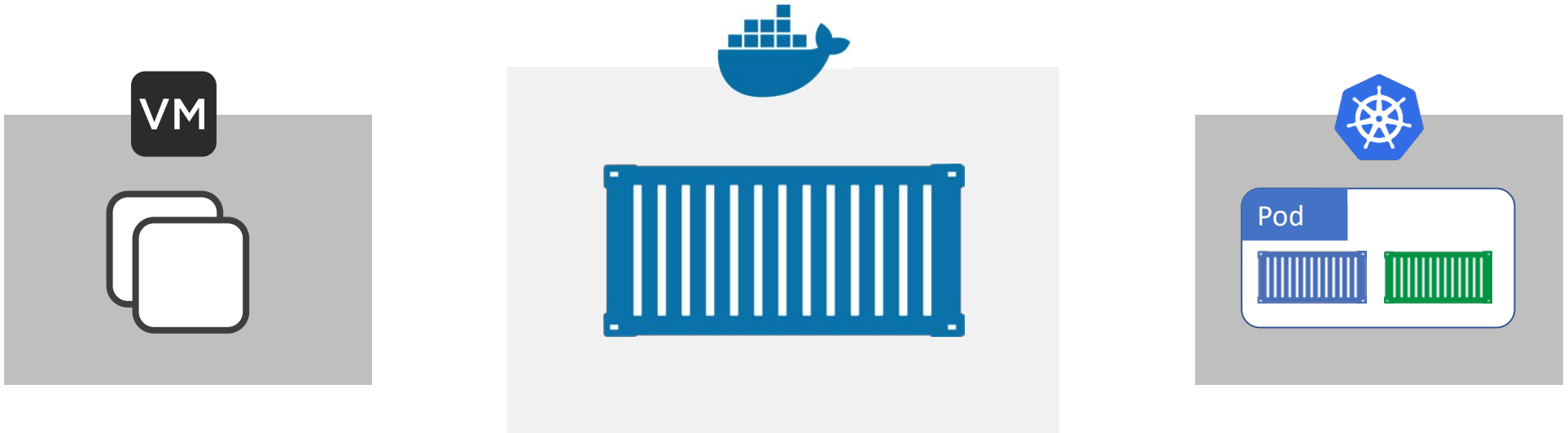
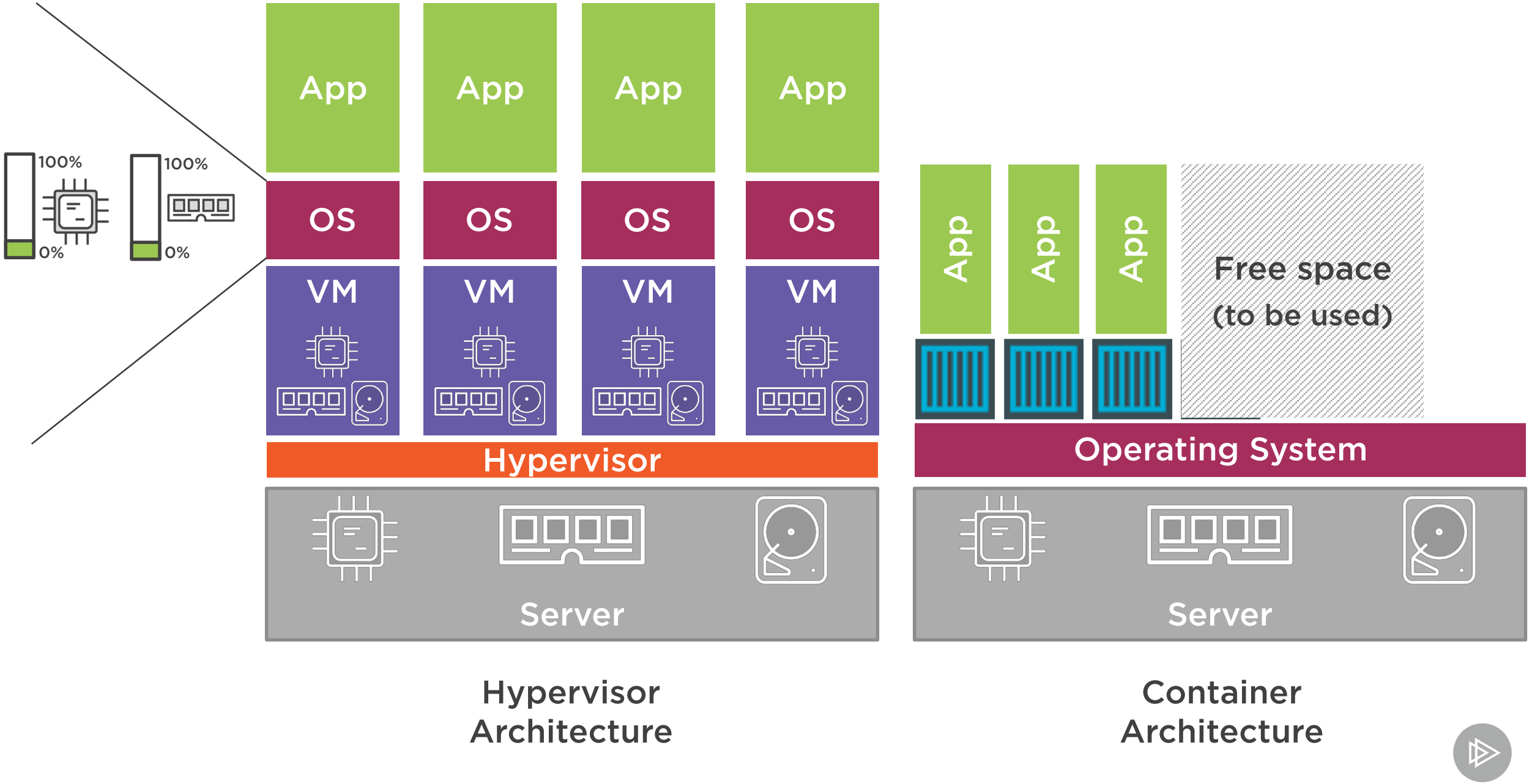
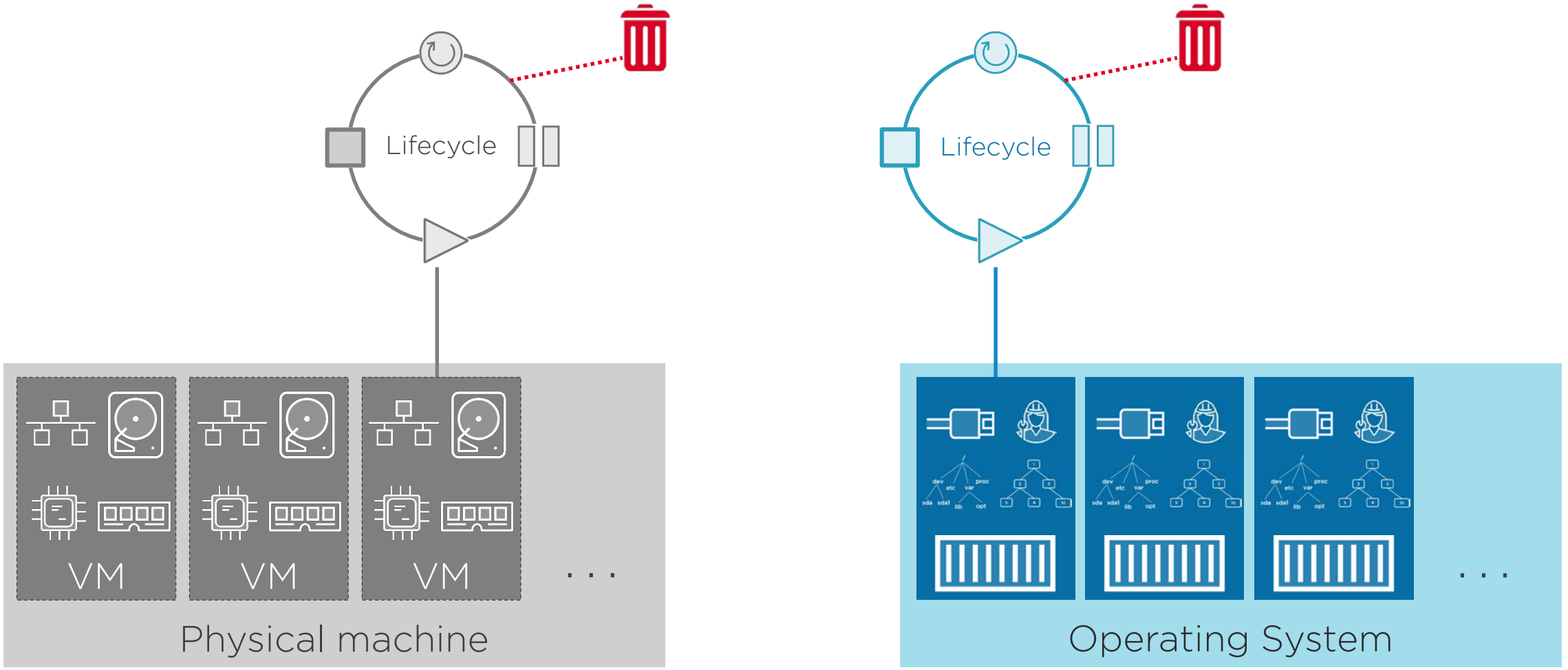

VM
Pod
Atomic units



Hypervisor Architecture

Container Architecture


Lifecycle
VM
VM
VM
. . .
Physical machine
Lifecycle
. . .
Operating System

The Benefits of Containers

- Resource isolation (sandboxing)
- Less overhead (compared to VM)
- Increased portability (run anywhere)
- Consistent environment
- Greater efficiency
- Elasticity
- Constraints (memory, CPU, etc.)

Docker Benefits

Containers

- Isolation
- Portability
- Efficient
- Fast start
- Disposable
- Minimal attack surface area

VMs

- Strong isolation
- Portability
- Resource hungry
- OS boot times
- Require patching
- OS needs hardening

Security

- Isolation
- Minimal attack surface area
- Vulnerability scanning
- Image signing

Docker

Linux/Windows Server

Server

(VM / bare metal / laptop)

Windows apps

Docker

Windows Server

(VM / bare metal / laptop)

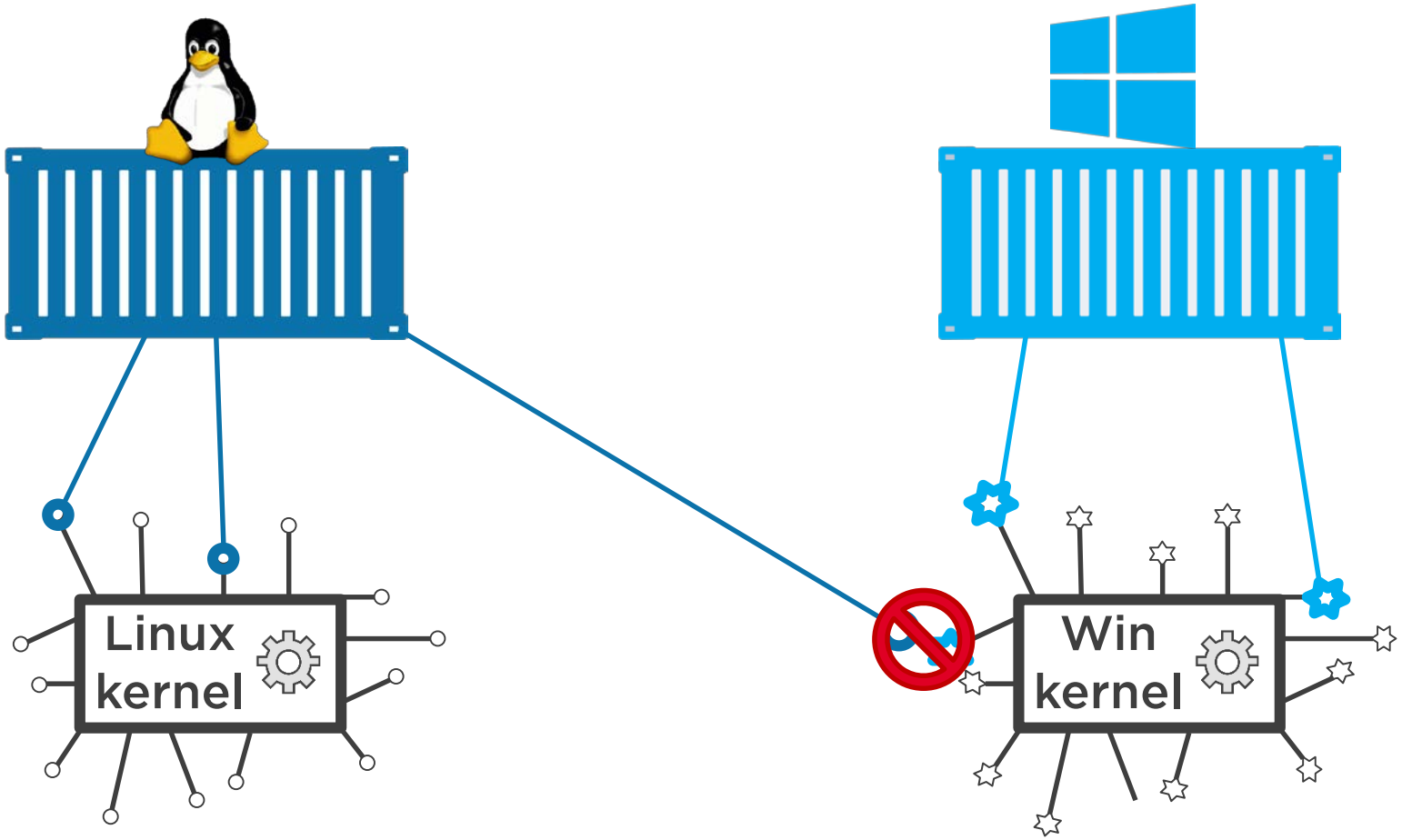
Linux apps

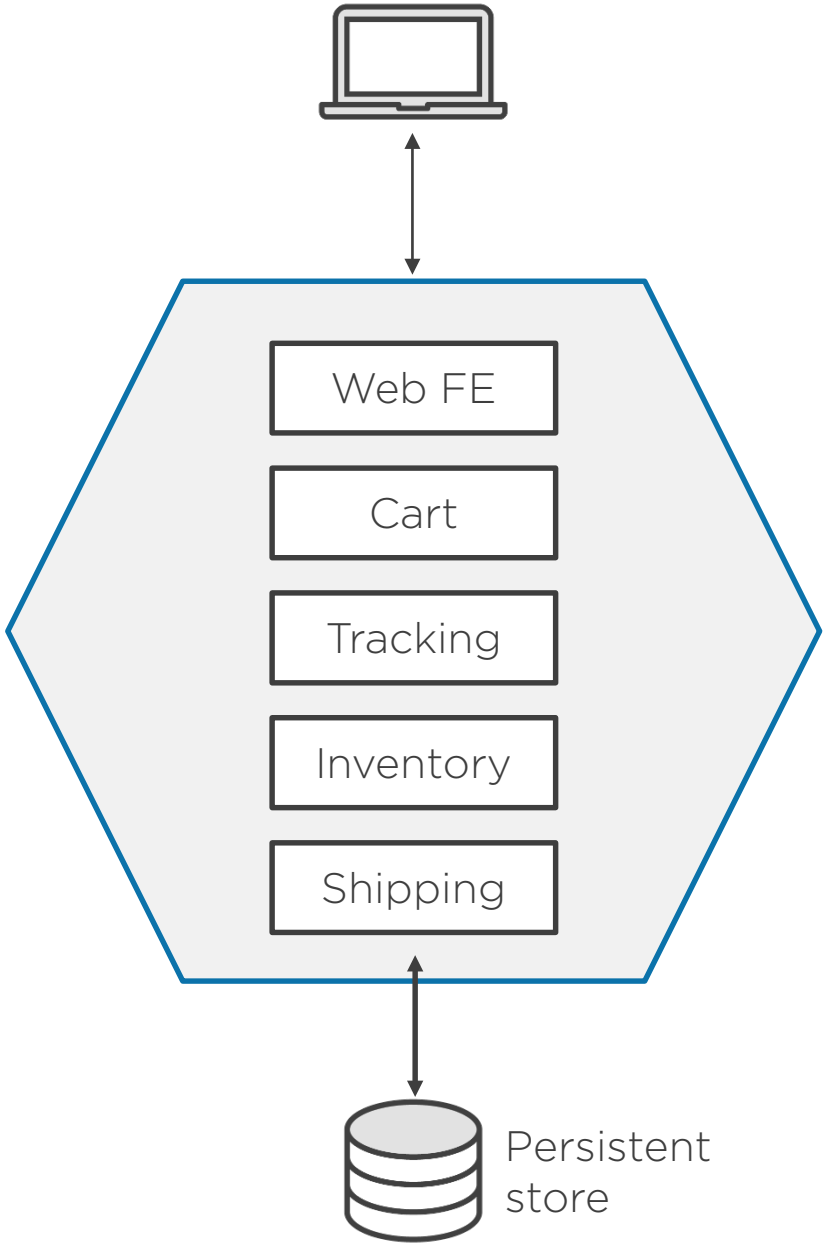
Docker

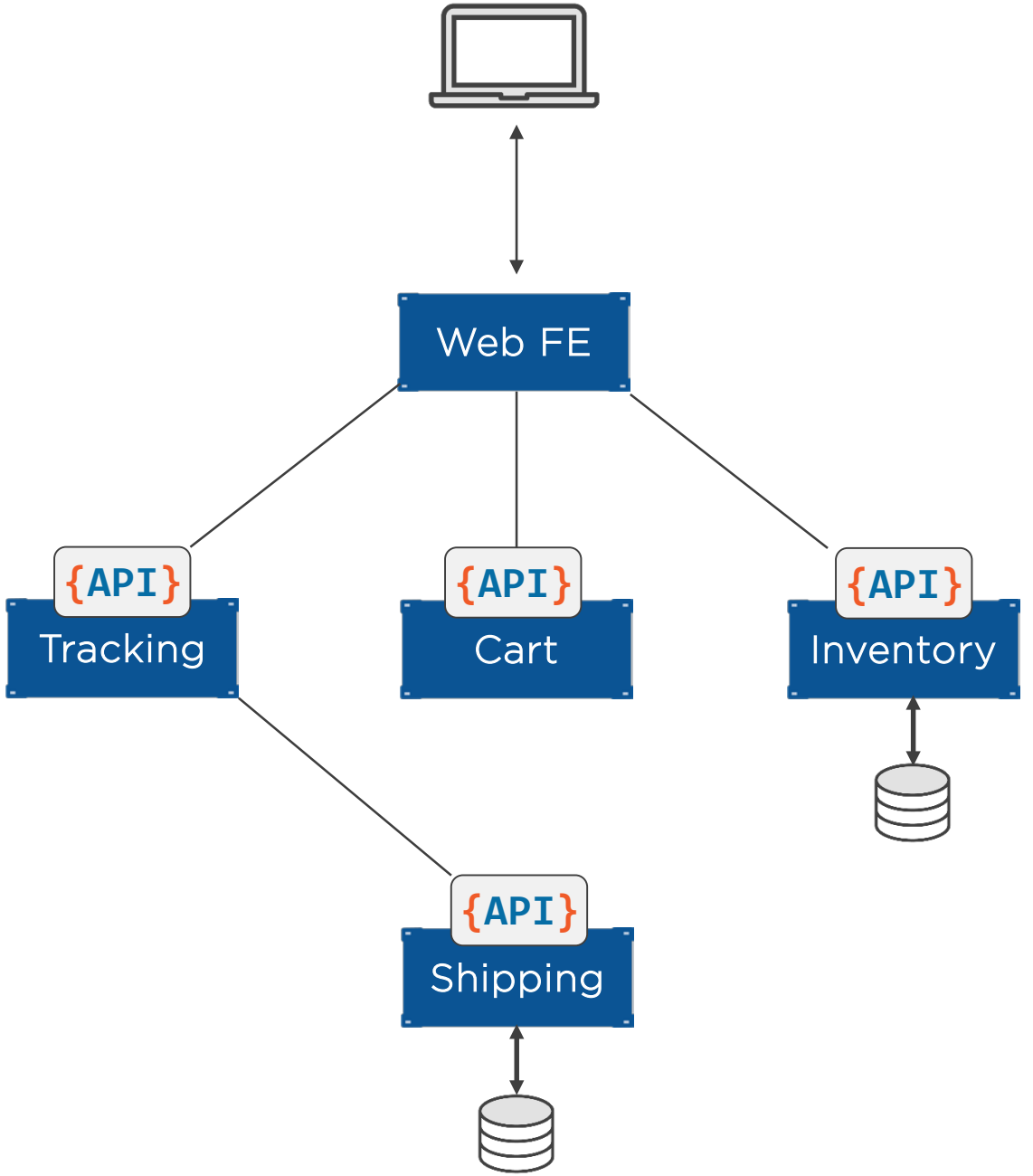
Linux

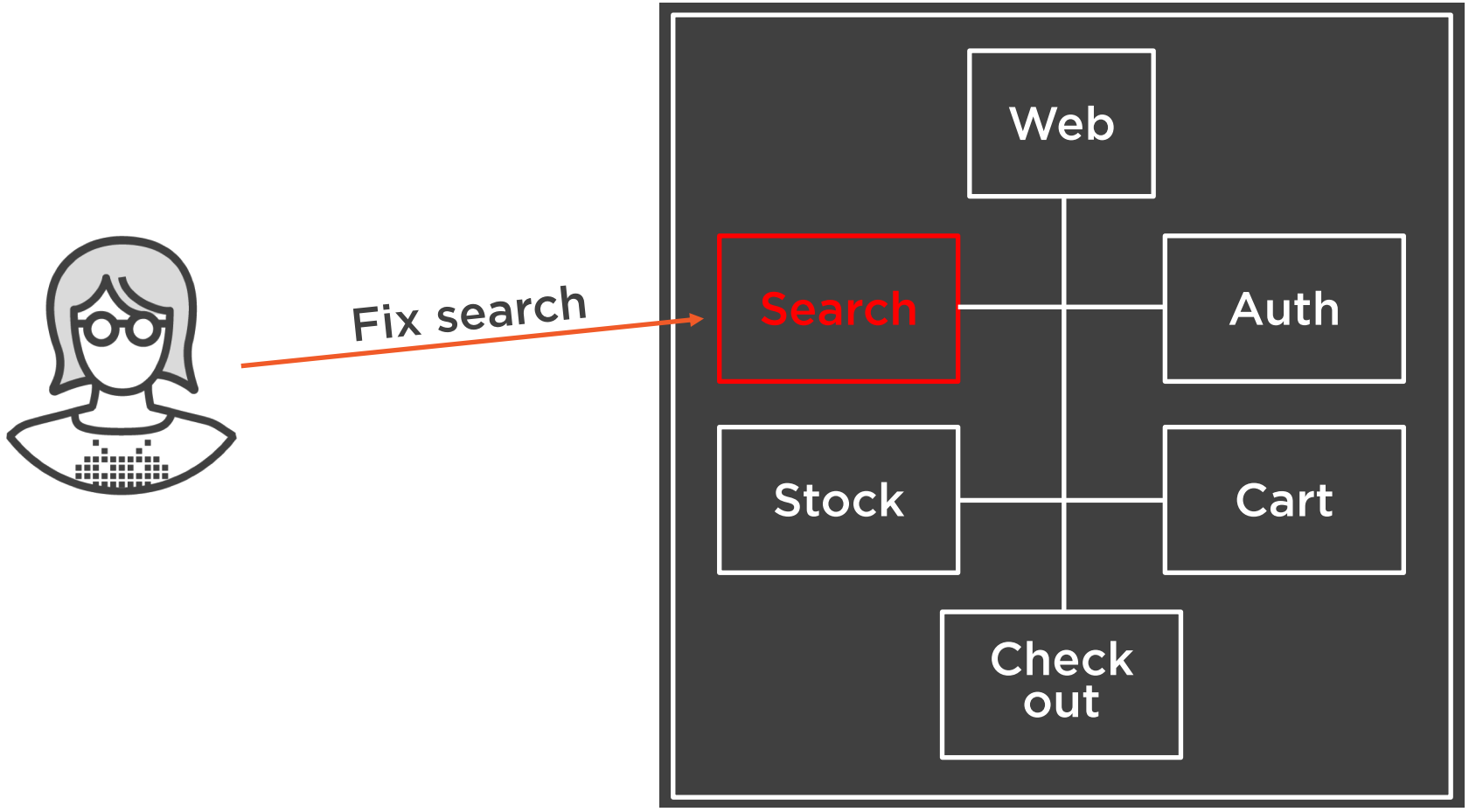
(VM / bare metal / laptop)

