la
total 32
drwxr-xr-x    1 root     root          4096 Mar 25 03:39 .
drwxr-xr-x    1 root     root          4096 Mar 25 03:40 ..
-rw-rw-r--    1 root     root            16 Mar 25 03:32 .dockerignore
-rw-------    1 root     root           190 Mar 24 17:07 dev1.pub
-rw-rw-r--    1 root     root           137 Mar 25 03:39 dockerfile
-rw-rw-r--    1 root     root           287 Mar 24 13:57 index.js
-rw-r--r--    1 root     root           245 Mar 25 03:39 package-lock.json
-rw-rw-r--    1 root     root           473 Mar 24 13:57 package.json
/app $
```

zsh
zsh
docker

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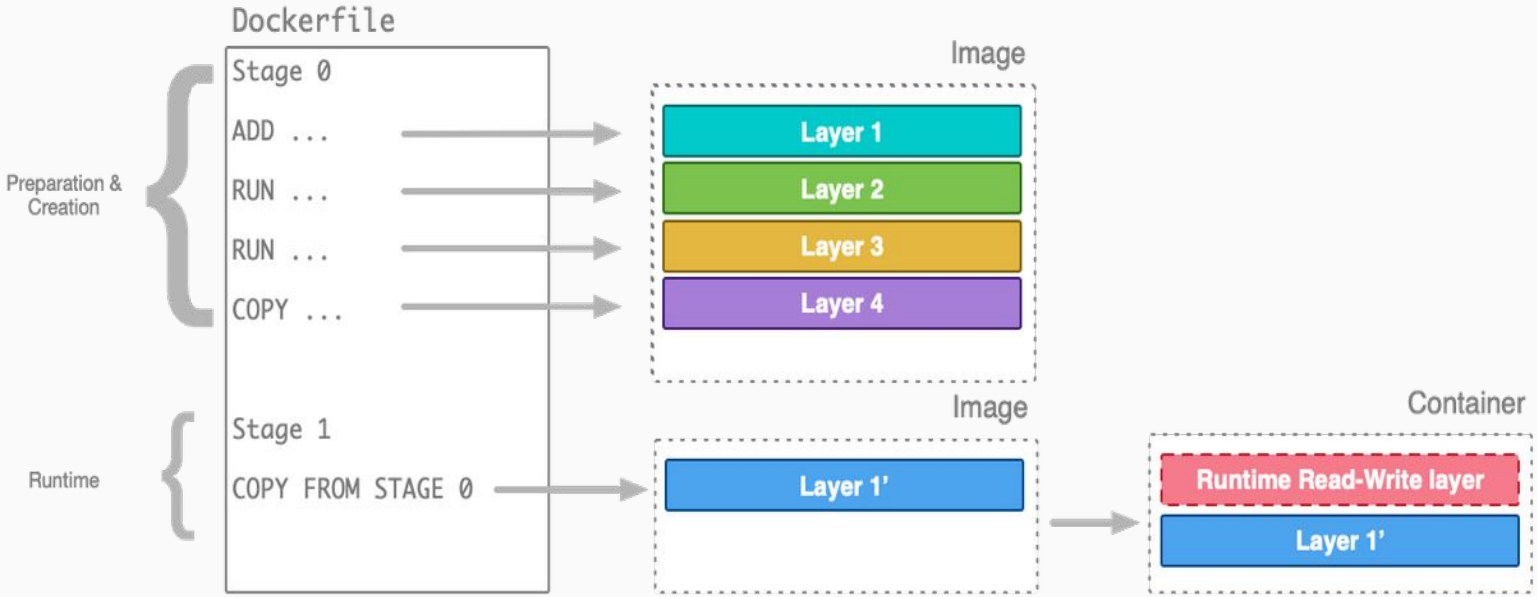
Use multi-stage builds for small secure images

Use multi-stage builds in order to produce smaller and cleaner images, thus minimizing the attack surface for bundled docker image dependencies.



multi-stage-dockerfile

```
FROM golang AS builder
LABEL maintainer="Akshay Ithape"

RUN mkdir /app
WORKDIR /app

COPY hello.go .
RUN go build hello.go

FROM scratch
COPY --from=builder /app/hello .