*It may be possible to run your Linux apps on Docker on Windows

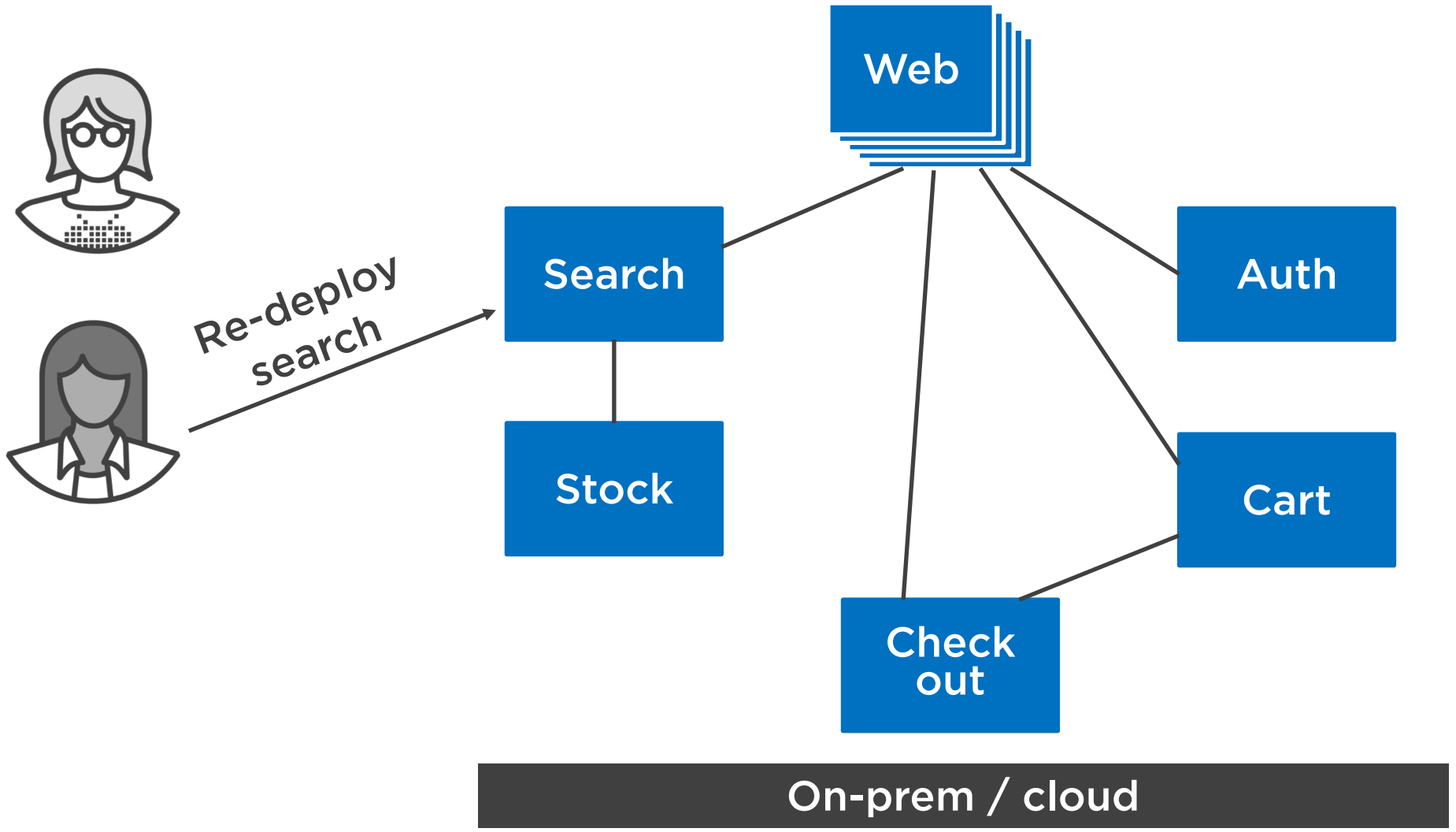

Linux
kernel
Win
kernel

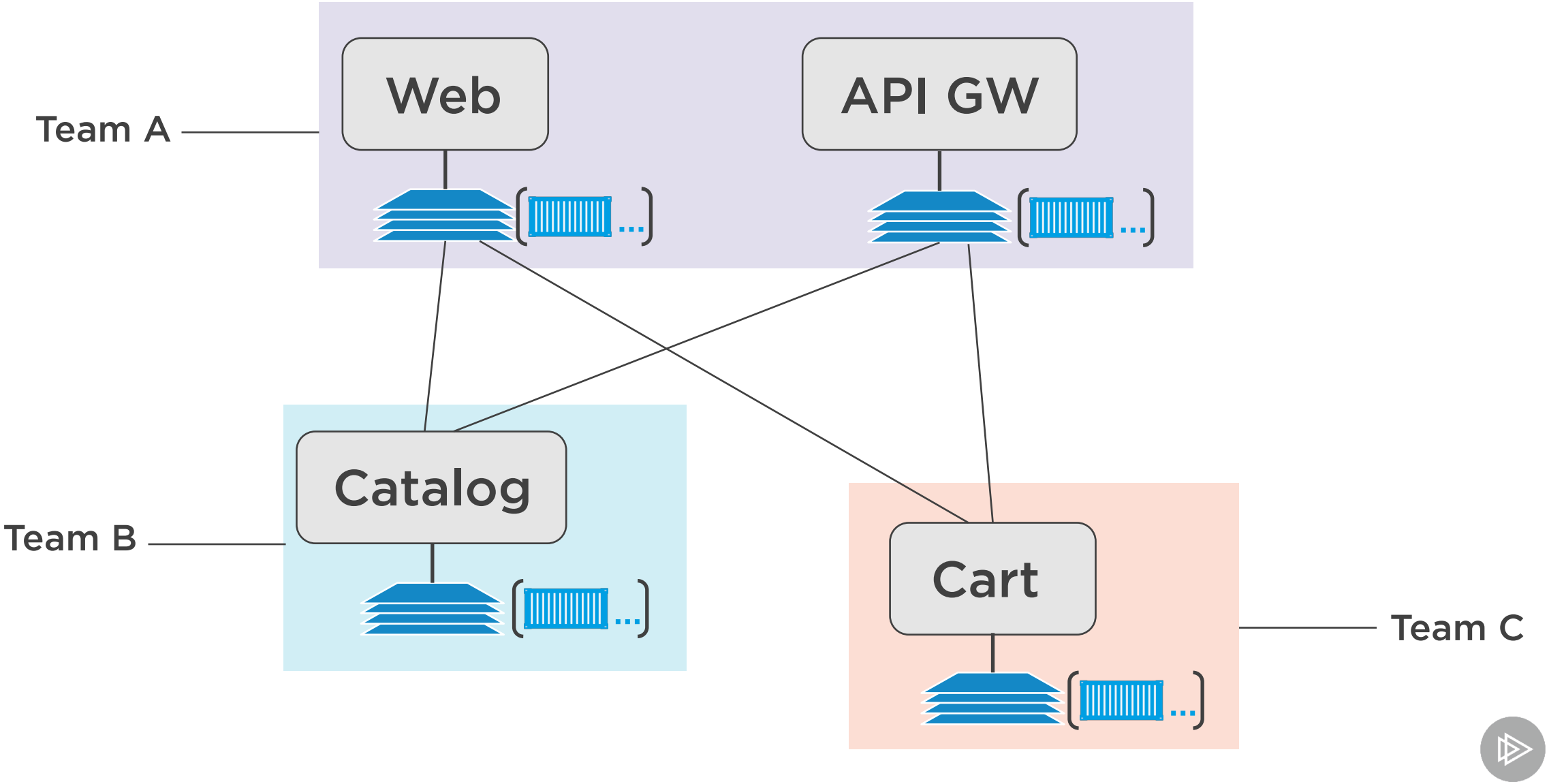

Web FE
Cart
Tracking
Inventory
Shipping
Persistent
store


Web FE
{API}
Tracking
{API}
Cart
{API}
Inventory
{API}
Shipping



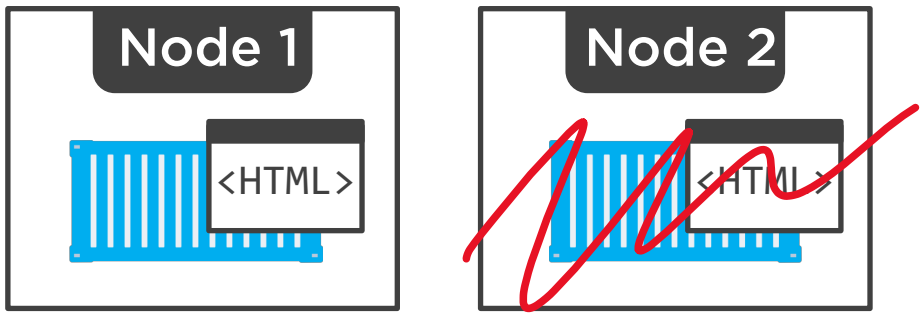
Monolith/Legacy App
(Single binary)

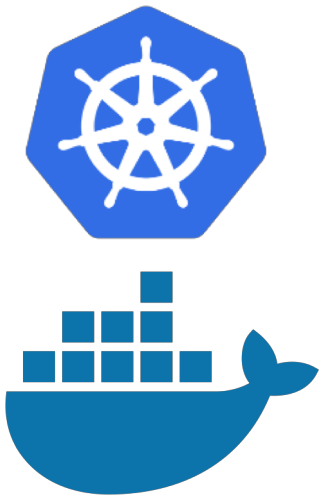

Web
Search
Auth
Re-deploy
search
Stock
Cart
Check
out
On-prem / cloud


Team A
Web
API GW
Team B
Catalog
Cart
Team C

✓ Stateless

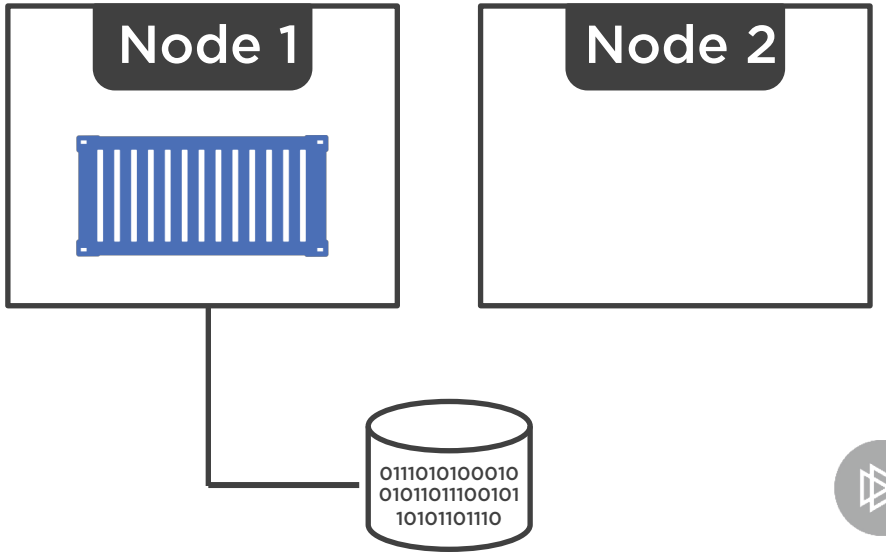
- Doesn't remember stuff



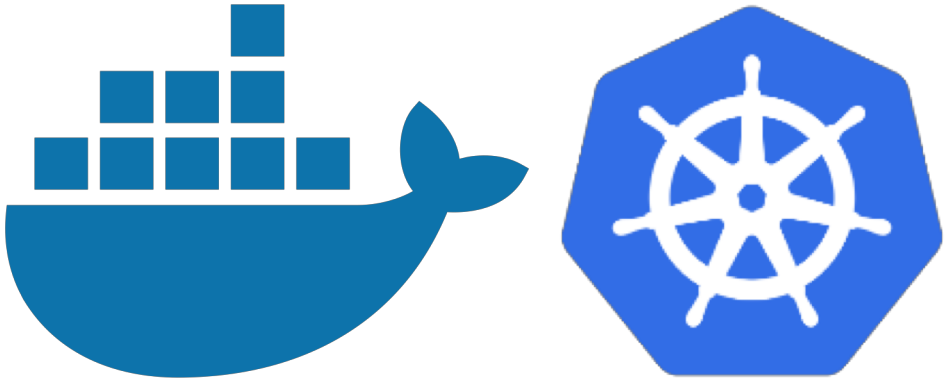


Stateful ✓

- Has to remember stuff

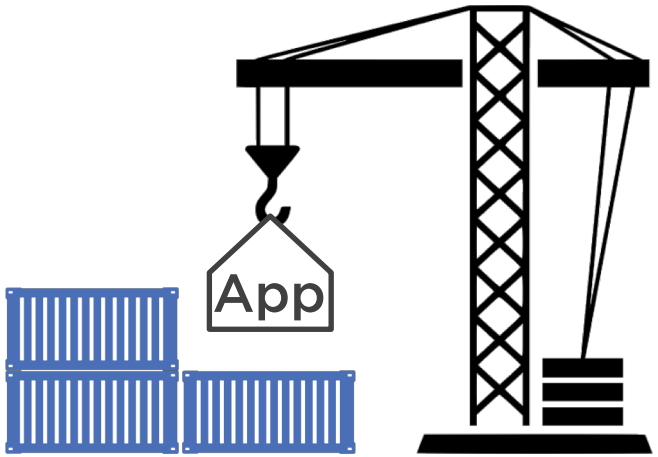


Stateful

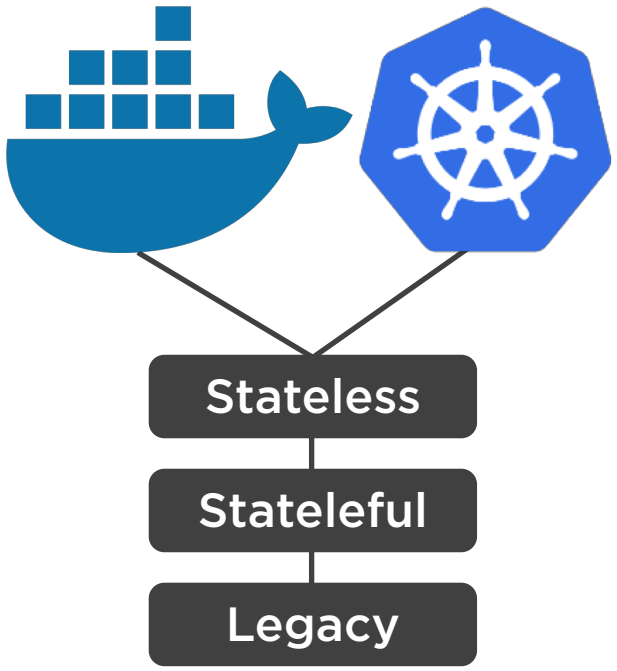


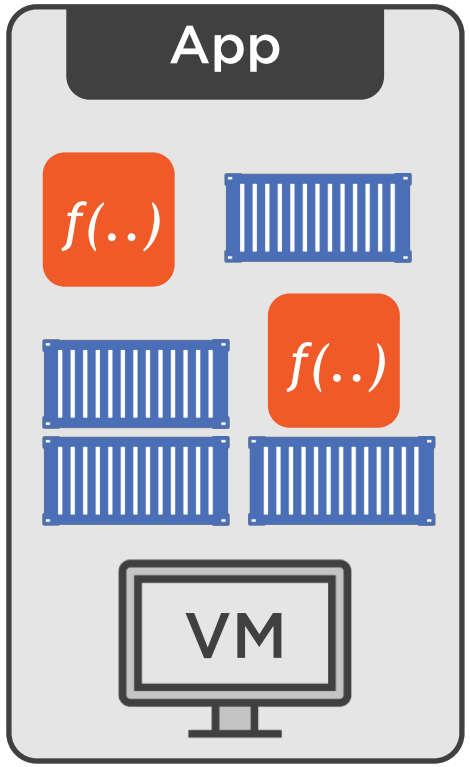
Added features for stateful apps

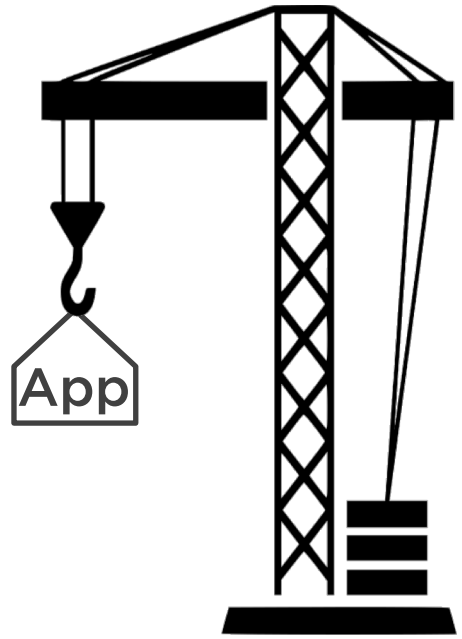
Legacy



Some apps can be migrated directly to containers


Stateless
Stateleful
Legacy


App
f(..)
f(..)
VM


App

Modernize Traditional Apps

Existing Application

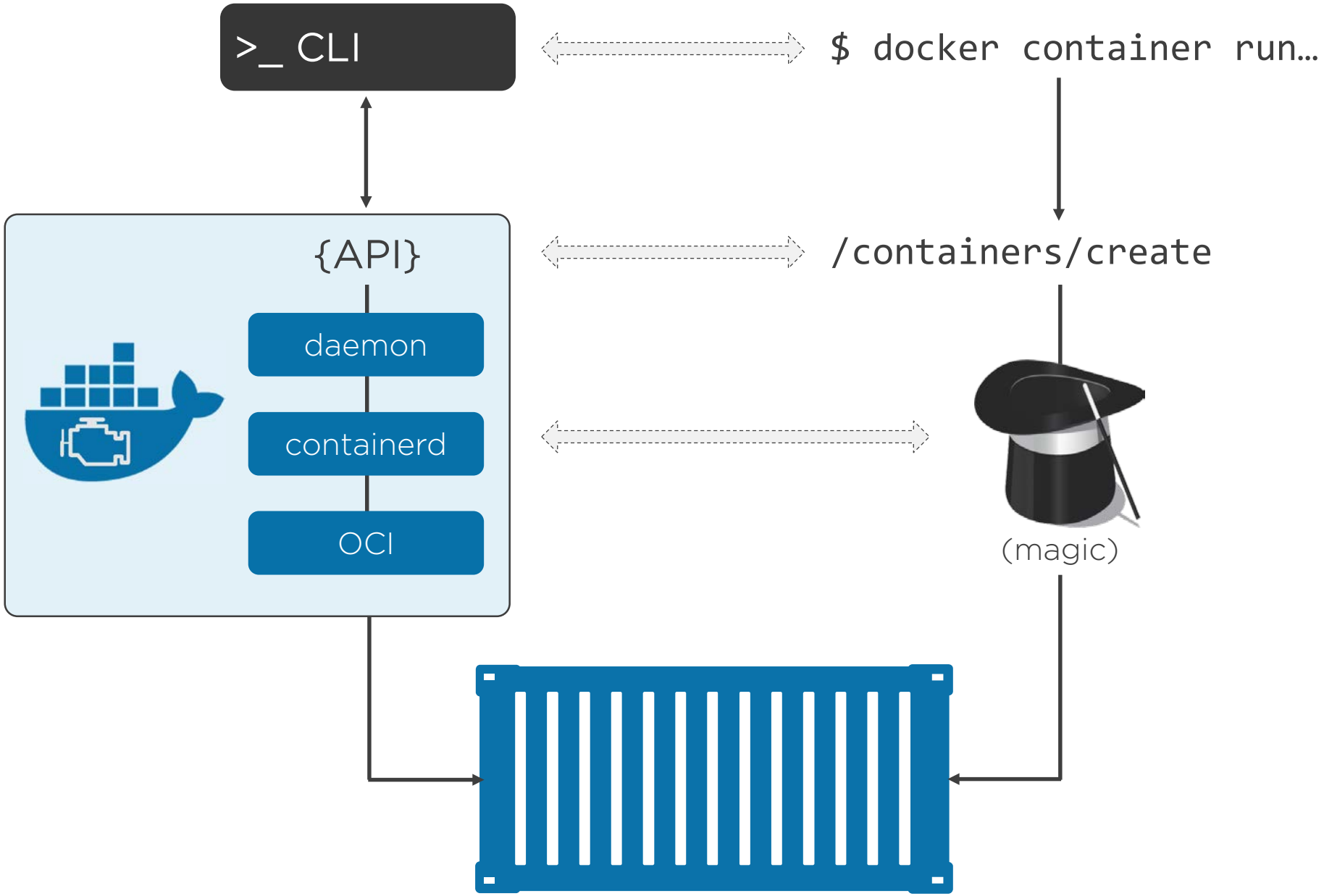
Convert to a **Container** with Docker EE

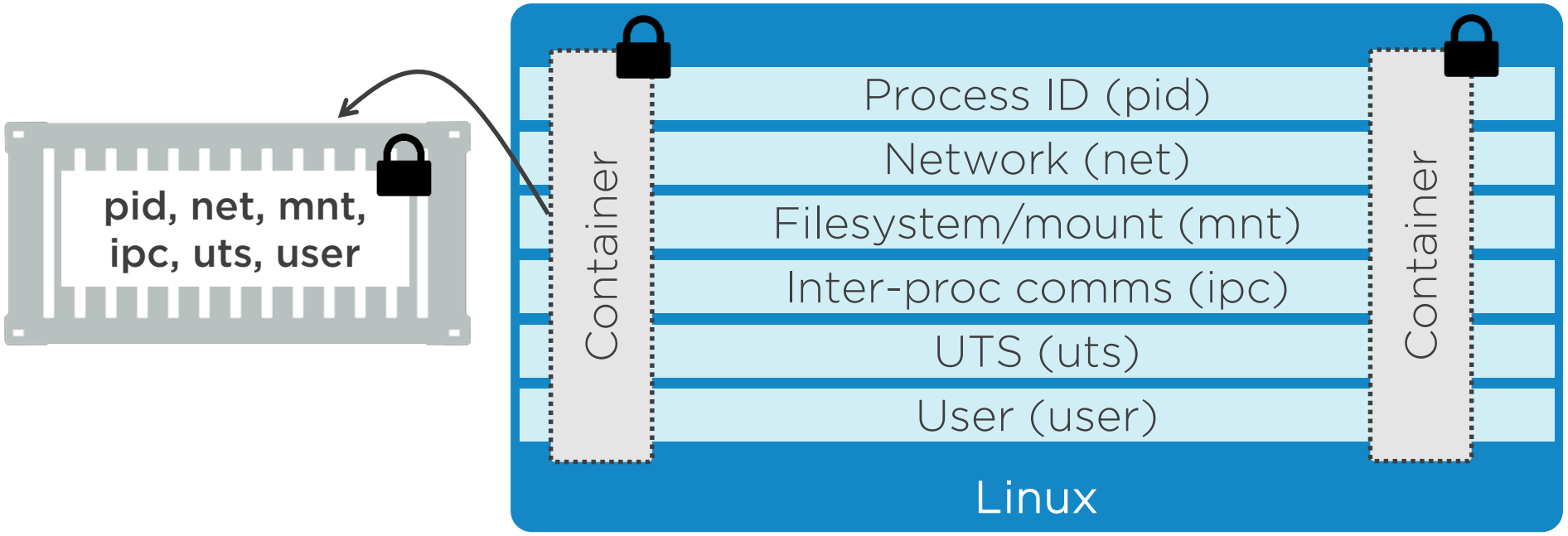
Modern Infrastructure
Built on premise, in the cloud, or as part of a hybrid environment

Modern Methodologies
Integrate to CI/CD and other automation systems

Modern Microservices
Add new services or start peeling off services from monolith code base

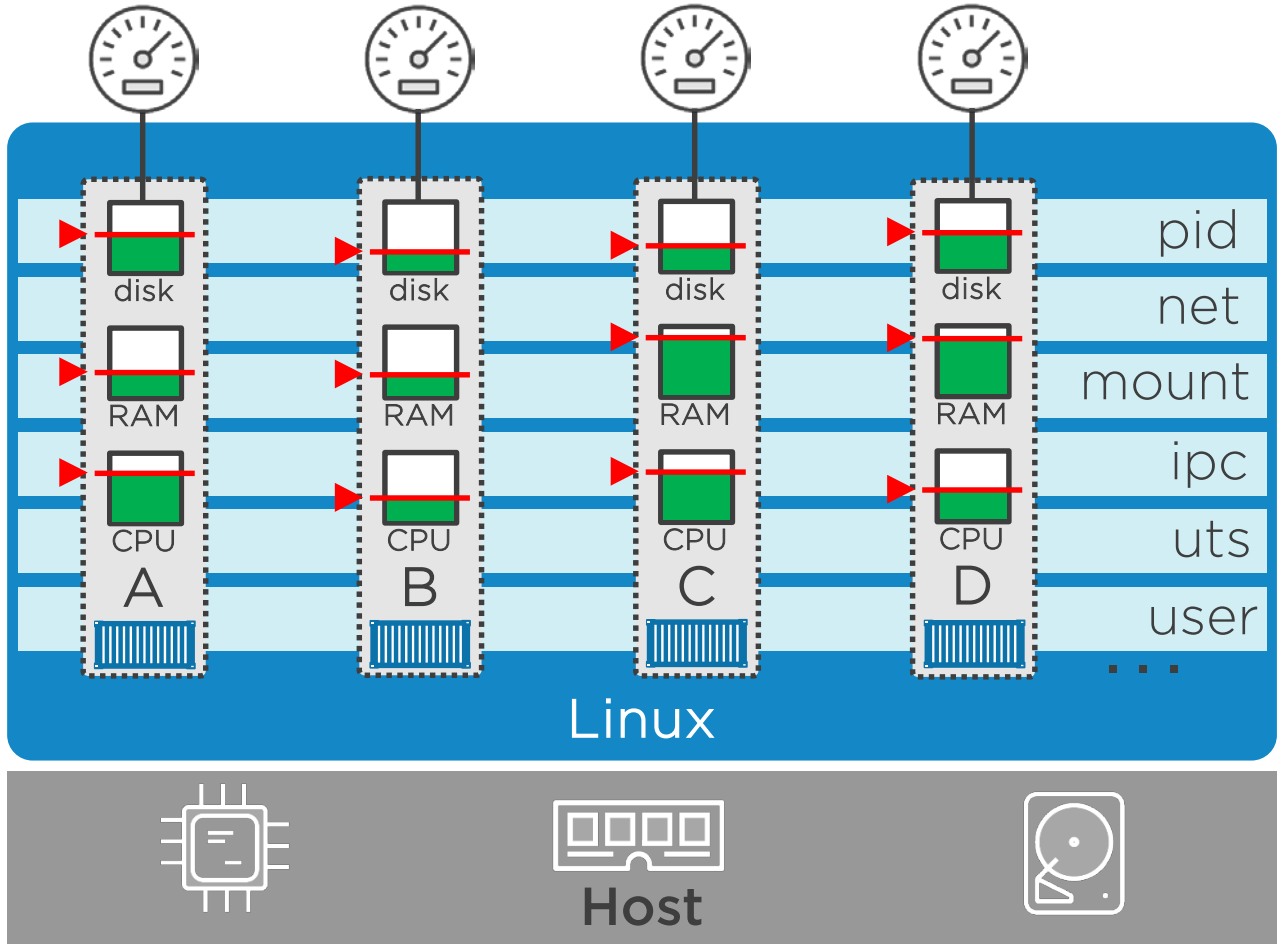
Image courtesy of www.docker.com


>_ CLI
$ docker container run…
{API}
/containers/create
daemon
containerd
OCI
(magic)



Namespaces

Control Groups



Layers

Union fs/mount & CoW

Namespaces

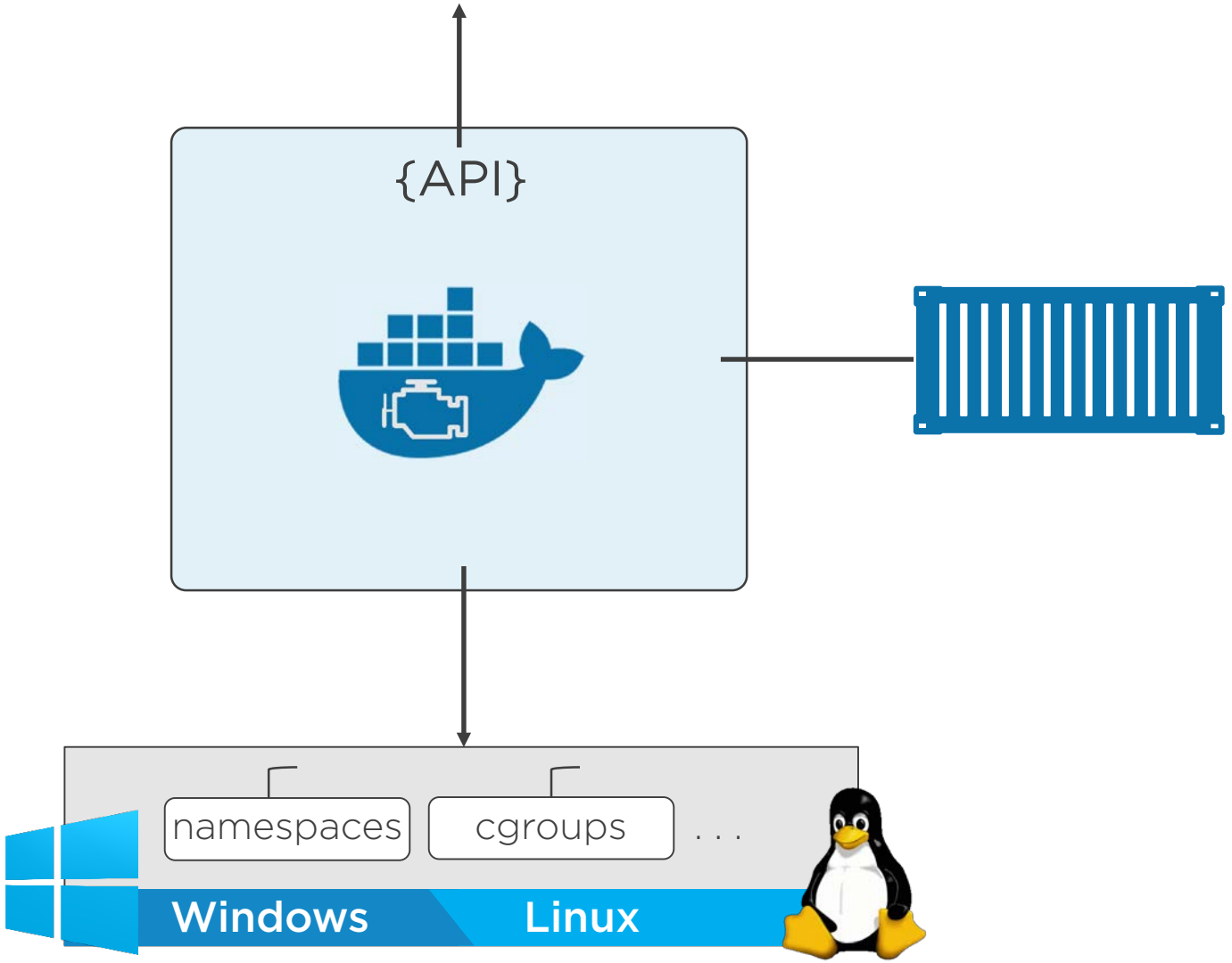
Linux
- pid
- net
- mount
- ...