ENTRYPOINT [ "./hello" ]
```

hello.go

```go
package main

import "fmt"

func main () {
  fmt.Println("Hello, world!")
}
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

```
~/docker-test                                   at 10:52:05 am
❯ docker run test-hello:v1
Hello, world!

~/docker-test                                   at 10:52:11 am
❯ docker image ls test-hello:v1
REPOSITORY   TAG       IMAGE ID       CREATED          SIZE
test-hello   v1        77b8b8d90863   37 seconds ago   1.75MB

~/docker-test                                   at 10:52:13 am
❯
```

zsh
zsh

Multi-Stage Build Example

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Use a Static Code Analysis

Enforce Dockerfile best practices automatically by using a static code analysis tool such as **hadolint** linter, that will detect and alert for issues found in a Dockerfile.

```
DL4000 Specify a maintainer of the Dockerfile
DL3006 Always tag the version of an image explicitely.
1 FROM debian
SC1007 Remove space after = if trying to assign a value (for empty string, use var='' ... ).
SC2154 node_verson is referenced but not assigned.
DL3009 Delete the apt-get lists after installing something
2 RUN node_version= "0.10" \
3  && apt-get update && apt-get -y install nodejs="$node_verson"
4 COPY package.json usr/src/app
DL3003 Use WORKDIR to switch to a directory
5 RUN cd /usr/src/app \
6  && npm install node-static
7
DL3011 Valid UNIX ports range from 0 to 65535
8 EXPOSE 80000
9 CMD ["npm", "start"]
```

Best Practices To Build & Scan Docker Image

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Verify and Sign images to mitigate MITM attacks

We put a lot of trust into docker images. It is critical to make sure the image we're pulling is the one pushed by the publisher, and that no one has tampered with it.

```
❯ export DOCKER_CONTENT_TRUST=1

❯ docker pull vigneshkumar73/vicky_nginx
Using default tag: latest
Error: remote trust data does not exist for docker.io/vigneshkumar73/vicky_nginx: notary.docker.io does not have trust data for docker.io/vigneshkumar73/vicky_nginx
```

```
~/docker-test
❯ docker trust key generate dev1
Generating key for dev1...
Enter passphrase for new dev1 key with ID 1ebd66c:
Repeat passphrase for new dev1 key with ID 1ebd66c:
Successfully generated and loaded private key. Corresponding public key available: /home/akshay/docker-test/dev1.pub

~/docker-test
❯ docker tag node-test:v1 imperishableakki/node-test:v1

~/docker-test
❯ docker trust signer add --key dev1.pub dev1 imperishableakki/node-test
Adding signer "dev1" to imperishableakki/node-test...
Initializing signed repository for imperishableakki/node-test...
You are about to create a new root signing key passphrase. This passphrase
will be used to protect the most sensitive key in your signing system. Please
choose a long, complex passphrase and be careful to keep the password and the
key file itself secure and backed up. It is highly recommended that you use a
password manager to generate the passphrase and keep it safe. There will be no
way to recover this key. You can find the key in your config directory.
Enter passphrase for new root key with ID 18b7bea:
Repeat passphrase for new root key with ID 18b7bea:
Enter passphrase for new repository key with ID aeaa583:
Repeat passphrase for new repository key with ID aeaa583:
Successfully initialized "imperishableakki/node-test"
Successfully added signer: dev1 to imperishableakki/node-test

~/docker-test
❯ docker trust sign imperishableakki/node-test:v1
Signing and pushing trust data for local image imperishableakki/node-test:v1, may overwrite remote trust data
The push refers to repository [docker.io/imperishableakki/node-test]
45f534bae6c2: Pushed
e5623c90b52f: Pushed
80f4d40e1c68: Pushed
0ad6919e1cc3: Mounted from library/node
5a09a182660a: Mounted from library/node
41c27a423d25: Mounted from library/node
ff768a1413ba: Mounted from library/node
v1: digest: sha256:d7e67a0b2cfab1476adbe69c3db2927f0b644ca56e7593111d9bad8d78a14d2d size: 1780
Signing and pushing trust metadata
Enter passphrase for dev1 key with ID 1ebd66c:
Successfully signed docker.io/imperishableakki/node-test:v1
```

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Find the docker image vulnerabilities

Scan your docker images for known vulnerabilities and integrate it as part of your continuous integration. There are many open sources available to scan images.

aquasecurity/
docker-bench

Checks whether Docker is deployed according to security best practices as defined in the CIS Docker Benchmark

12 Contributors | 6 Issues | 167 Stars | 58 Forks

aqua trivy

snyk

clair

& Many More!

Trivy Demo

aqua
trivy

Reference Link

- https://snyk.io/blog/10-docker-image-security-best-practices/
- https://www.docker.com/blog/docker-and-snyk-extend-partnership-to-docker-official-and-certified-images/
- https://www.docker.com/blog/improve-the-security-of-hub-container-images-with-automatic-vulnerability-scans/
- https://www.docker.com/blog/advanced-dockerfiles-faster-builds-and-smaller-images-using-buildkit-and-multistage-builds/
- https://betterprogramming.pub/docker-content-trust-security-digital-signatures-eeae9348140d
- https://snyk.io/plans/
- https://aquasecurity.github.io/trivy/v0.18.3/installation/

Thank You EveryOne

Be In Touch

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