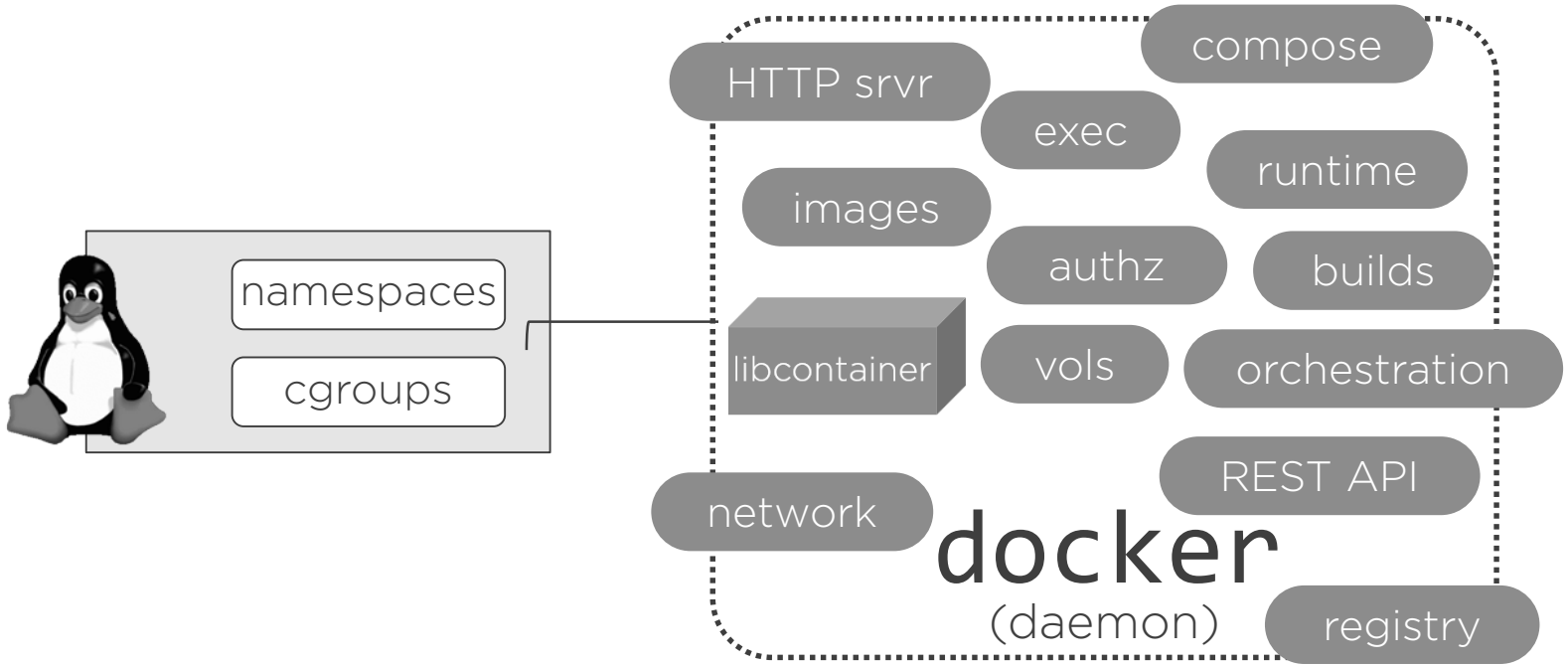
Windows
- object
- proc table
- networking
- ...

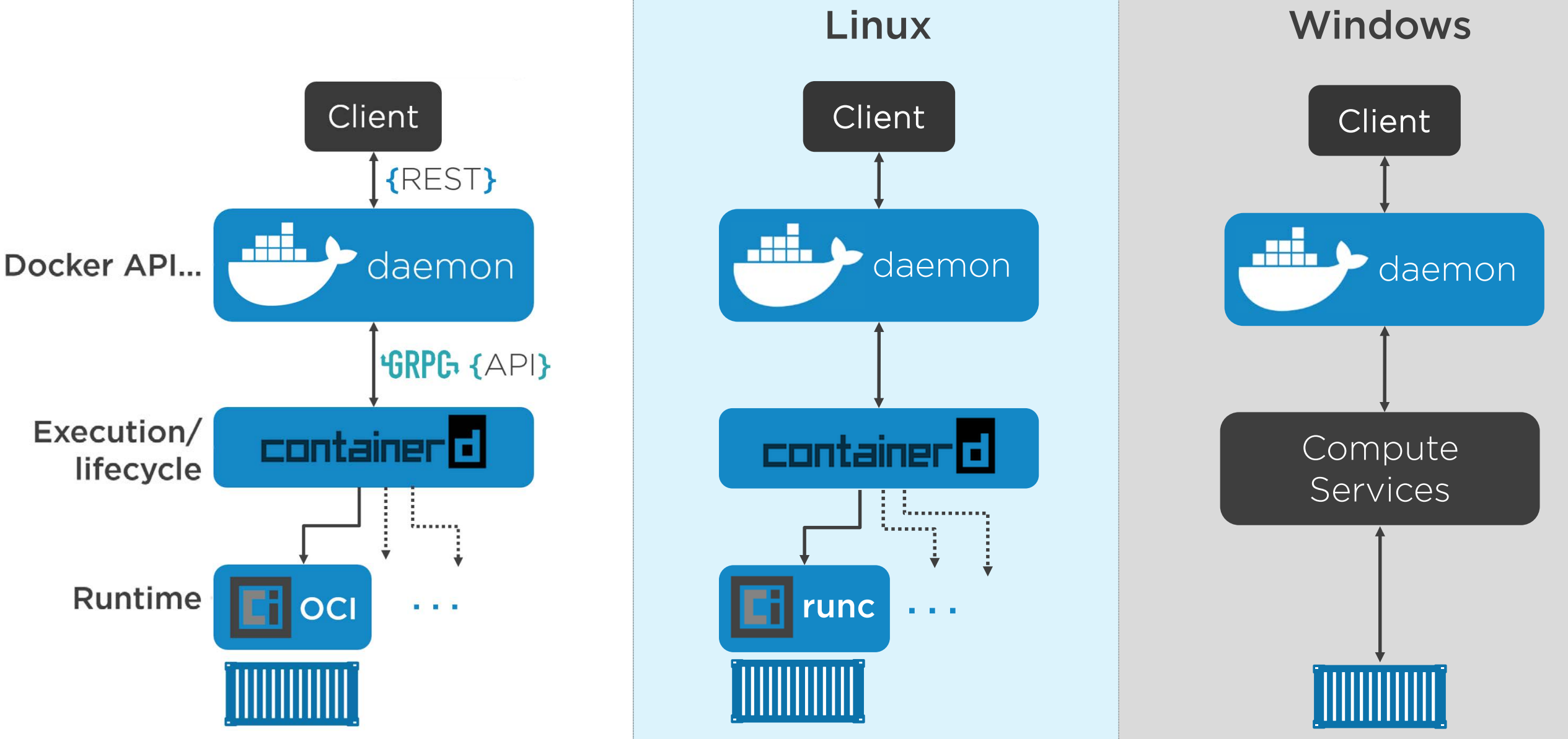
Control Groups

(Windows a.k.a. Job Objects)

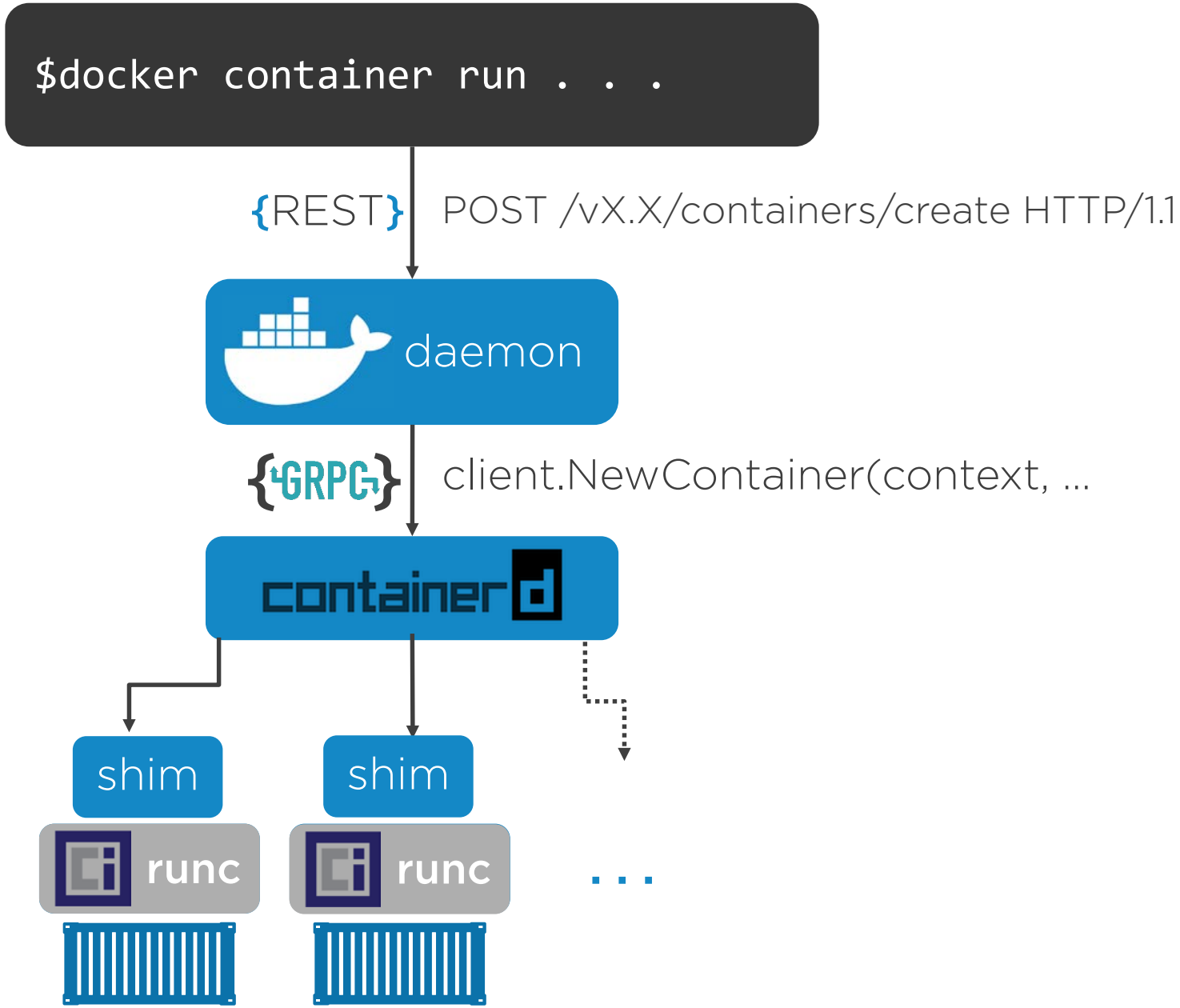
- Grouping processes
- Imposing resource limits


{API}
namespaces
cgroups
. . .
Windows
Linux

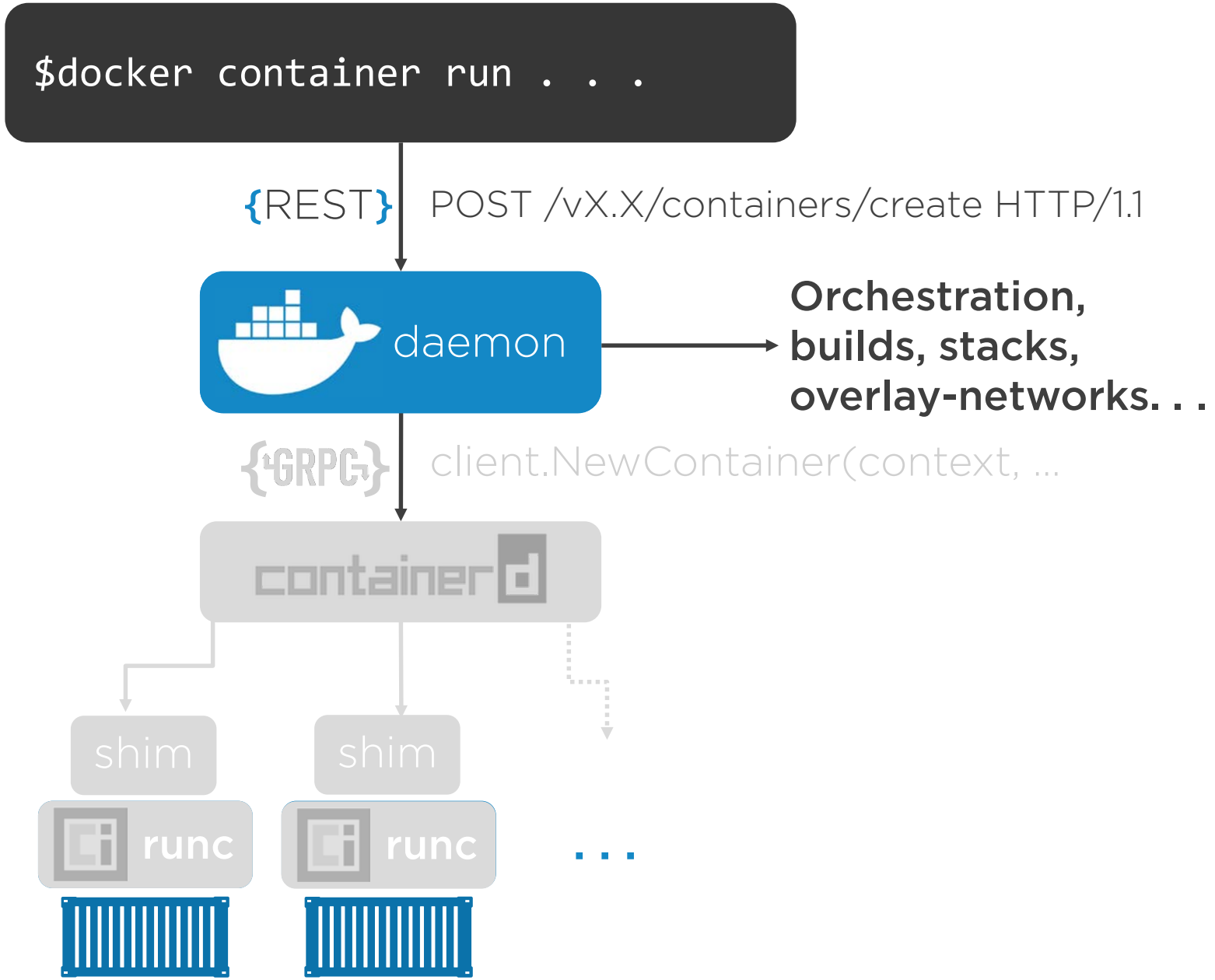

namespaces
cgroups
libcontainer
HTTP srvr
compose
exec
runtime
images
authz
builds
vols
orchestration
REST API
network
docker
(daemon)
registry


Linux
Windows
Client
{REST}
Docker API...
daemon
GRPC {API}
Execution/
lifecycle
containerd
Runtime
OCI
runc
Compute
Services

Example:
Creating a new container on Linux



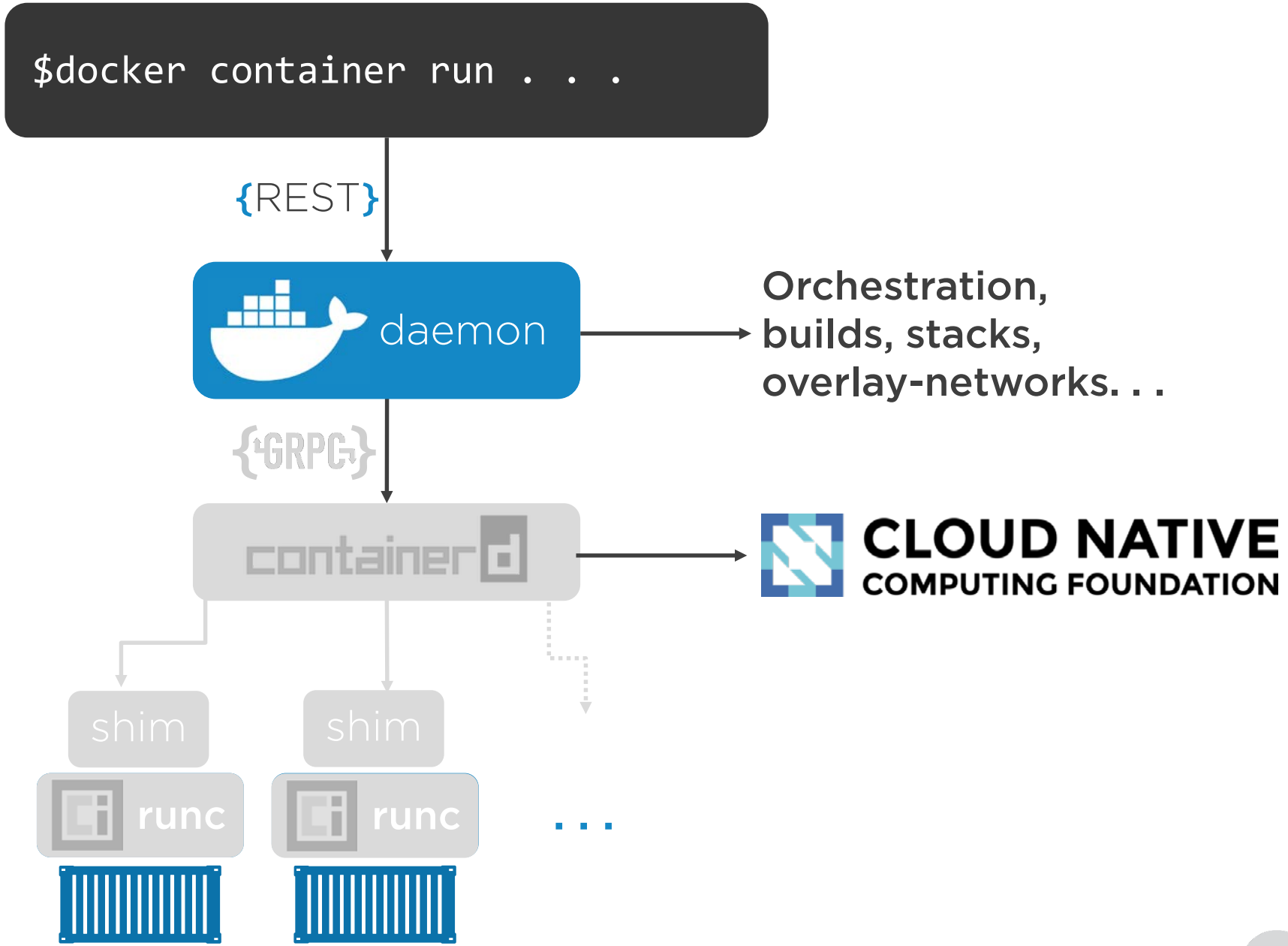
Example:
Creating a new container on Linux

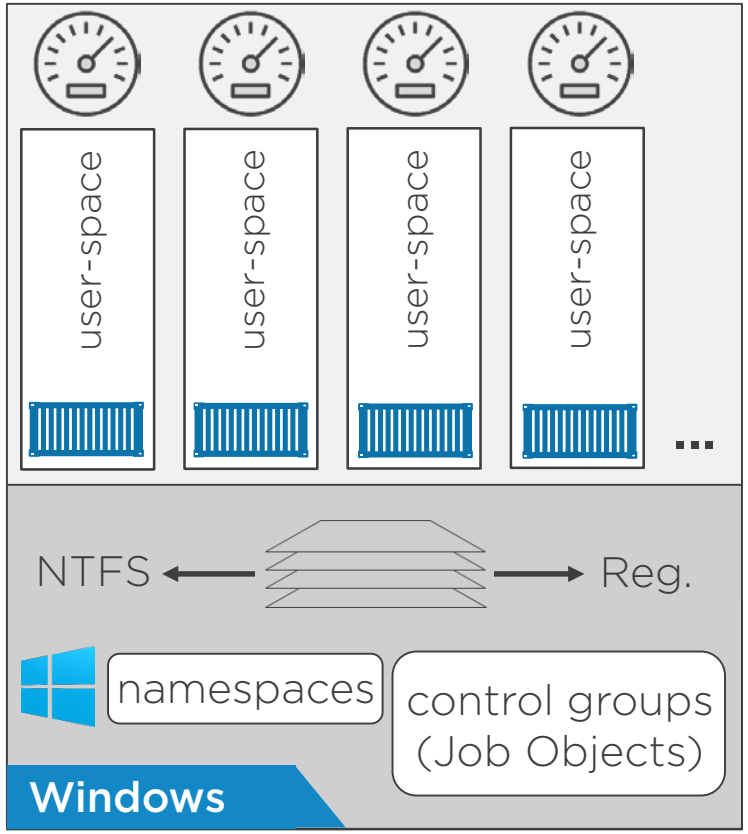


There's a branch of containerd that's implementing things like:

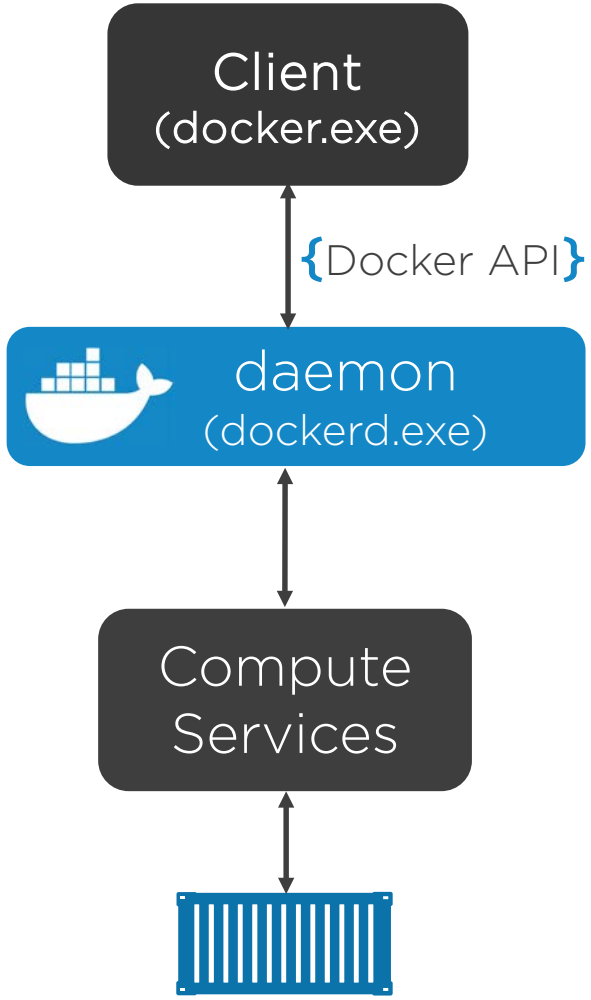
- Basic networking
- Basic storage
- Basic image distribution
- ...

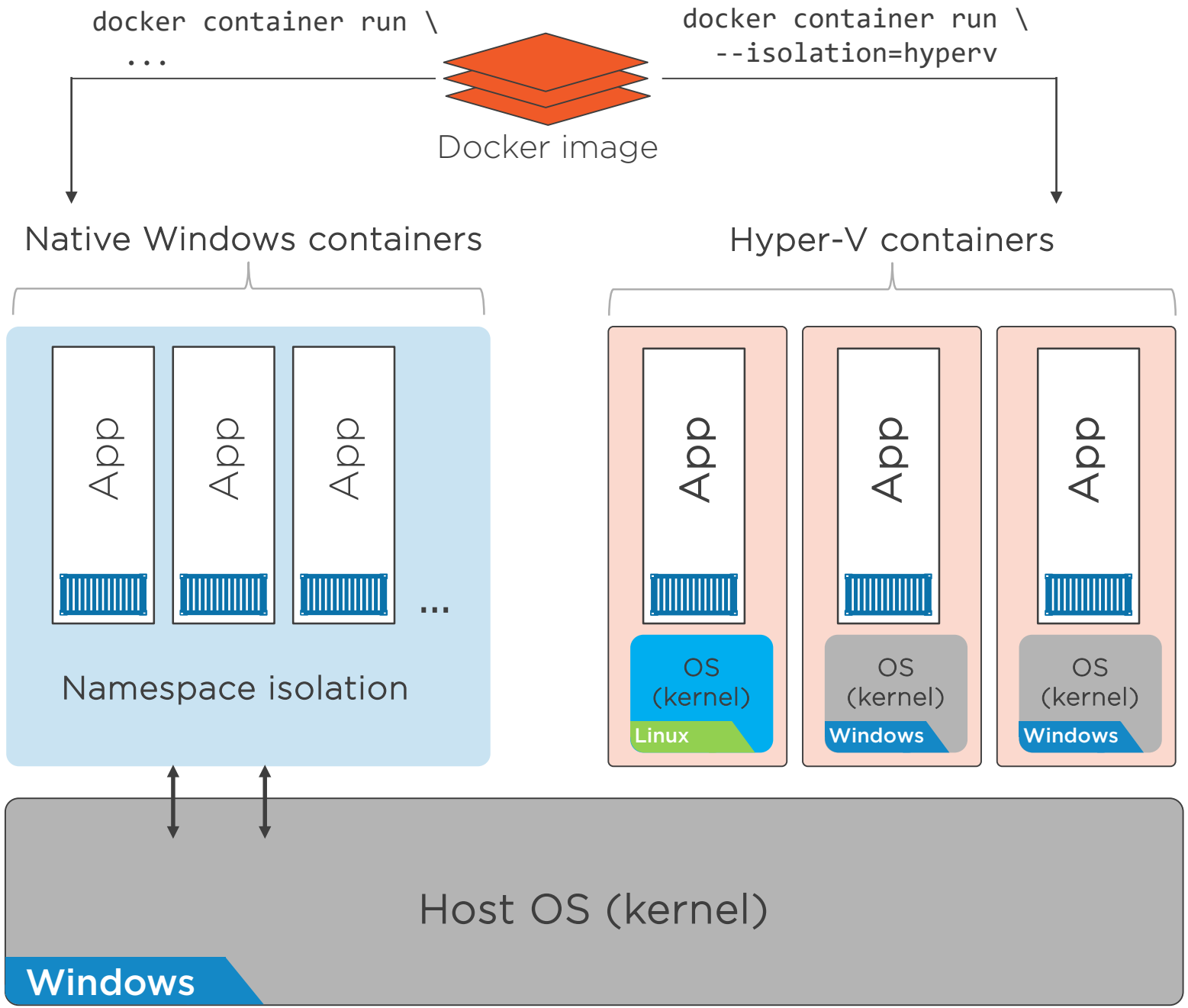
Each one is well-defined and not tightly coupled.






```
PS C:\> ps
Handles NPM(K) PM(K) WS(K) CPU(s) Id SI ProcessName
------- ------ ----- ----- ------ -- -- -----------
      0      5   964  1292   0.00 4716 4 CExecSvc
      0      5   592   956   0.00 4524 4 csrss
      0      0     0     4           0 0 Idle
      0     18  3984  8624   0.13  700 4 lsass
      0     52 26624 19400   1.64 2100 4 powershell
      0     38 28324 49616   1.69 4464 4 powershell
      0      8  1488  3032   0.06 2488 4 services
      0      2   288   504   0.00 4508 0 smss
      0      8  1600  3004   0.03  908 4 svchost
      0     12  1492  3504   0.06 4572 4 svchost
      0     15 20284 23428   5.64 4628 4 svchost
      0     15  3704  7536   0.09 4688 4 svchost
      0     28  5708  6588   0.45 4712 4 svchost
      0     10  2028  4736   0.03 4840 4 svchost
      0     11  5364  4824   0.08 4928 4 svchost
      0      0   128   136  37.02    4 0 System
      0      7   920  1832   0.02 3752 4 wininit
      0      8  5472 11124   0.77 5568 4 WmiPrvSE
```




docker container run \
...
docker container run \
--isolation=hyperv
Docker image
Native Windows containers
Hyper-V containers
App
App
App
...
Namespace isolation
App
App
App
OS
(kernel)
Linux
OS
(kernel)
Windows
OS
(kernel)
Windows
Host OS (kernel)
Windows

Hyper-V Containers

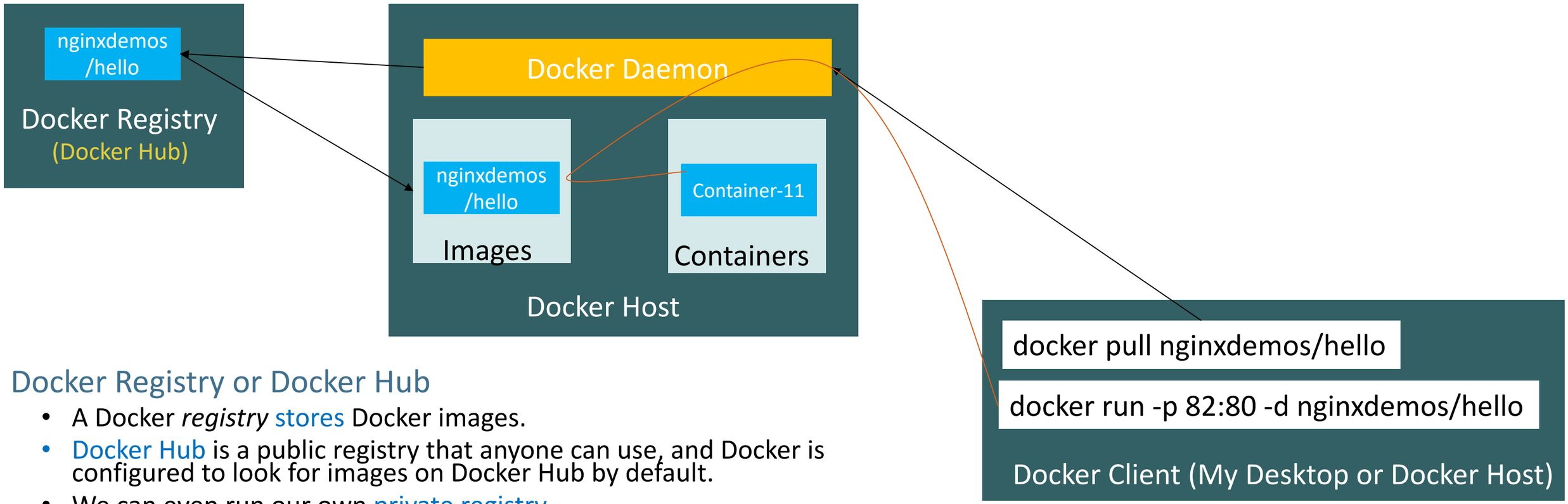
Based on Hyper-V Virtual Machines

Highly Optimized

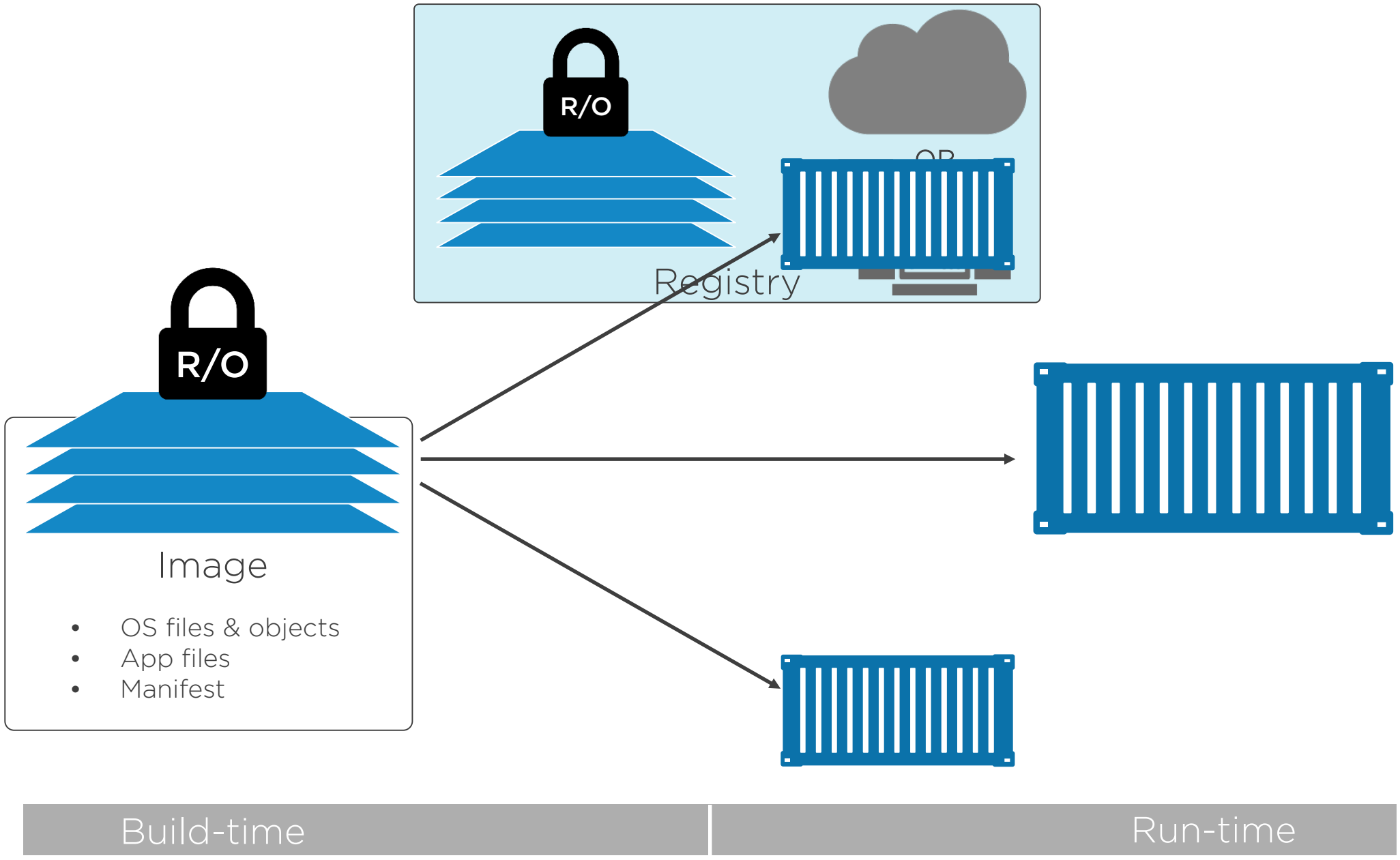
Allow older images to work on newer versions of Windows

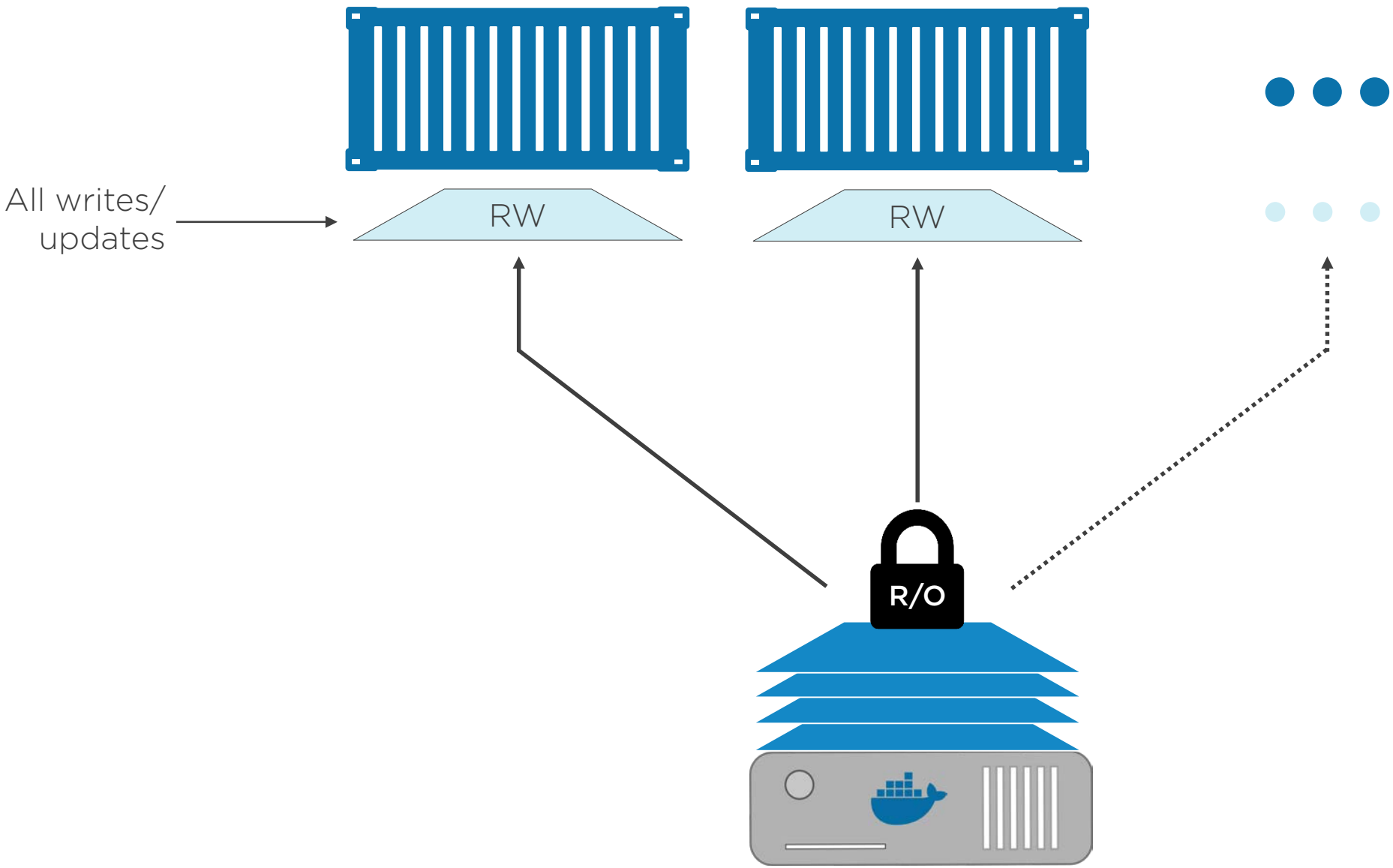
Resource utilization worse than Windows Server Containers

Docker - Fundamentals



- Docker Registry or Docker Hub
  - A Docker *registry* stores Docker images.
  - Docker Hub is a public registry that anyone can use, and Docker is configured to look for images on Docker Hub by default.
  - We can even run our own private registry.
  - When we use the docker pull or docker run commands, the required images are pulled from our configured registry.
  - When we use the docker push command, our image is pushed to our configured registry.


R/O
Registry
R/O
Image
• OS files & objects
• App files
• Manifest
Build-time
Run-time


All writes/
updates
RW
RW
R/O

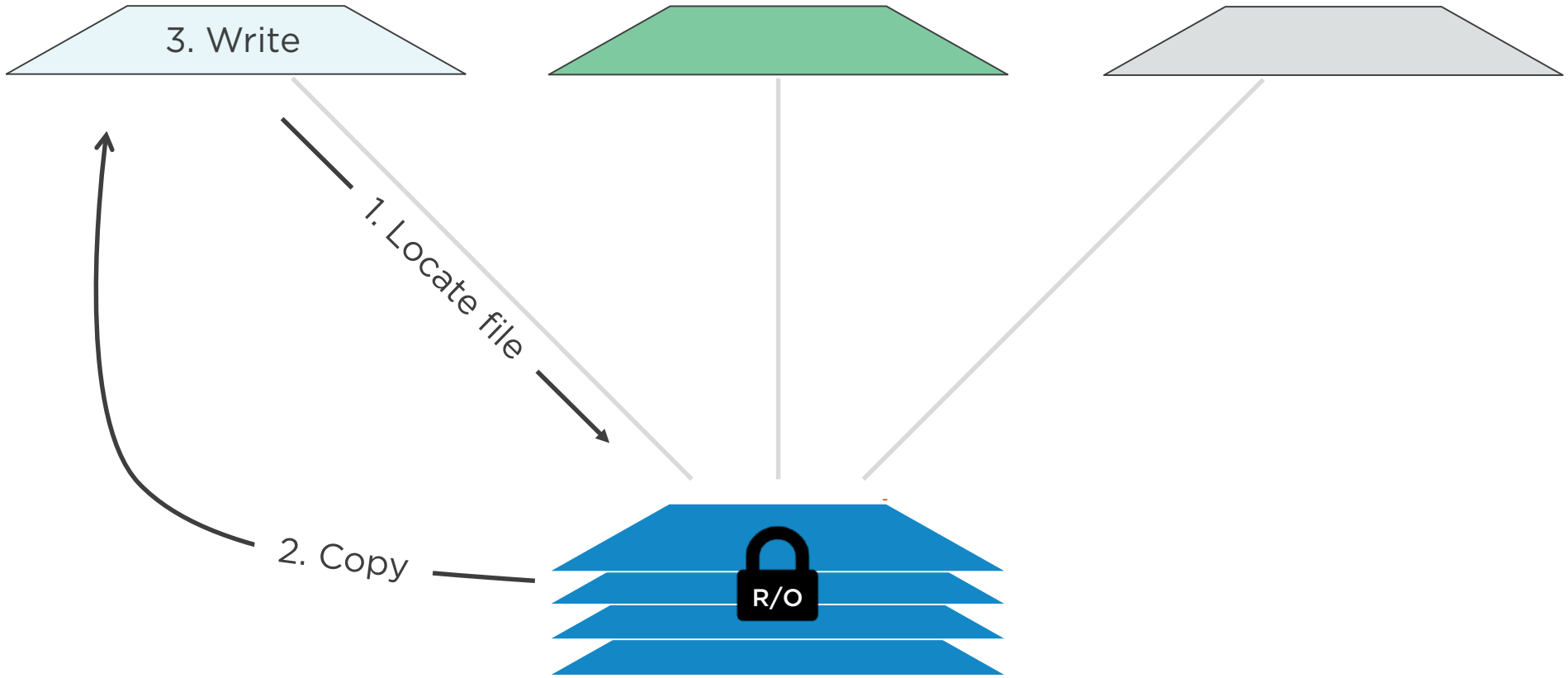
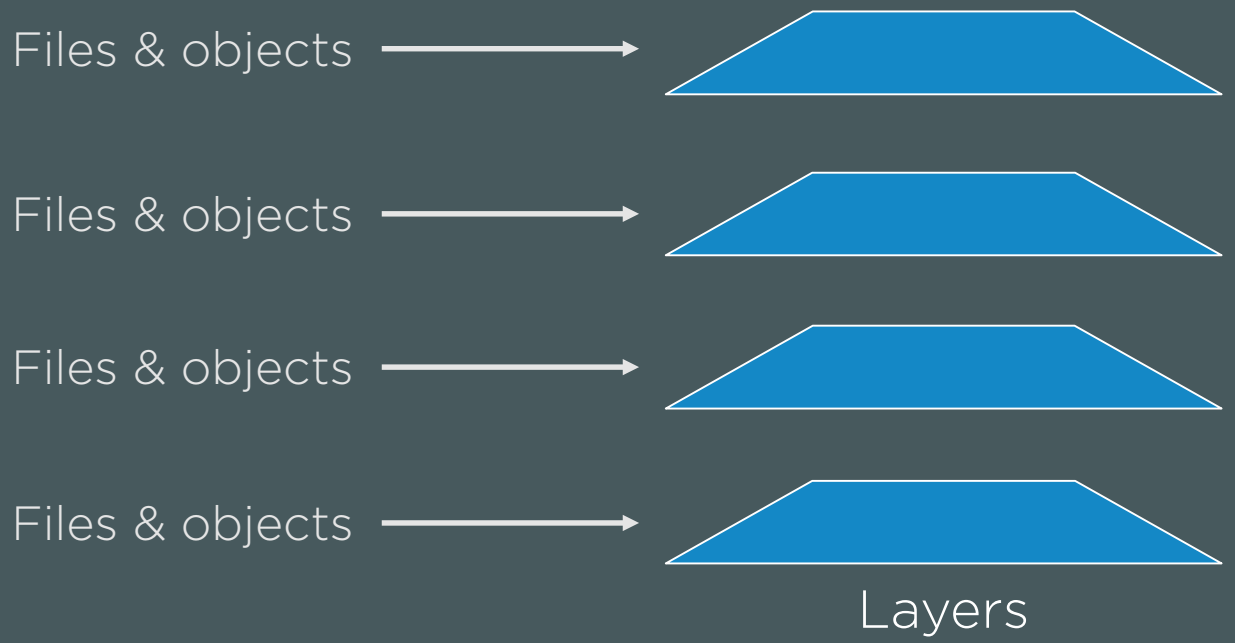
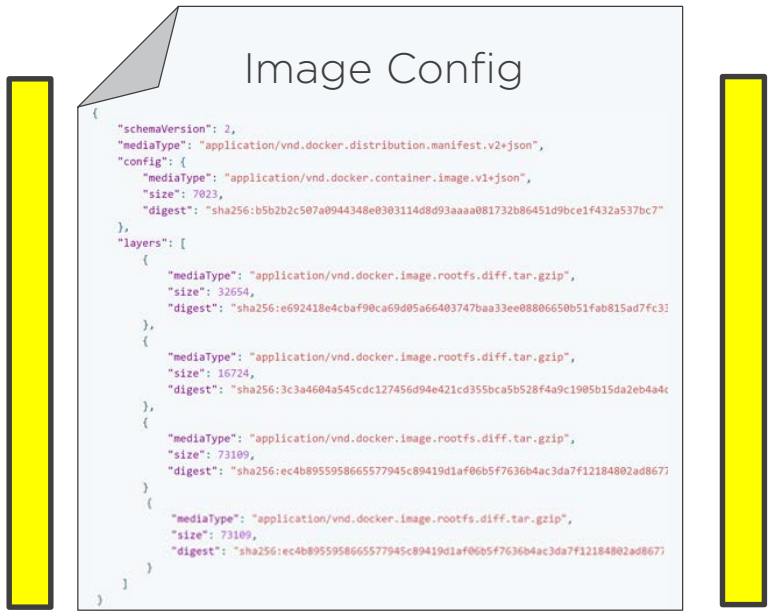

3. Write
1. Locate file
2. Copy
R/O

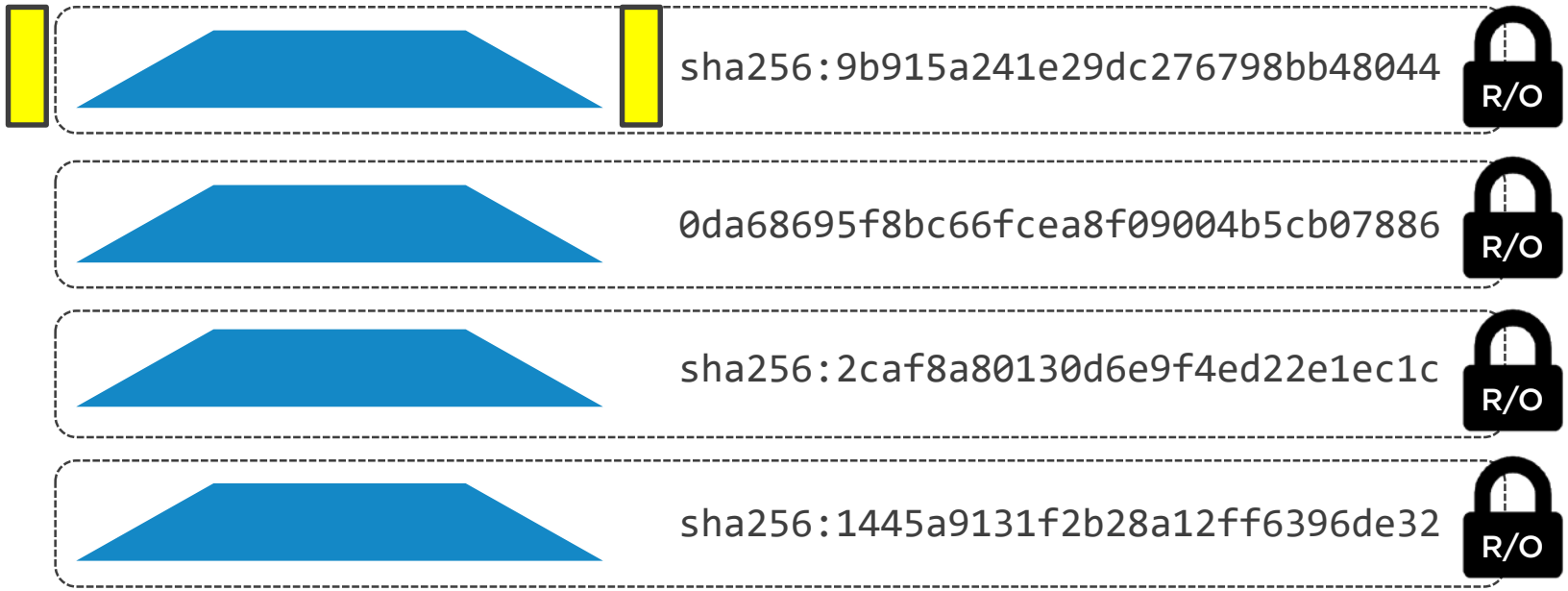
Image Manifest


```
{
    "schemaVersion": 2,
    "mediaType": "application/vnd.docker.distribution.manifest.v2+json",
    "config": {
        "mediaType": "application/vnd.docker.container.image.v1+json",
        "size": 7023,
        "digest": "sha256:b5b2b2c507a0944348e0303114d8d93aaaa081732b86451d9bce1f432a537bc7"
    },
    "layers": [
        {
            "mediaType": "application/vnd.docker.image.rootfs.diff.tar.gzip",
            "size": 32654,
            "digest": "sha256:e692418e4cbaf90ca69d05a66403747baa33ee08806650b51fab815ad7fc3
        },
        {
            "mediaType": "application/vnd.docker.image.rootfs.diff.tar.gzip",
            "size": 16724,
            "digest": "sha256:3c3a4604a545cdc127456d94e421cd355bca5b528f4a9c1905b15da2eb4a4
        },
        {
            "mediaType": "application/vnd.docker.image.rootfs.diff.tar.gzip",
            "size": 73109,
            "digest": "sha256:ec4b8955958665577945c89419d1af06b5f7636b4ac3da7f12184802ad867
        }
        {
            "mediaType": "application/vnd.docker.image.rootfs.diff.tar.gzip",
            "size": 73109,
            "digest": "sha256:ec4b8955958665577945c89419d1af06b5f7636b4ac3da7f12184802ad867
        }
    ]
}
```



sha256:d124781fc06a73b05



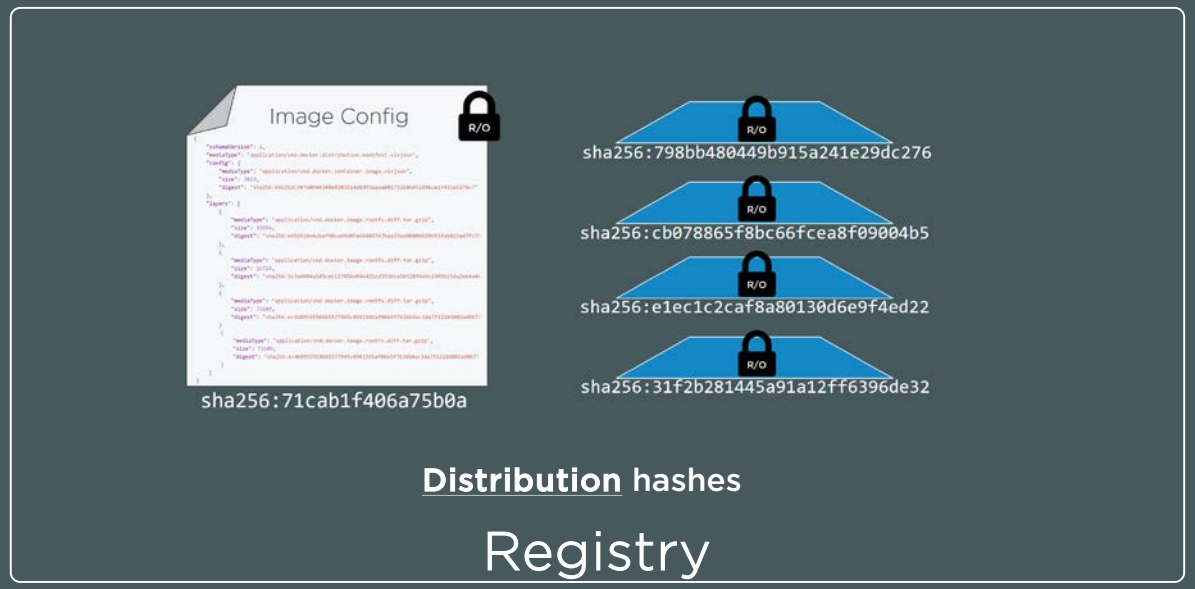
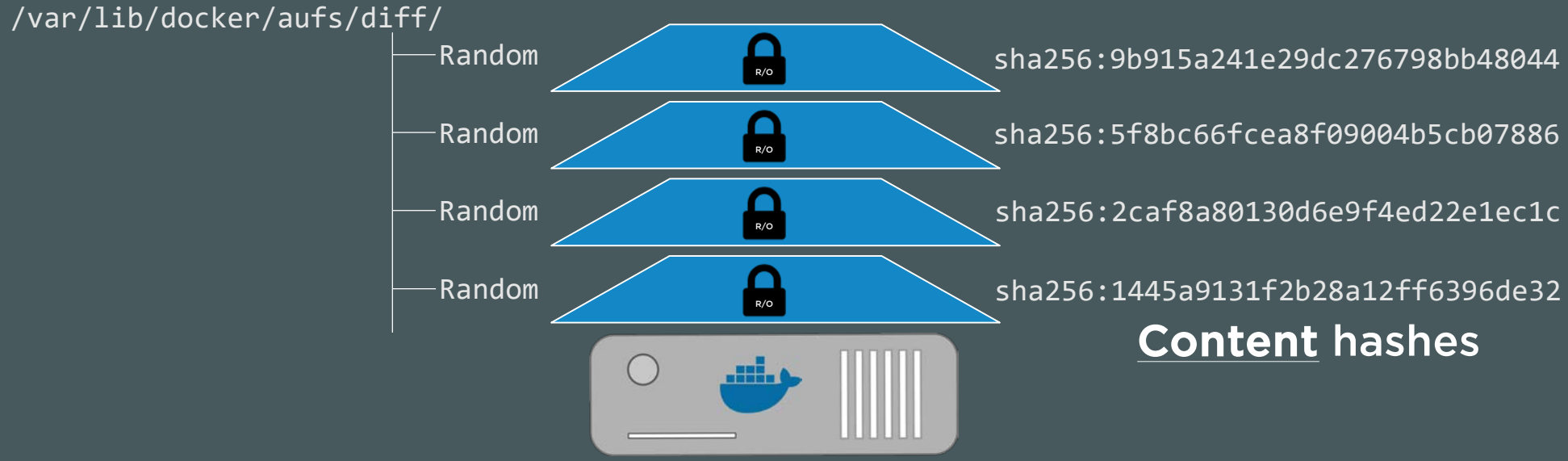
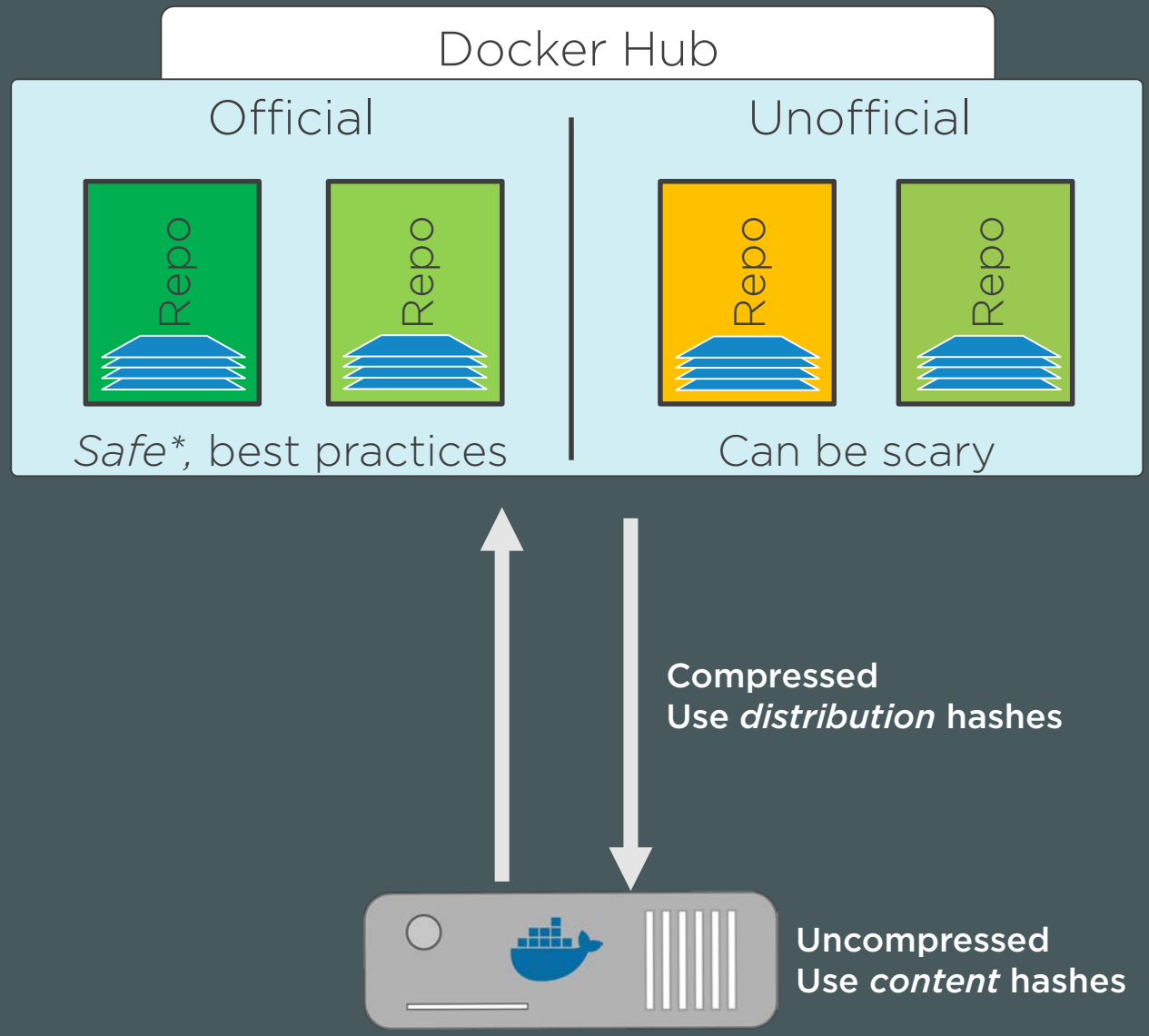
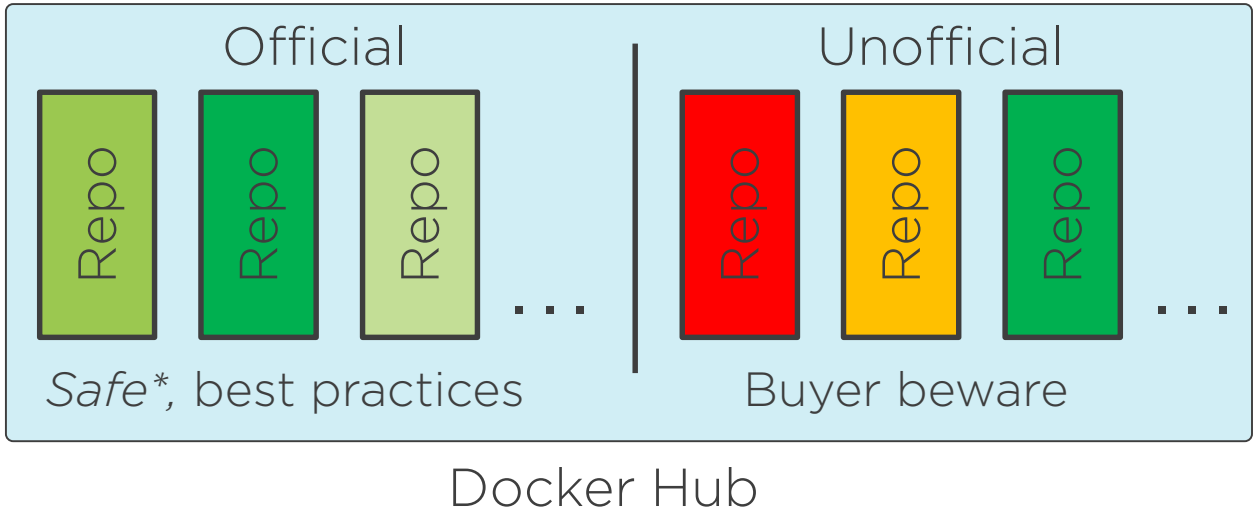


Image Config
R/O
sha256:71cab1f406a75b0a
R/O
sha256:798bb480449b915a241e29dc276
R/O
sha256:cb078865f8bc66fcea8f09004b5
R/O
sha256:e1ec1c2caf8a80130d6e9f4ed22
R/O
sha256:31f2b281445a91a12ff6396de32
Distribution hashes
Registry


/var/lib/docker/aufs/diff/
Random
Random
Random
Random
R/O
R/O
R/O
R/O
sha256:9b915a241e29dc276798bb48044
sha256:5f8bc66fcea8f09004b5cb07886
sha256:2caf8a80130d6e9f4ed22e1ec1c
sha256:1445a9131f2b28a12ff6396de32
Content hashes


Docker Hub
Official
Unofficial
Repo
Repo
Repo
Repo
*Safe**, best practices
Can be scary
Compressed
Use *distribution* hashes
Uncompressed
Use *content* hashes

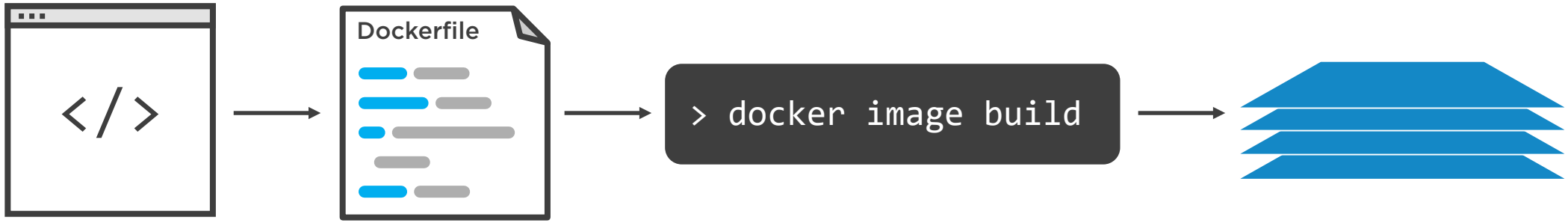



```
$ docker image push
```

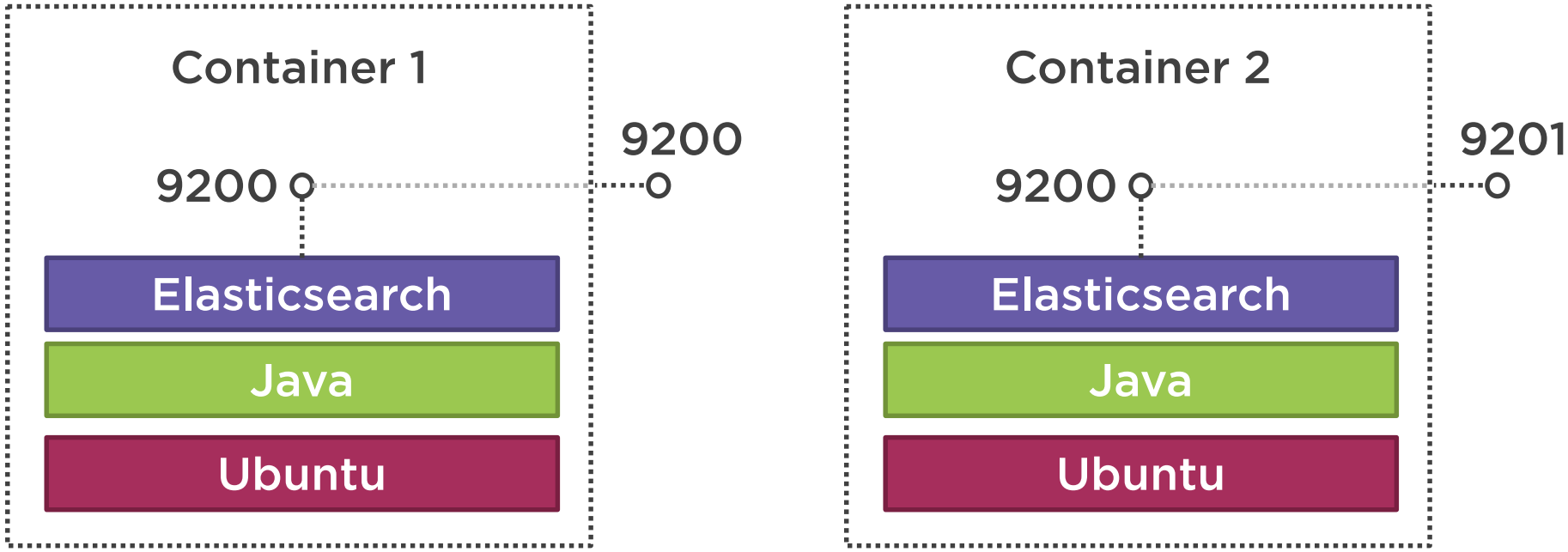
```
$ docker image pull
```

```
$ docker image inspect
```

```
$ docker image rm
```


Dockerfile
> docker image build

Network



Containers can publish a port

Docker hosts can map a port

Environment Variables

Containers have their own environment variables

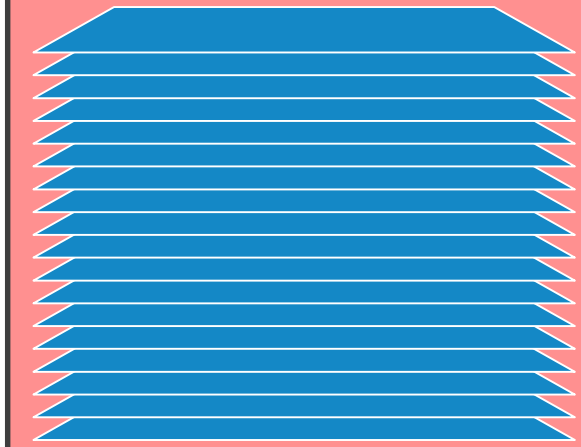
Key Dockerfile Instructions

FROM	LABEL (ex: maintainer/author)	RUN
COPY	ENTRYPOINT	WORKDIR
EXPOSE	ENV	VOLUME

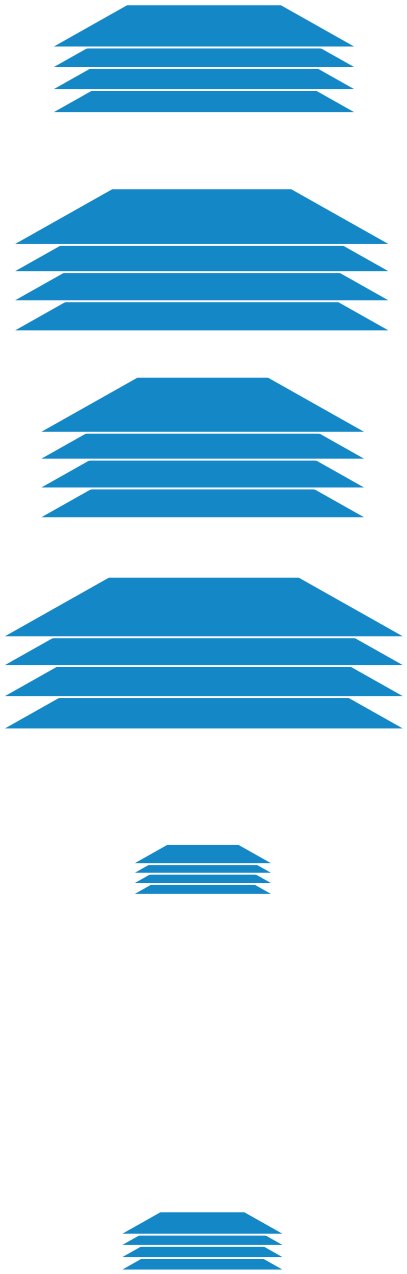
Small Images

Minimal OS
and packages

Bloated Images



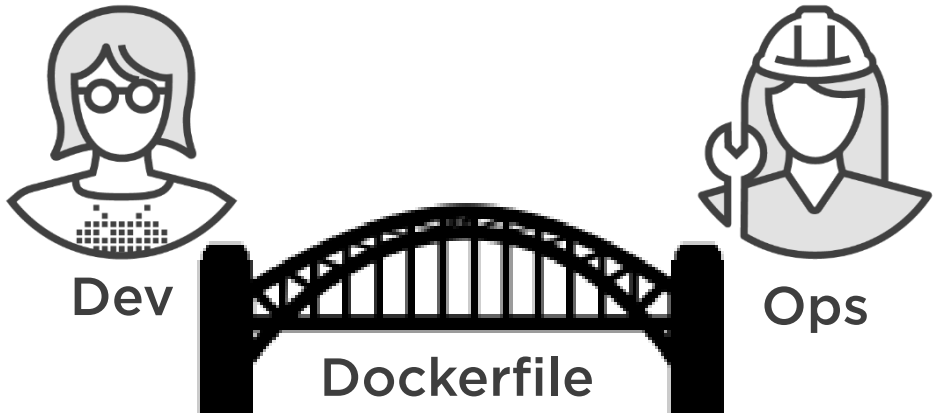
Too much OS
Too many packages



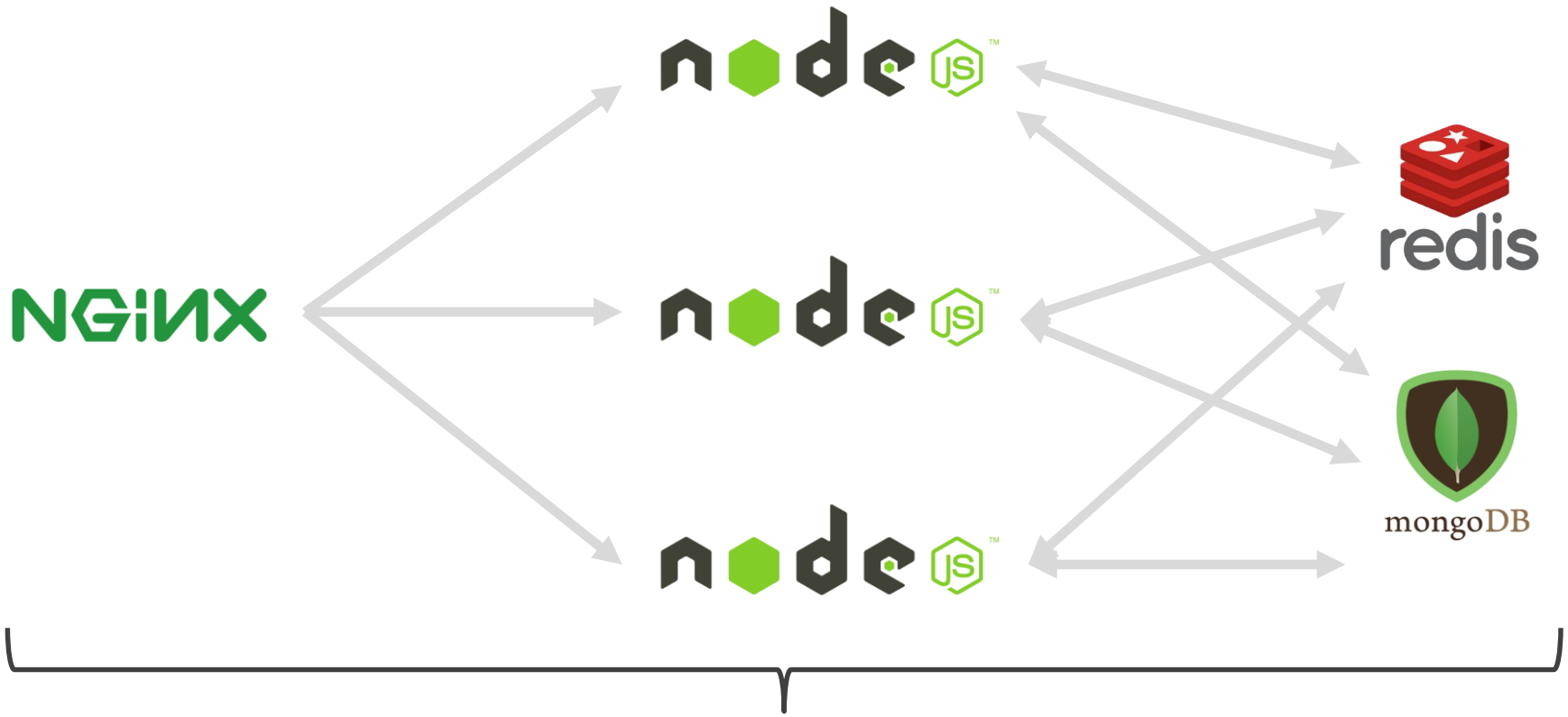
```
FROM node:latest AS storefront
WORKDIR /usr/src/atsea/app/react-app
COPY react-app .
RUN npm install
RUN npm run build

FROM maven:latest AS appserver
WORKDIR /usr/src/atsea
COPY pom.xml .
RUN mvn -B -f pom.xml -s /usr/share/maven/ref/settings-docker.xml dependency:resolve
COPY . .
RUN mvn -B -s /usr/share/maven/ref/settings-docker.xml package -DskipTests

FROM java:8-jdk-alpine AS production
RUN adduser -Dh /home/gordon gordon
WORKDIR /static
COPY --from=storefront /usr/src/atsea/app/react-app/build/ .
WORKDIR /app
COPY --from=appserver /usr/src/atsea/target/AtSea-0.0.1-SNAPSHOT.jar .
ENTRYPOINT ["java", "-jar", "/app/AtSea-0.0.1-SNAPSHOT.jar"]
CMD ["--spring.profiles.active=postgres"]
```

Dockerfile

```
FROM … AS Build-Stage-0

FROM … AS Build-Stage-1

FROM … AS Production-Stage
```

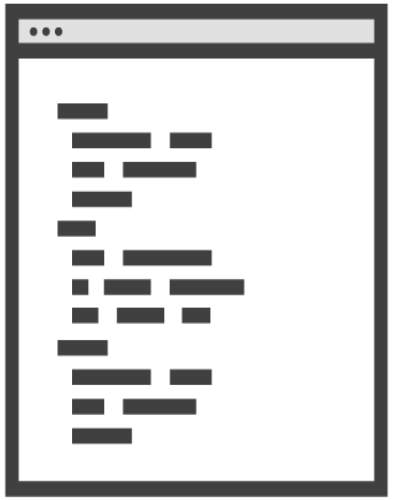


The Need For Docker Compose



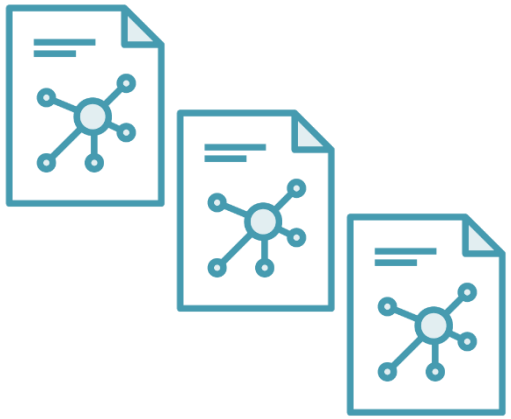
Docker Compose
(docker-compose.yml)

The Role of the Docker Compose File



docker-compose.yml
(service configuration)

Docker Compose
Build



Docker Images
(services)

Key Service Configuration Options

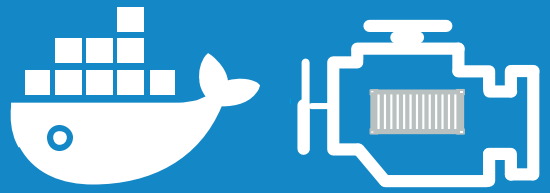
build	**environment**	**image**
networks	**ports**	**volumes**

docker-compose.yml Example

```
version: "3.x"
services:
  node:
    build:
      context: .
      dockerfile: node.dockerfile
    networks:
      -nodeapp-network

  mongodb:
     image: mongo
     networks:
       - nodeapp-network

networks:
  nodeapp-network
    driver: bridge
```

Logging

Engine/daemon



Linux

- **systemd:**

  `journalctl -u docker.service`

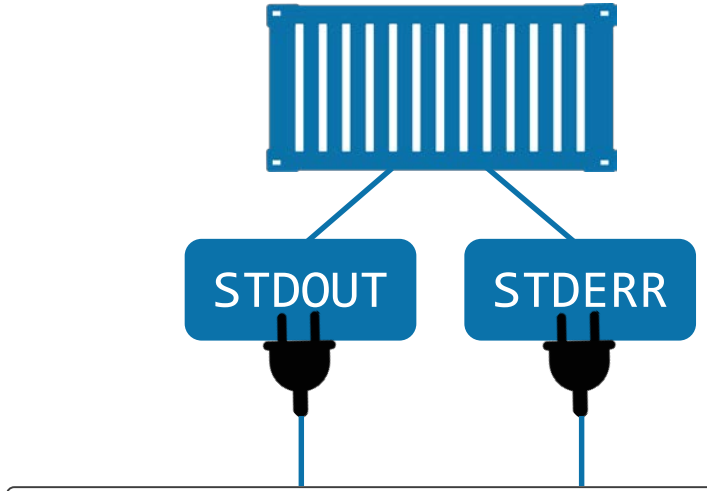
- **Non-systemd:**

  Try `/var/log/messages`

Windows:

`~/AppData/Local/Docker`

Container/App

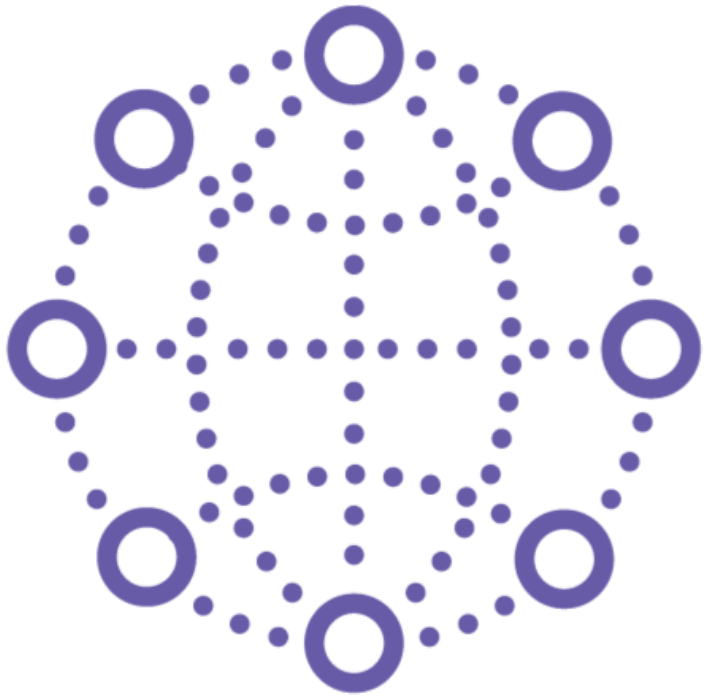


Set default logging driver in `daemon.json`

Override per-container with
`--log-driver --log-opts`

Inspect logs with `docker logs <container>`
- Doesn't work with all drivers

Orchestration

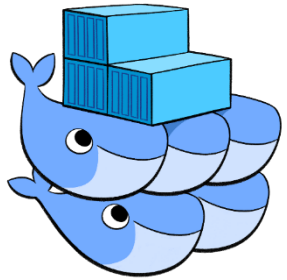


- Deploying at scale
- Scheduling workload
- Monitoring health
- Automated failover
- Service discovery
- Coordinated upgrades
- Cluster node affinity

The Benefits of Clusters

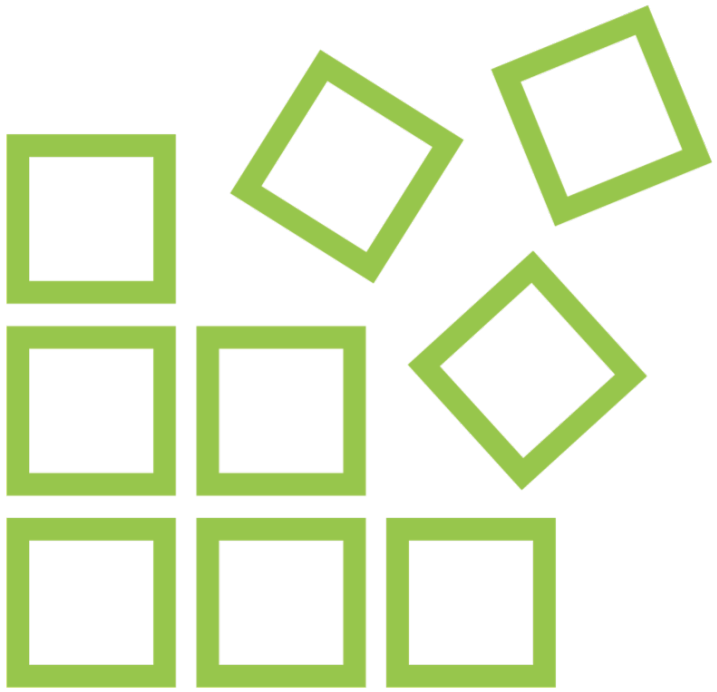
- Auto-scaling
- Load-balancing
- Abstracting individual machines
- Scalability
- Zero-downtime deployments
- Deployment rollback
- Simplified networking
- High availability

Operating at scale is hard!



Here to help!

Docker Swarm



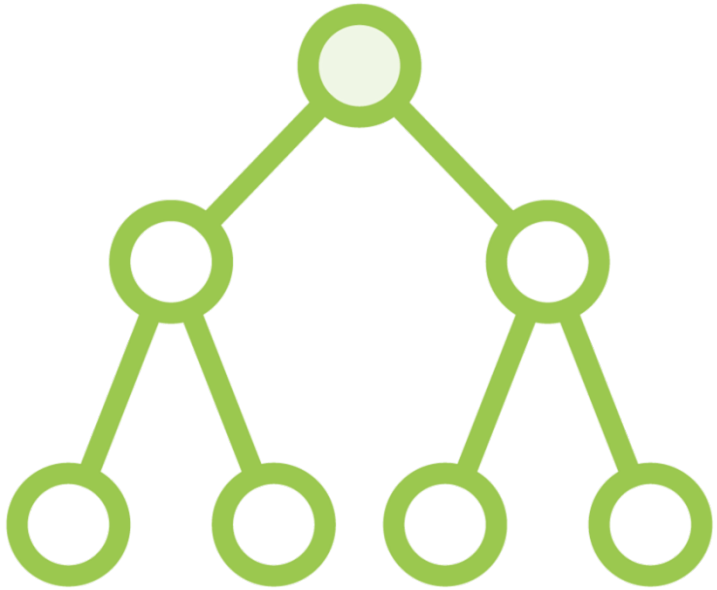
Created by Docker Inc.

Part of a default installation

Uses the same Docker CLI and API

Works with Docker Compose services

Kubernetes

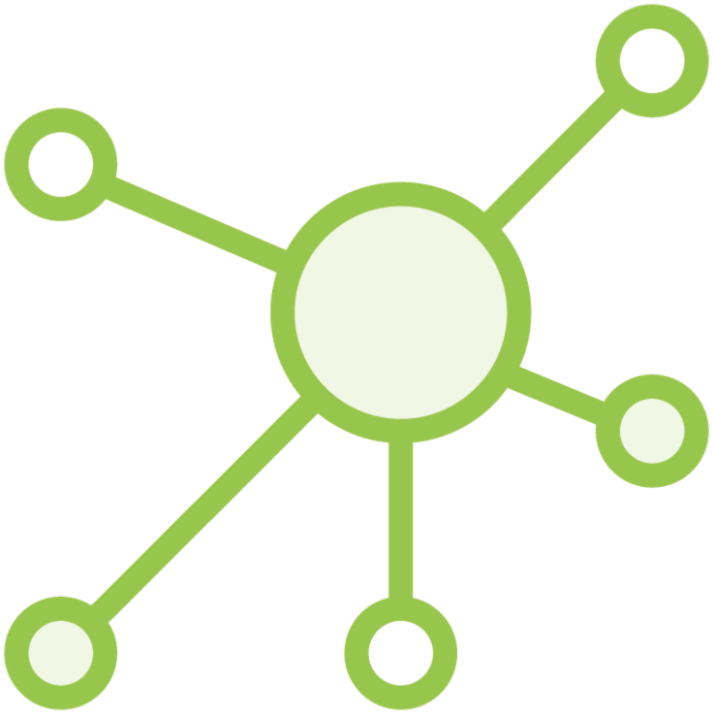


- Created by Google
- Based on Borg (internal tool used to run Google Search)
- Introduces new concepts such as pods and deployments
- Features own API and CLI
- Several distributions and managed services exist

Swarm vs. Kubernetes

Swarm	Kubernetes
Easier to migrate from Docker Compose	Harder to migrate from Docker Compose
Easier to set up if you use Docker	Harder to set up from scratch
Less features	More features
Smaller community	Large community
Very few integrations and extensions	A lot of integrations and extensions
Less popular as a managed service	Popular as a managed service
Simple	Complex

Mixed Linux/Windows Clusters



Docker Swarm is compatible with Windows containers

Kubernetes control plane runs on Linux

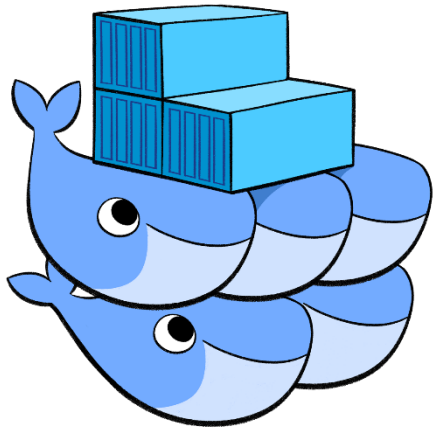
Worker nodes can run Windows

Windows Server 2016 is unsupported

Different Windows SAC releases are supported by different versions of Kubernetes

Swarm

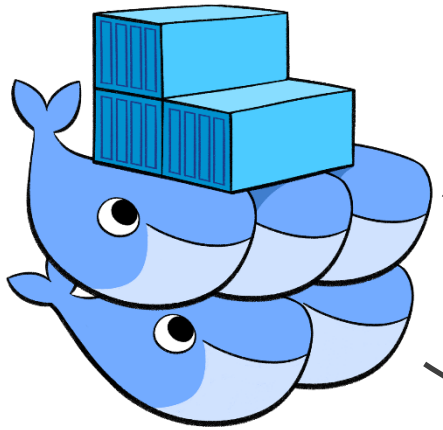
The future of Docker.

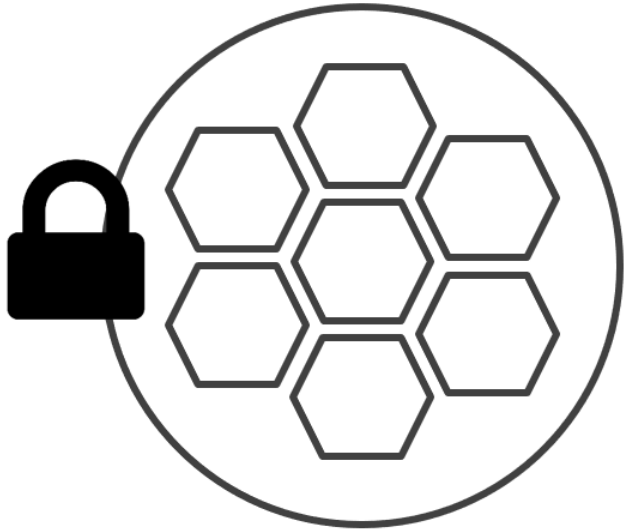


VS

Swarm

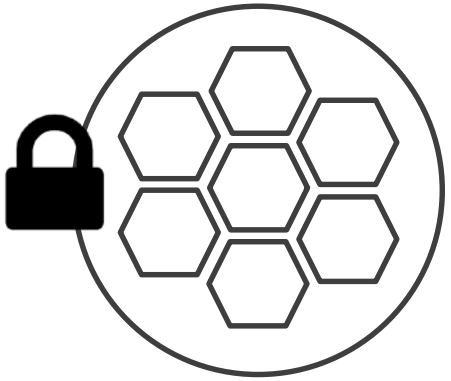
The future of Docker.



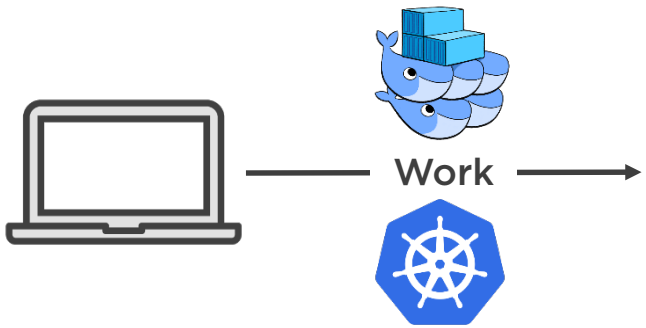


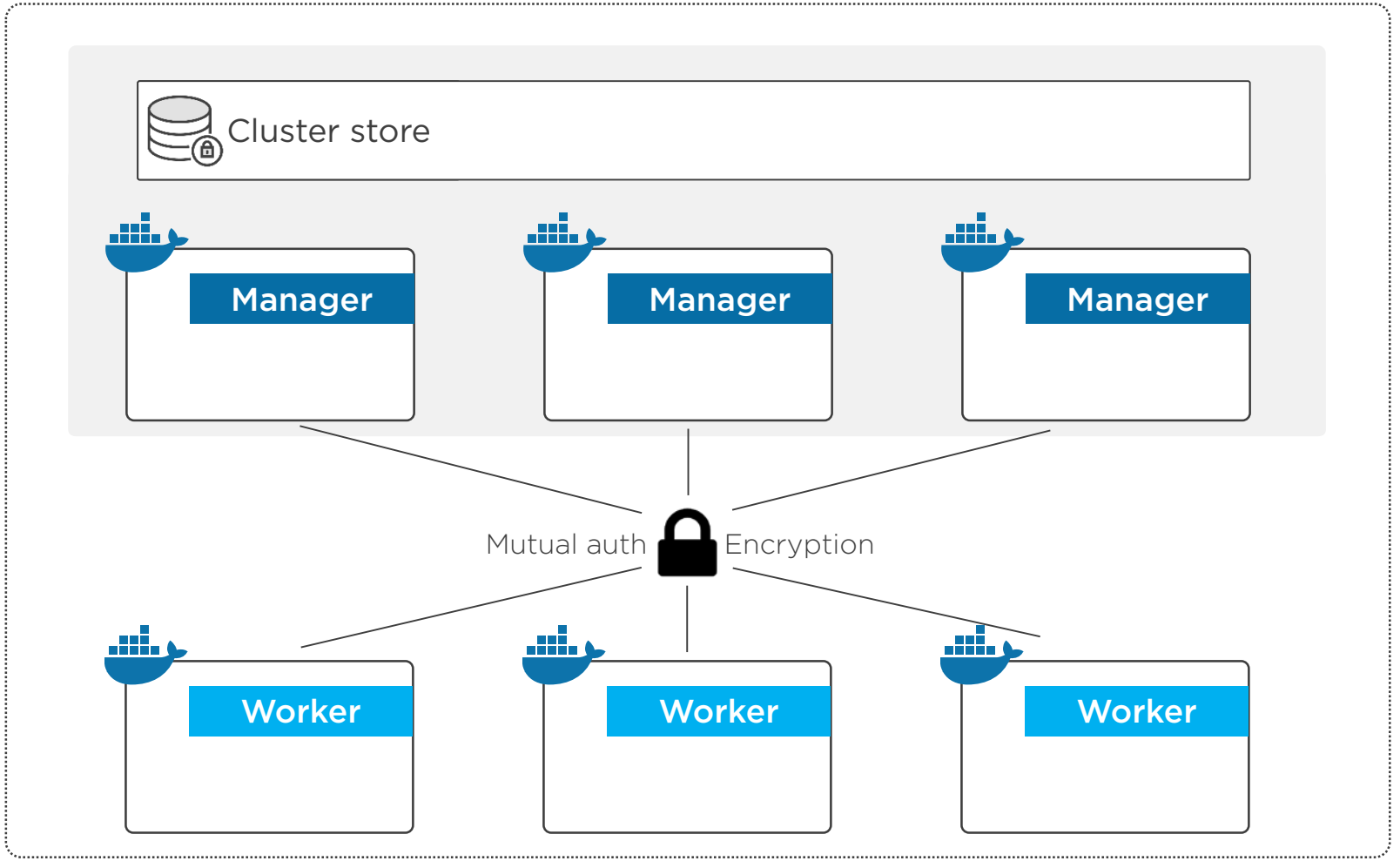
Secure cluster

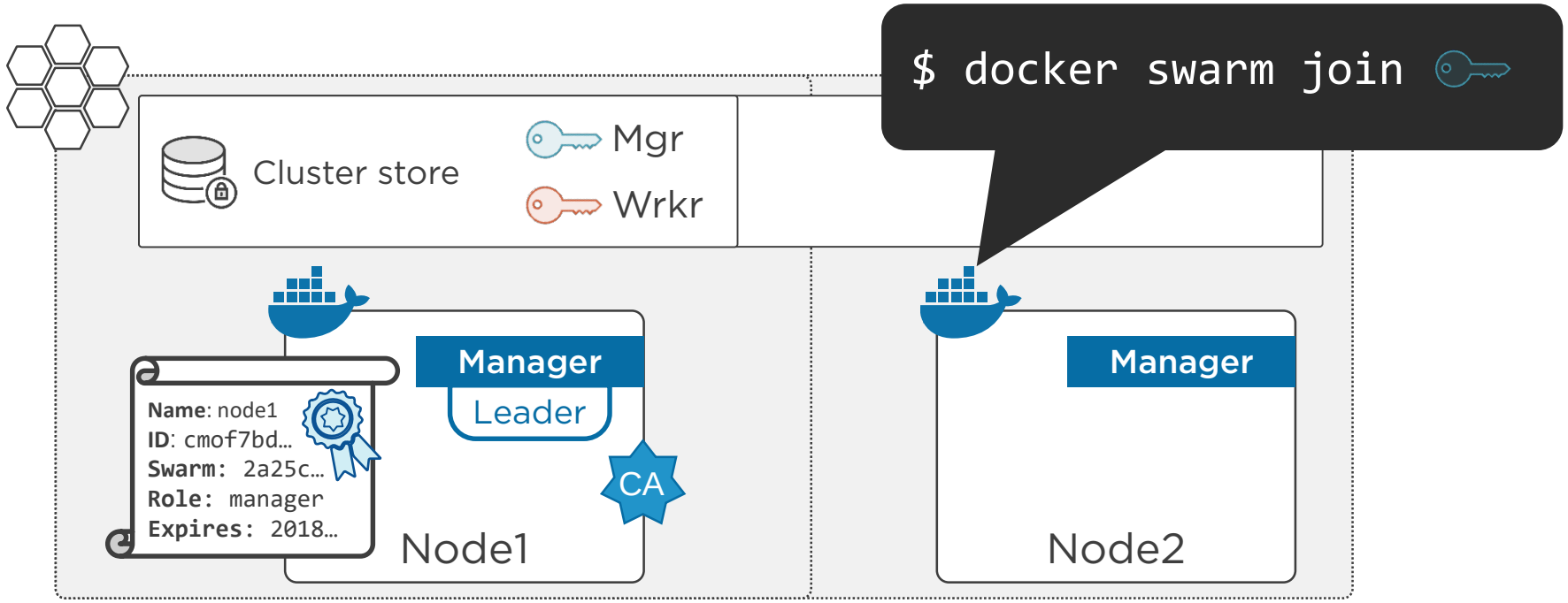
Orchestrator

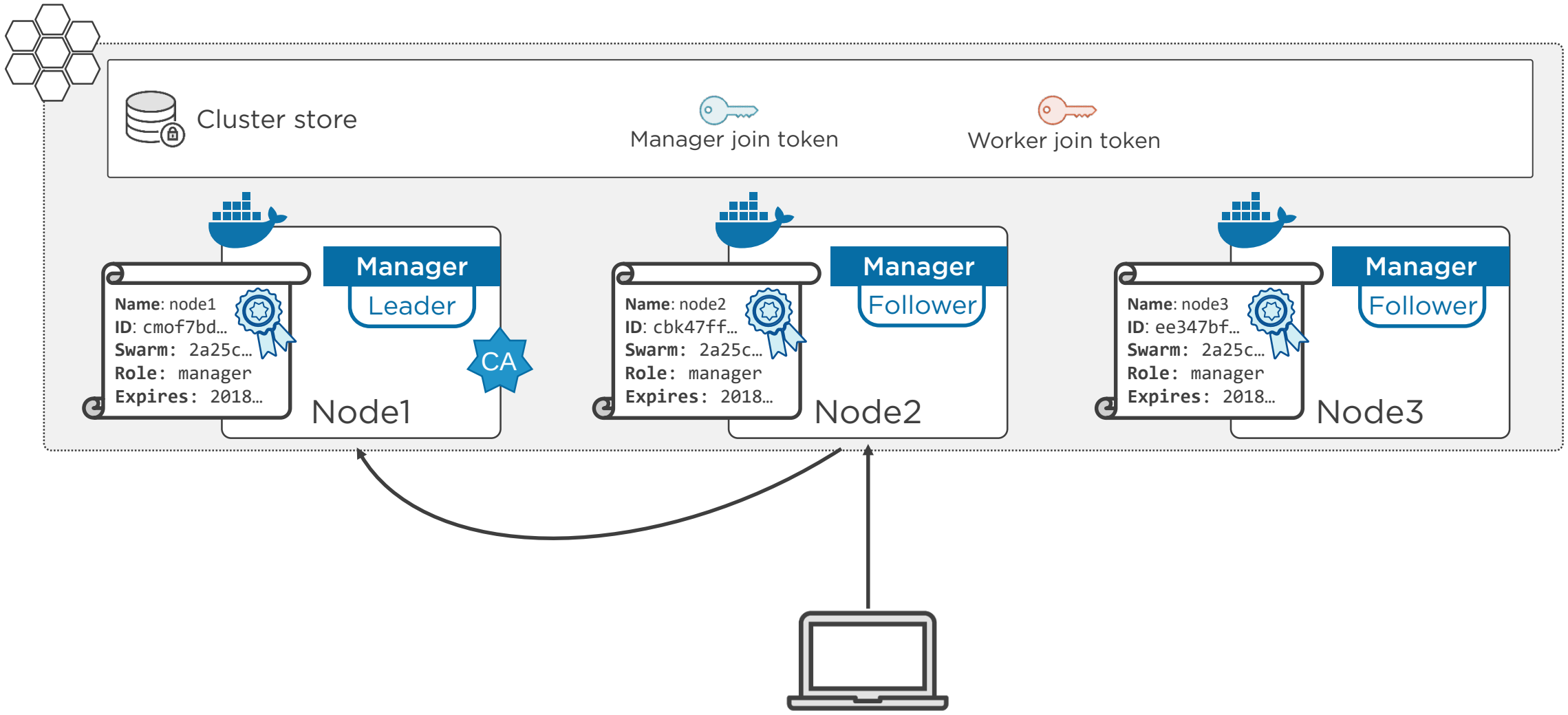


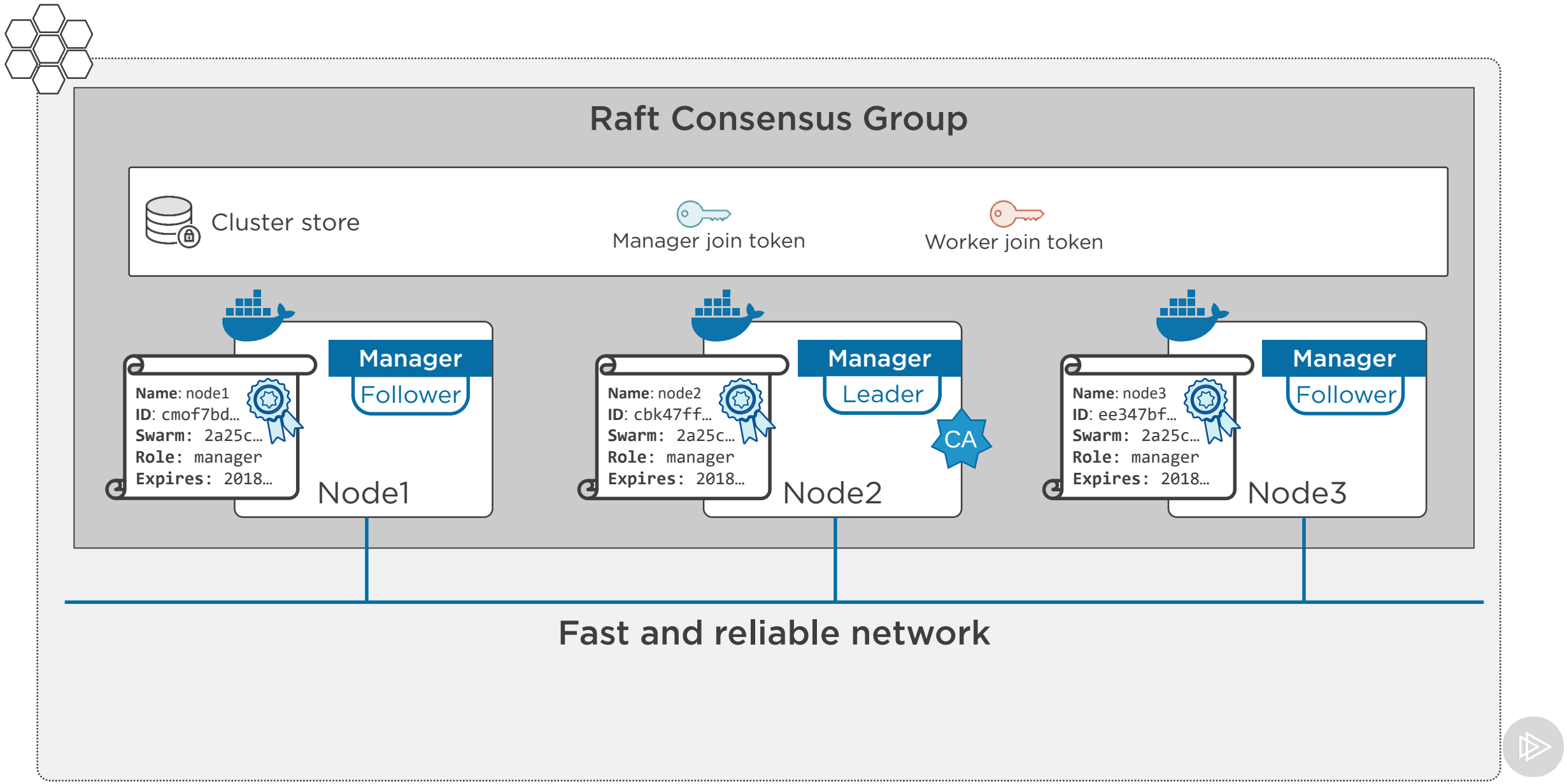
Secure Swarm cluster

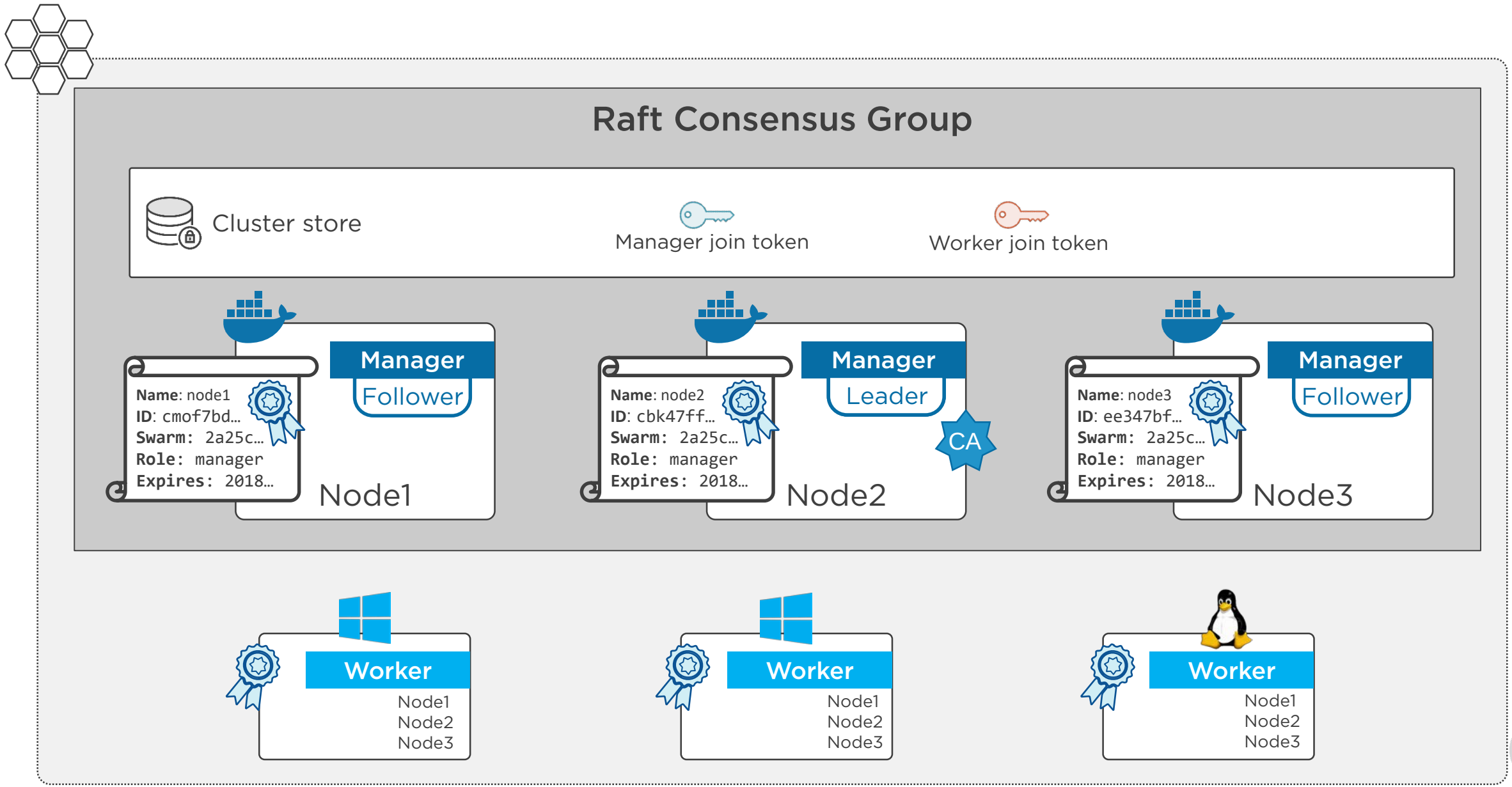





$ docker swarm join
Cluster store
Mgr
Wrkr
Name: node1
ID: cmof7bd...
Swarm: 2a25c...
Role: manager
Expires: 2018...
Manager
Leader
CA
Node1
Manager
Node2


Cluster store
Manager join token
Worker join token
Manager
Leader
Name: node1
ID: cmof7bd...
Swarm: 2a25c...
Role: manager
Expires: 2018...
CA
Node1
Manager
Follower
Name: node2
ID: cbk47ff...
Swarm: 2a25c...
Role: manager
Expires: 2018...
Node2
Manager
Follower
Name: node3
ID: ee347bf...
Swarm: 2a25c...
Role: manager
Expires: 2018...
Node3

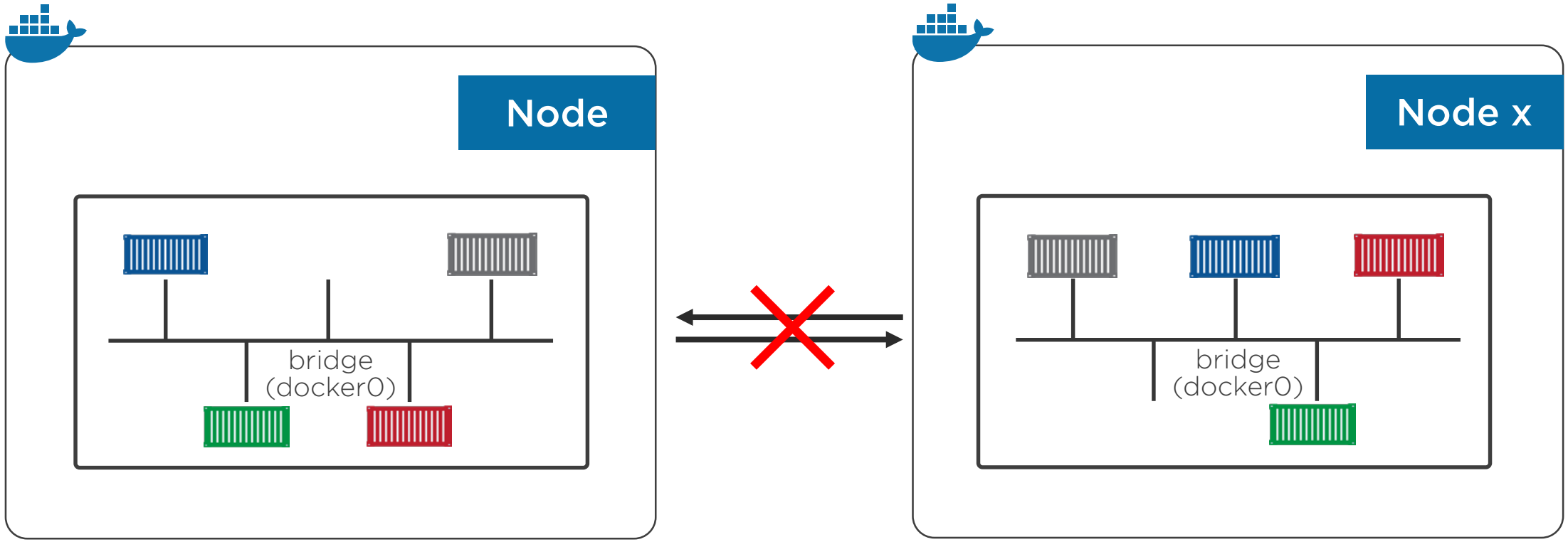

Raft Consensus Group
Cluster store
Manager join token
Worker join token
Manager
Follower
Name: node1
ID: cmof7bd...
Swarm: 2a25c...
Role: manager
Expires: 2018...
Node1
Manager
Leader
CA
Name: node2
ID: cbk47ff...
Swarm: 2a25c...
Role: manager
Expires: 2018...
Node2
Manager
Follower
Name: node3
ID: ee347bf...
Swarm: 2a25c...
Role: manager
Expires: 2018...
Node3
Fast and reliable network


Raft Consensus Group
Cluster store
Manager join token
Worker join token
Manager
Follower
Name: node1
ID: cmof7bd...
Swarm: 2a25c...
Role: manager
Expires: 2018...
Node1
Manager
Leader
CA
Name: node2
ID: cbk47ff...
Swarm: 2a25c...
Role: manager
Expires: 2018...
Node2
Manager
Follower
Name: node3
ID: ee347bf...
Swarm: 2a25c...
Role: manager
Expires: 2018...
Node3
Worker
Node1
Node2
Node3
Worker
Node1
Node2
Node3
Worker
Node1
Node2
Node3

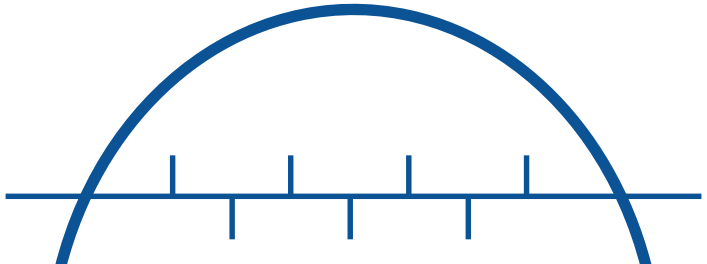
Create a Swarm (anywhere)

- Create a Swarm manager
  - Assign it a crypto ID
  - Elect it as the Swarm leader
- Create an Swarm config DB
  - Encrypt it
  - Configure it to automatically replicate with all Swarm managers
- Create a Swarm join token for new workers
- Create a Swarm join token for new manager
- Configure a new Root CA on the leader
  - Configure a 90 day certificate rotation period

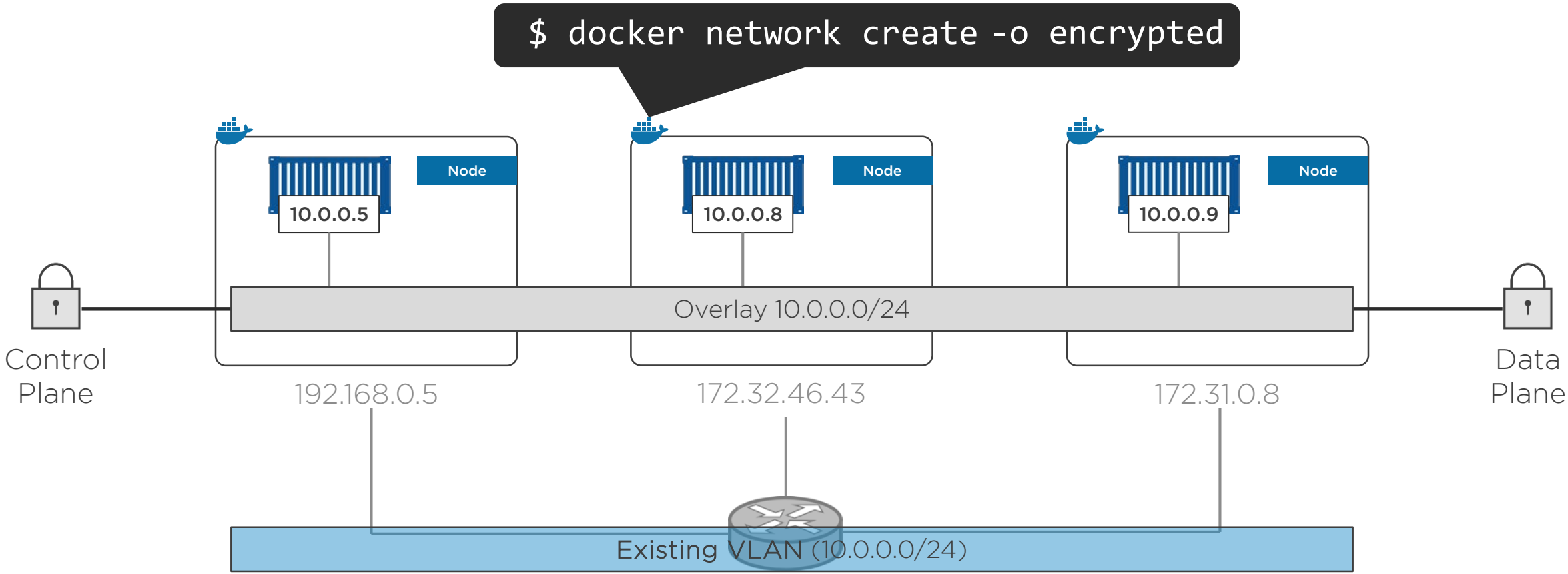
Bridge Networking



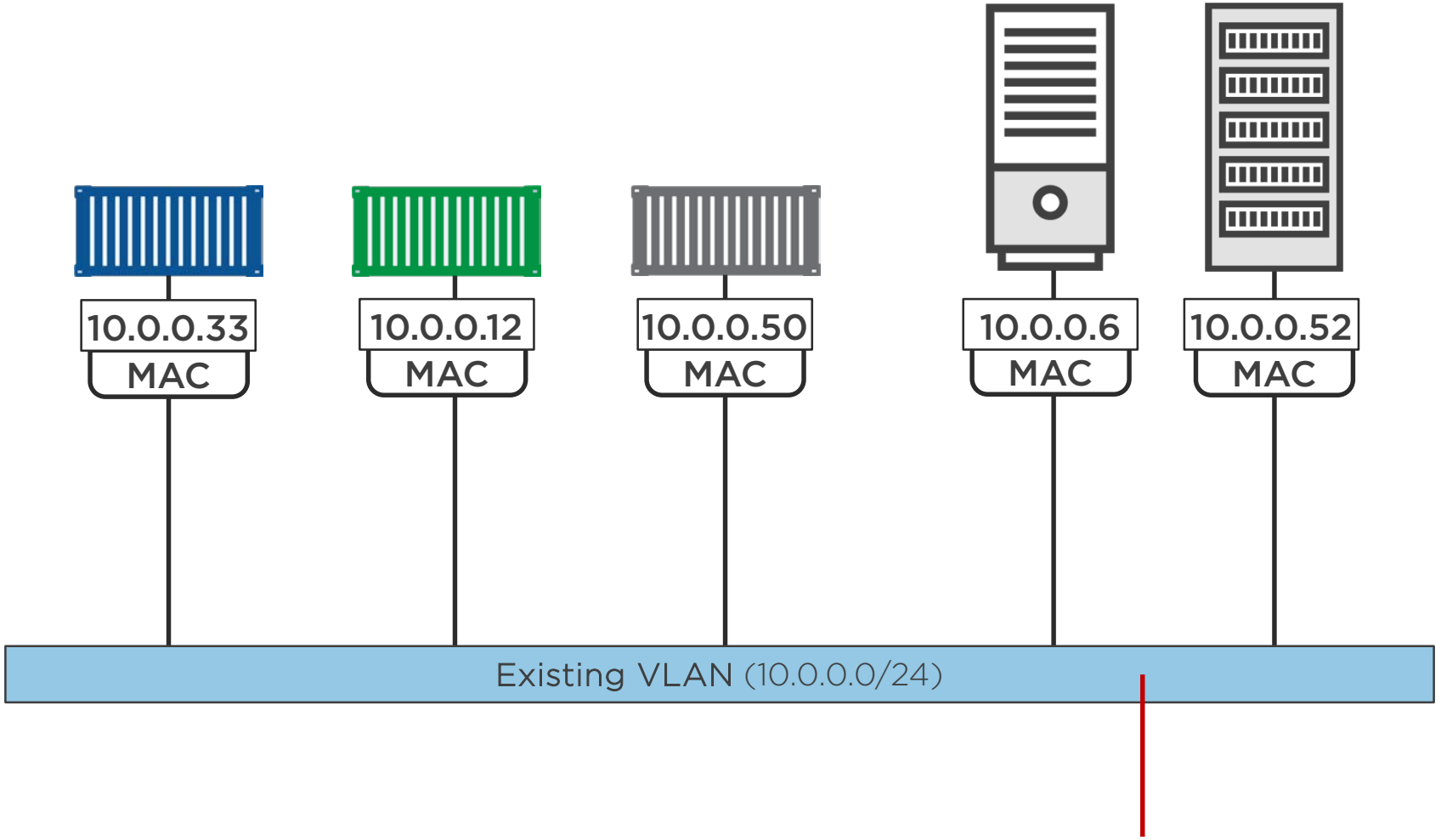
bridge driver Linux
nat driver Windows



Overlay Networking



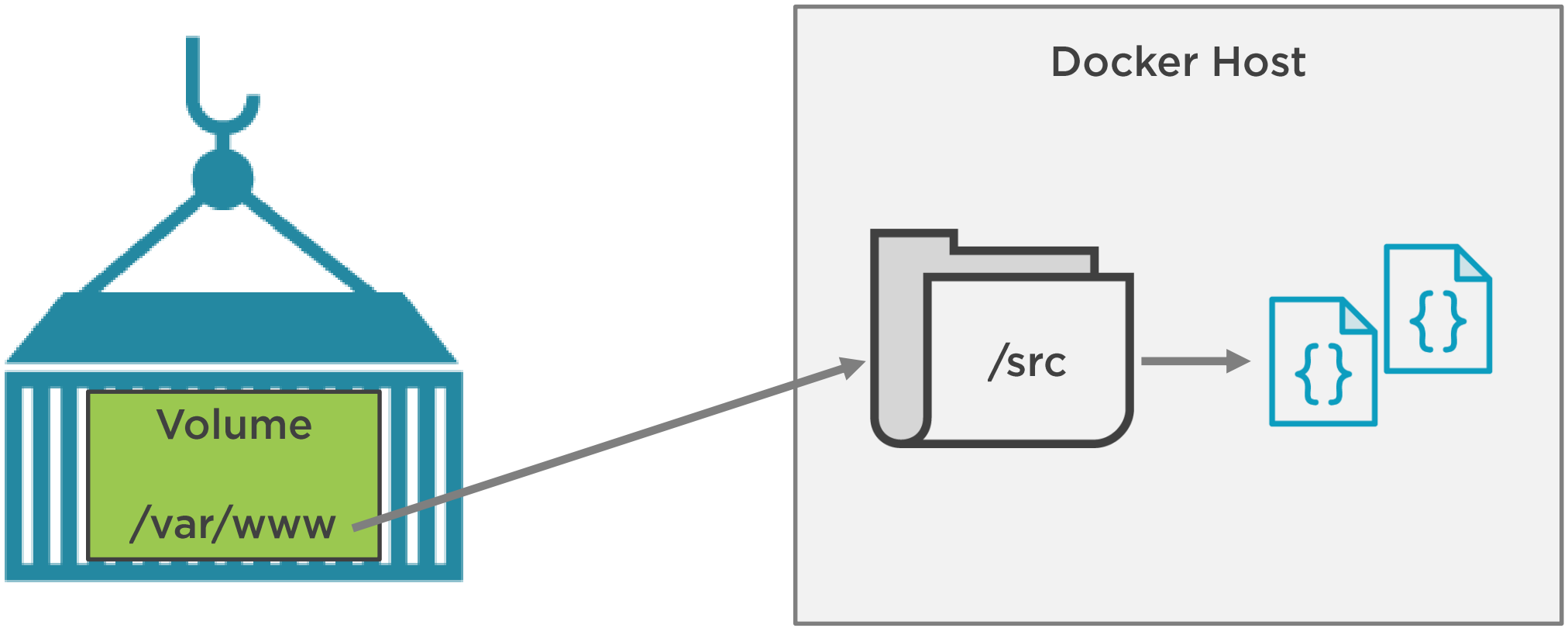
MACVLAN

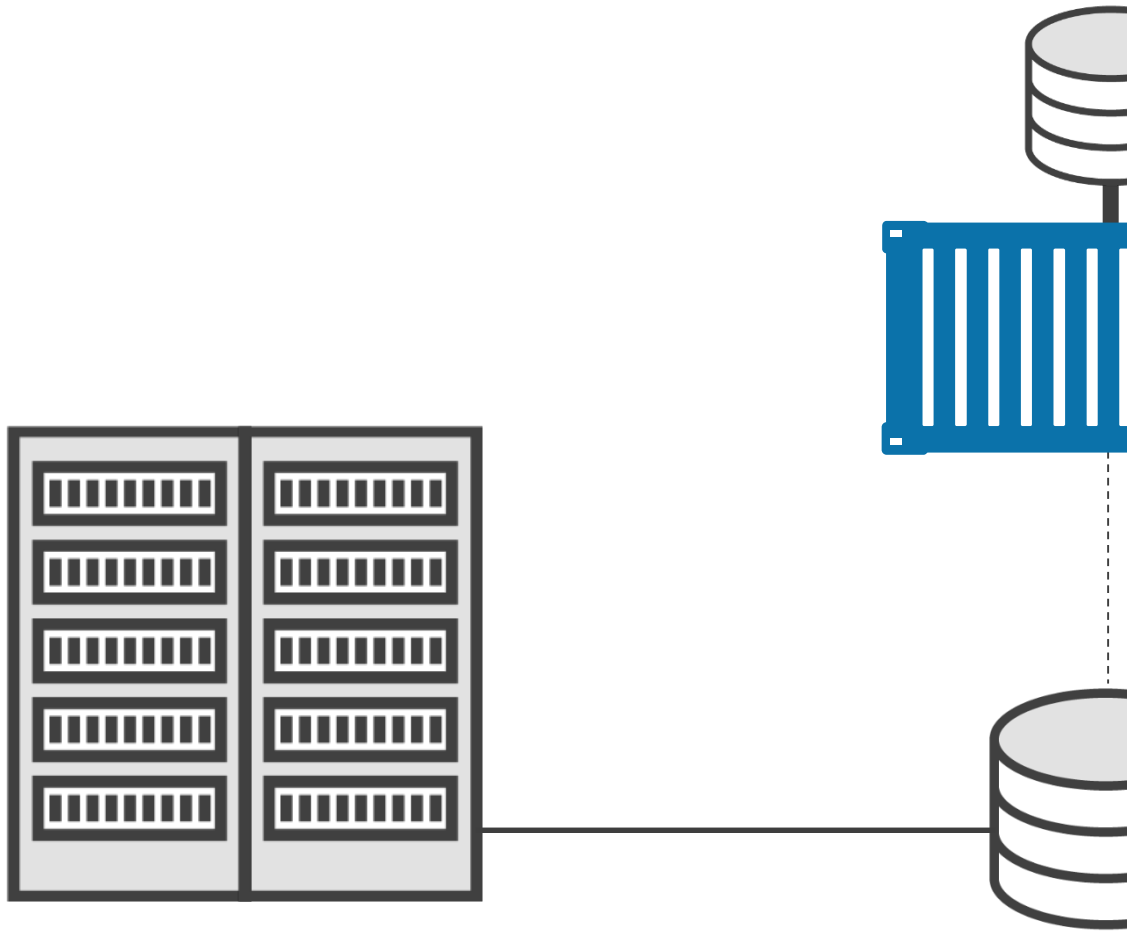


Must allow promiscuous mode

transparent driver Windows

Docker Volumes





```
$ docker volume create | ls | inspect…
```

Docker Secrets

String. <=500K

Safe

Secure

Infrastructure independent

Requires *Swarm-mode*

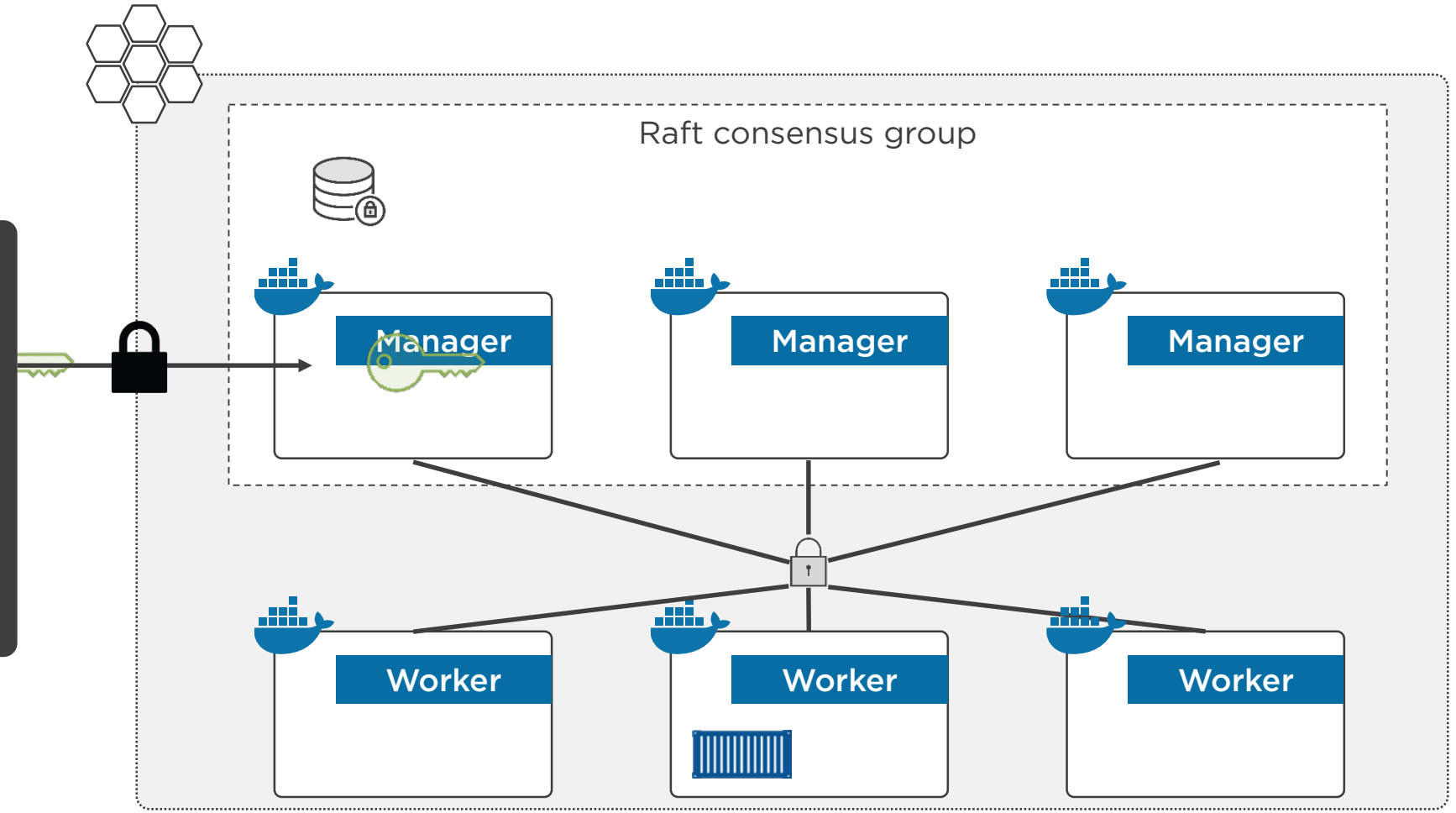
Docker Secrets

Swarm-mode Services only

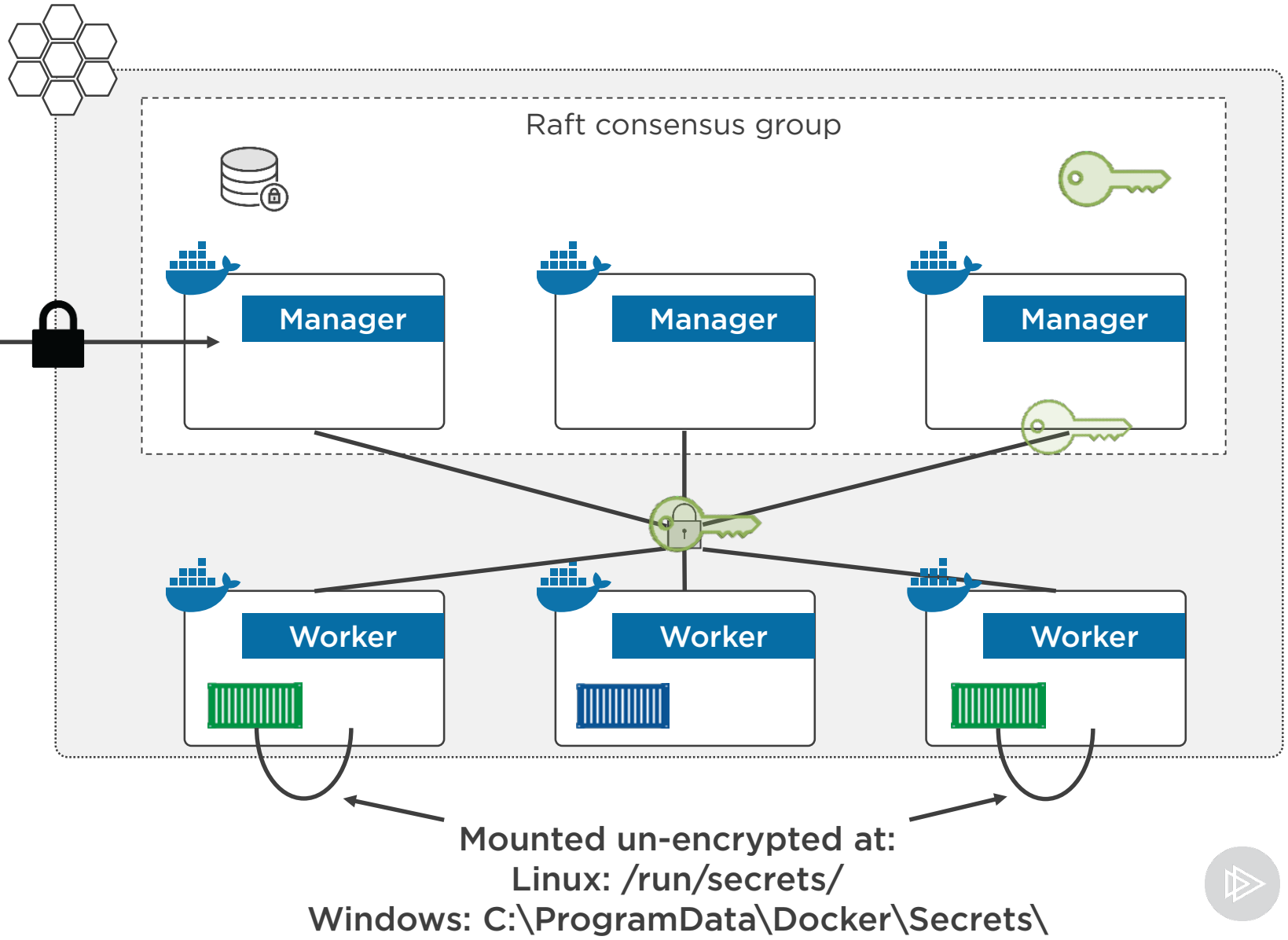
Linux: 1.13+

Windows: 17.06+

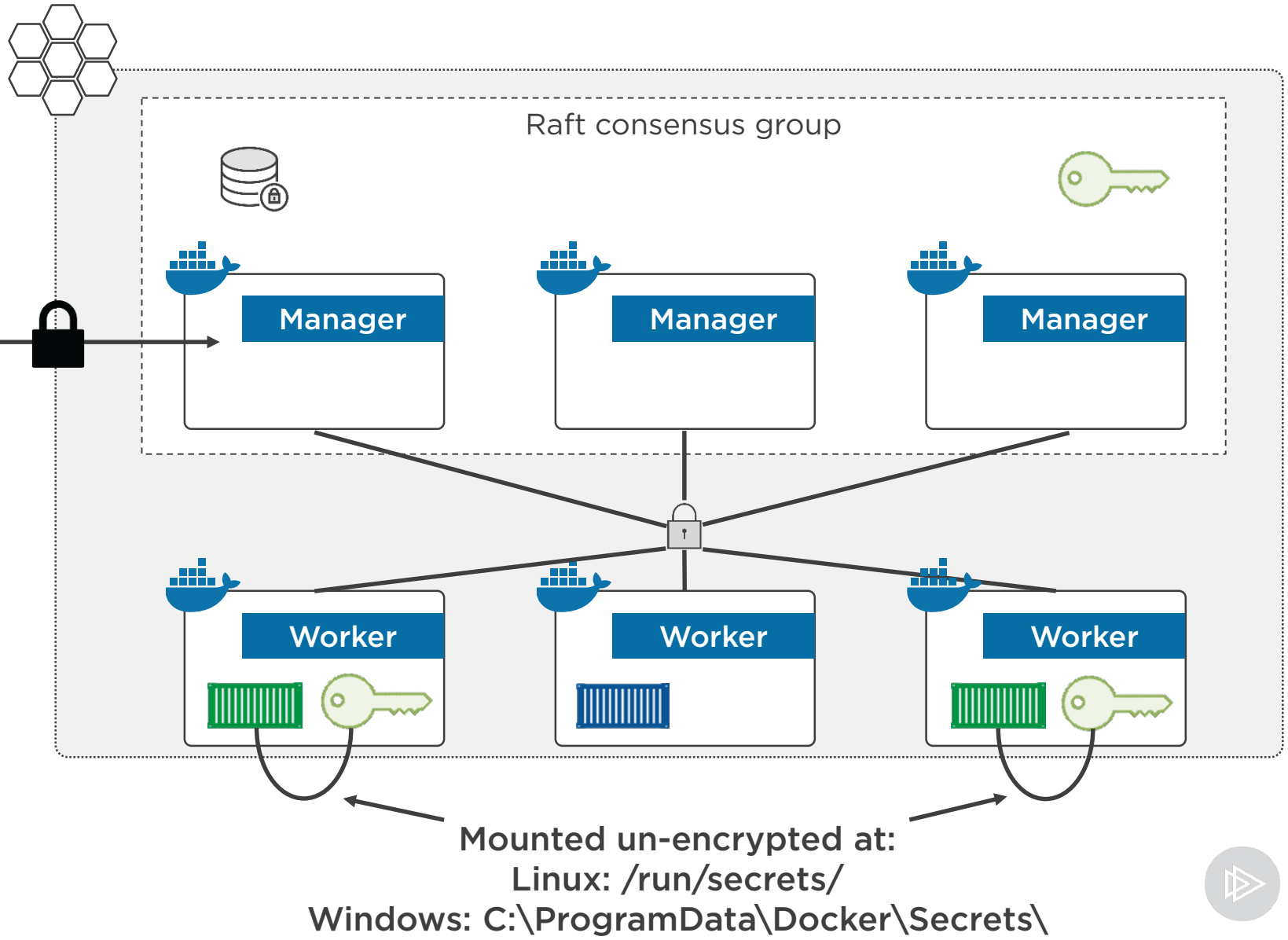
```
docker secret create...
```



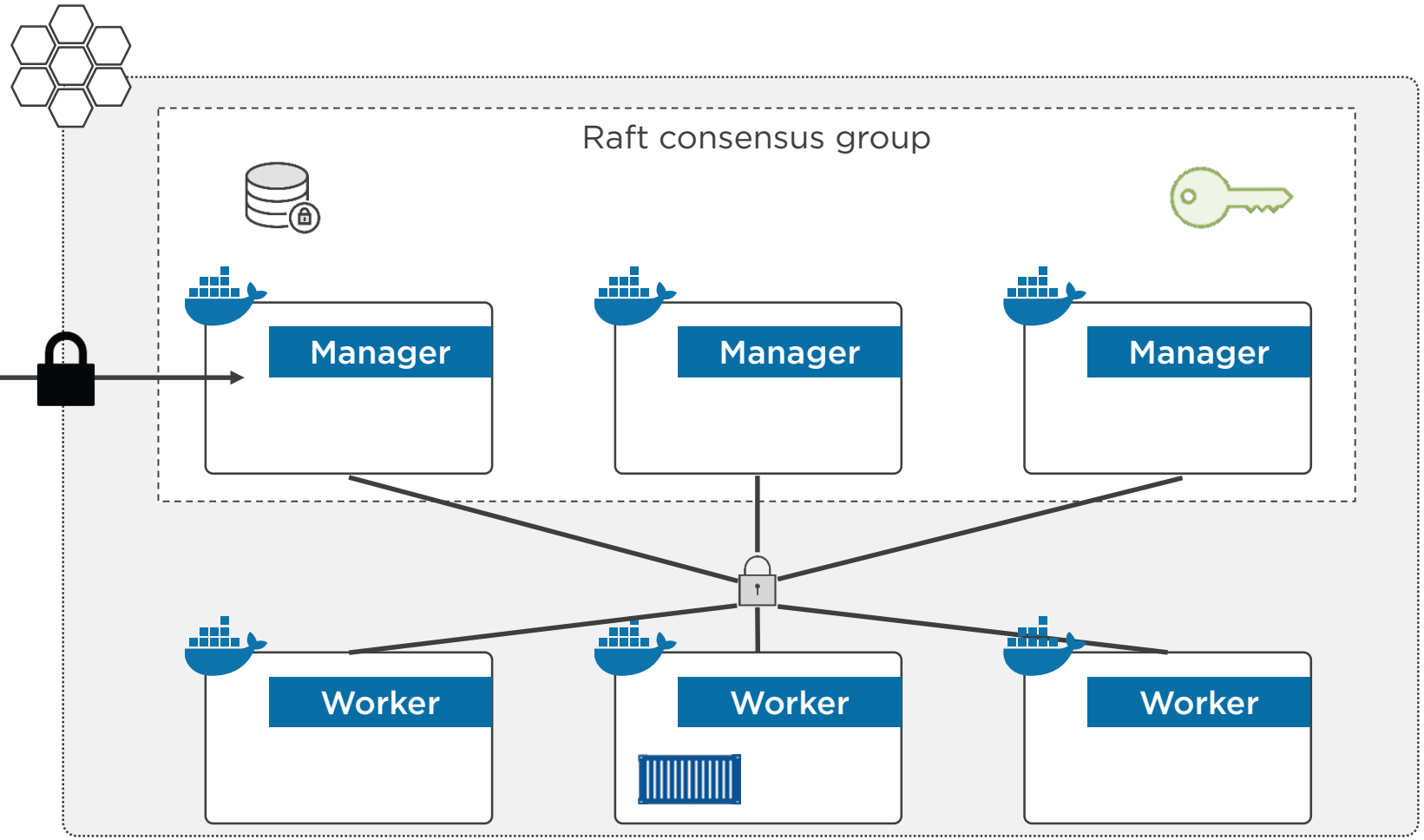
```
docker service create \
  --name green \
  --secret sec1 \
  --replicas 2 \
  ...
```



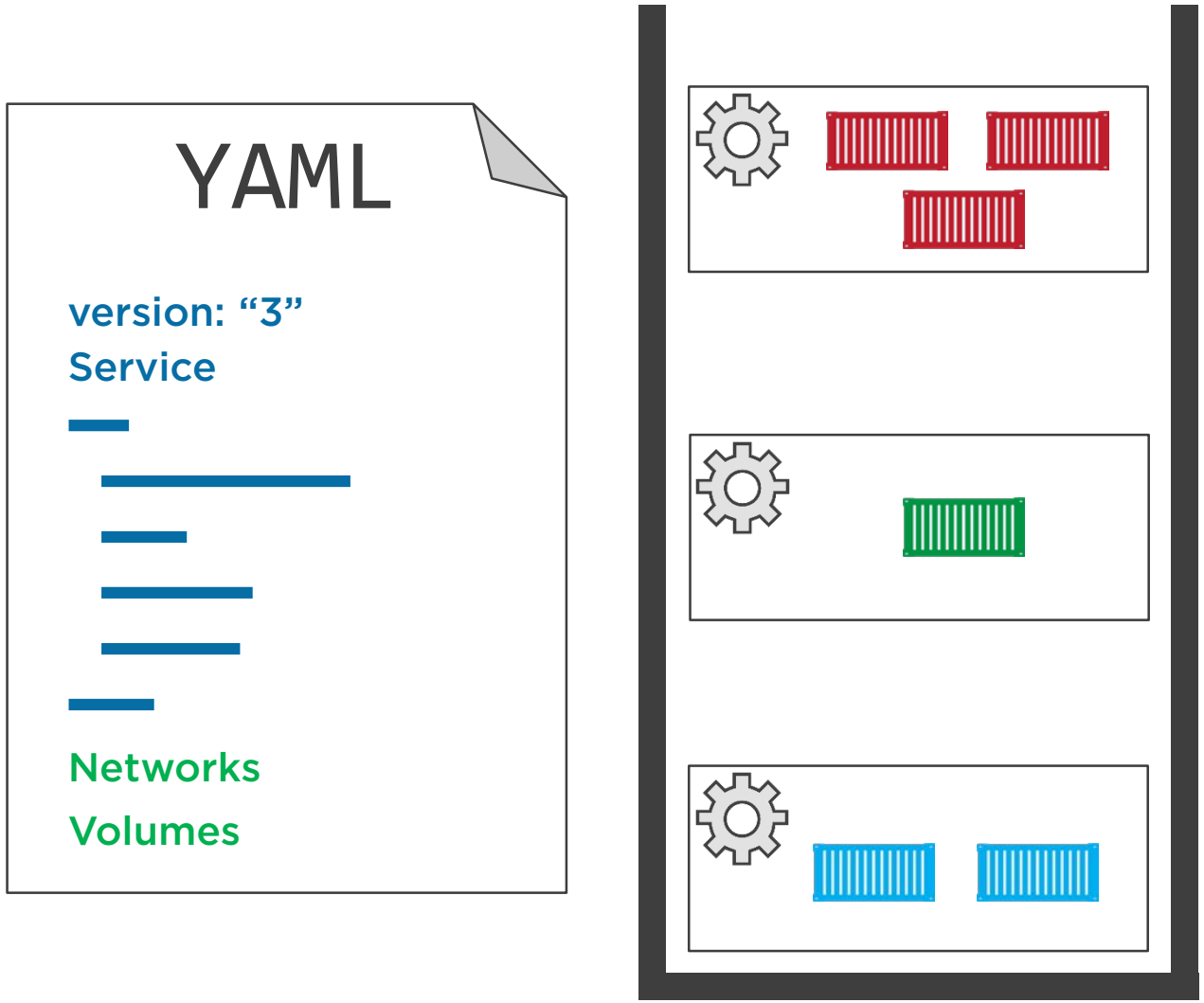
```
docker service rm green
```

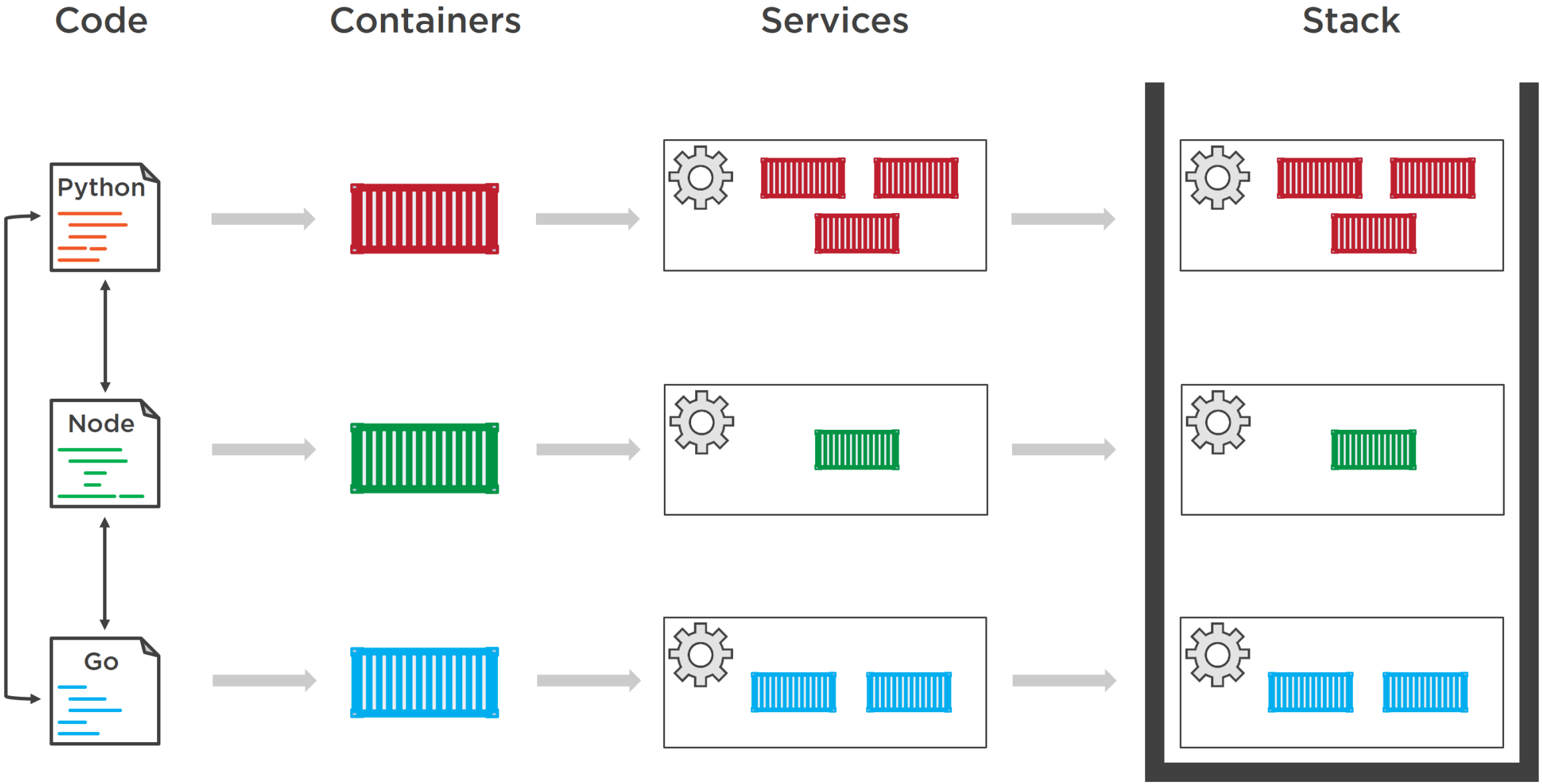


```
docker service rm green
```



Stack

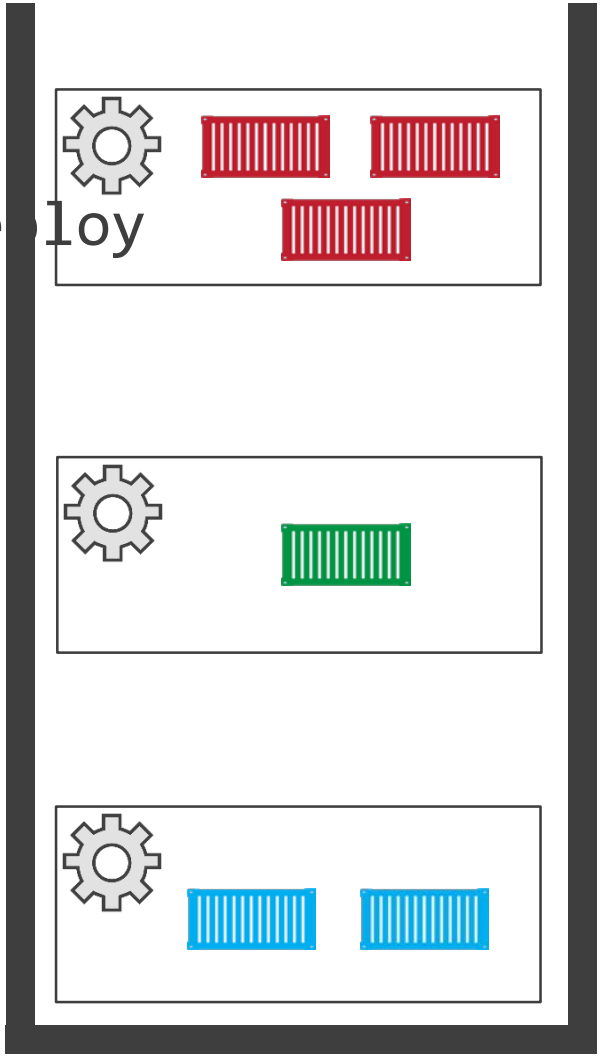


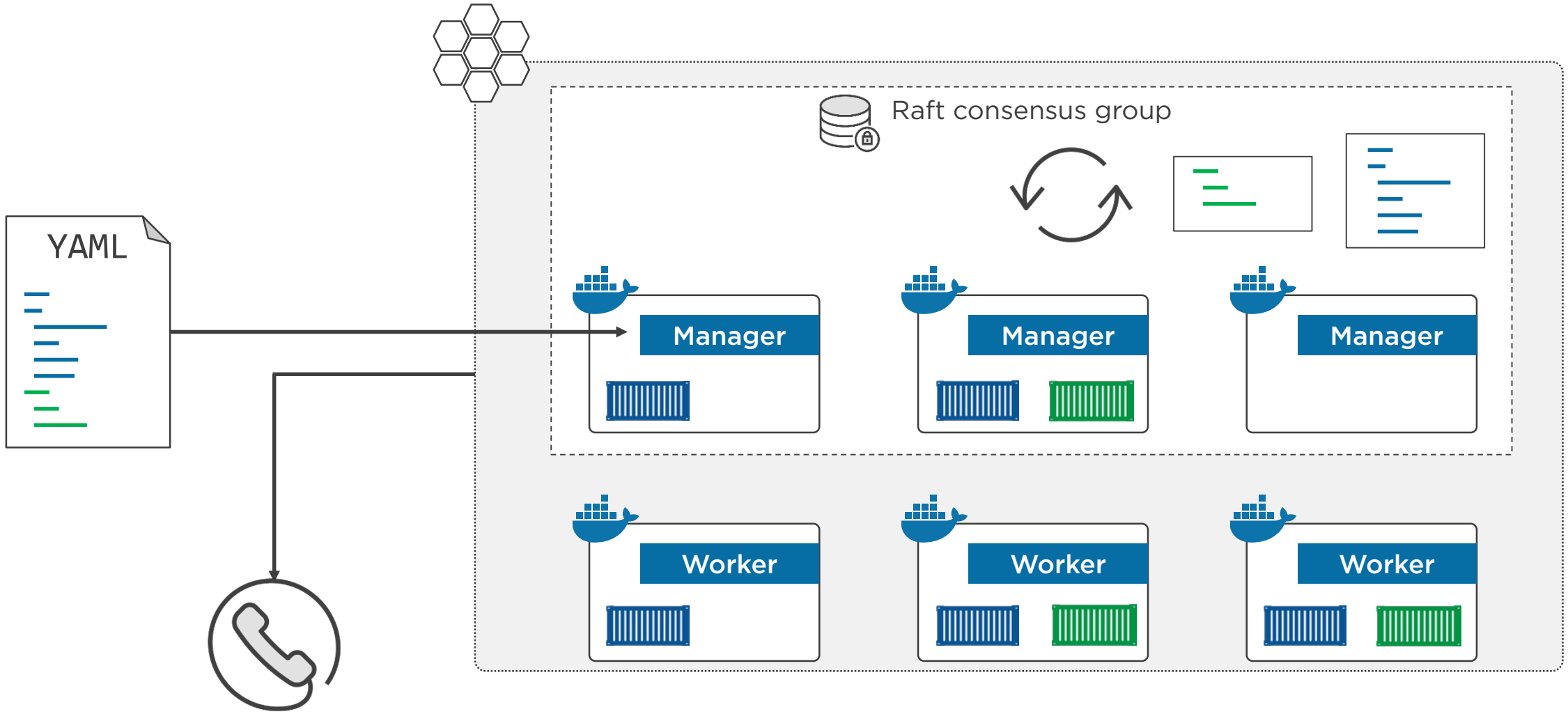

Code
Containers
Services
Stack
Python
Node
Go

$ docker stack deploy

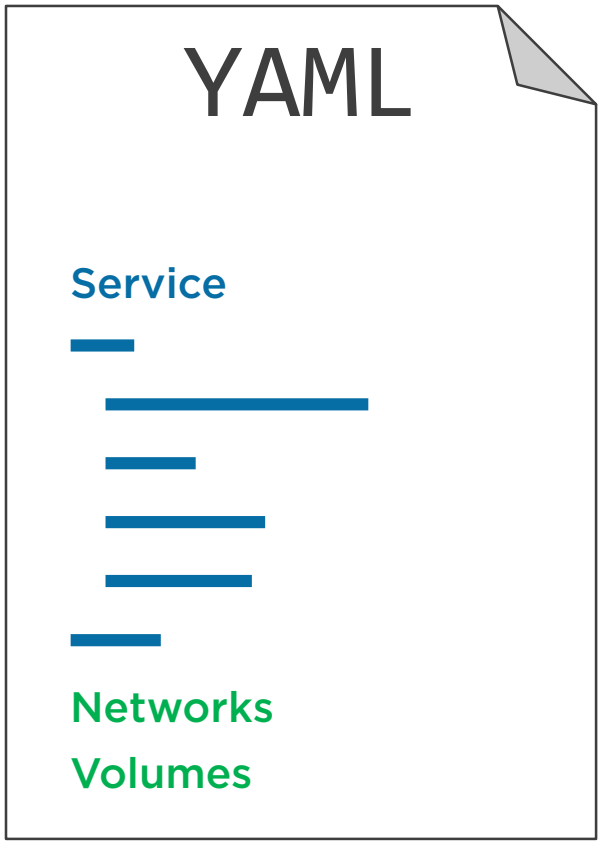
Docker UCP

Docker Cloud

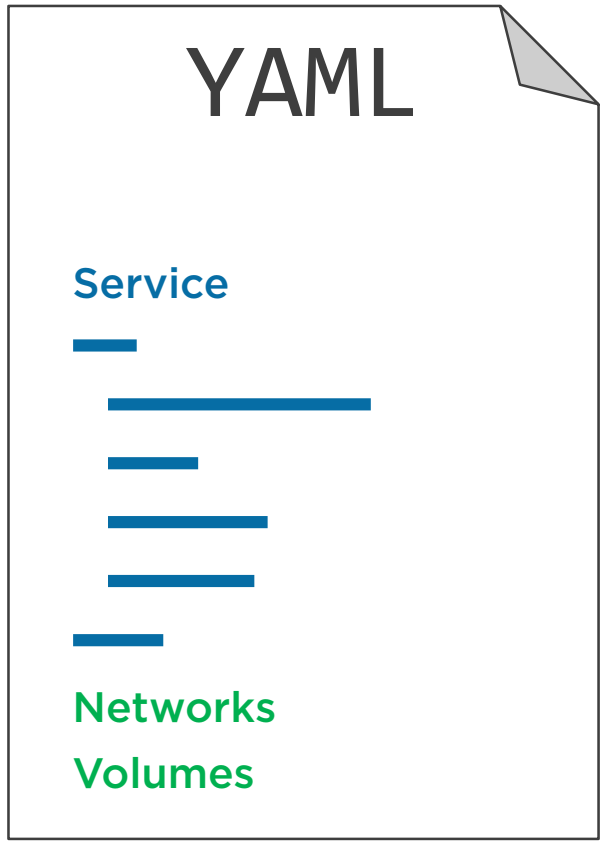



Raft consensus group
YAML
Manager
Manager
Manager
Worker
Worker
Worker

Dev



Test



Prod

Docker Distributions for Windows

- Docker Toolbox
- Docker in WSL2
- Docker Desktop
- Docker Engine Enterprise

Orchestration Solutions for Windows Containers

- Azure Kubernetes Service (AKS)
- Azure Service Fabric
- Azure Stack with AKS Engine
- Kubernetes
- Docker Swarm

Switching Between Linux and Windows Containers

To Linux:

```
[Environment]::SetEnvironmentVariable
("LCOW_SUPPORTED", "1", "Machine")
Restart-Service docker
```

To Windows:

```
[Environment]::SetEnvironmentVariable
("LCOW_SUPPORTED", $null, "Machine")
Restart-Service docker
```

Maintenance

Installing Specific Version

```
Install-Package -Name docker \
-ProviderName DockerMsftProvider \
-Force -RequiredVersion 19.03
```

Updating Mirantis Container Engine

```
Install-Package -Name docker \
-ProviderName DockerMsftProvider \
-RequiredVersion 19.03 -Update -Force
```

Checking the Windows Version

```
Get-ItemProperty -Path "HKLM:\Software\Microsoft\Windows NT\CurrentVersion" |
Select ProductName, ReleaseId, InstallationType,
CurrentMajorVersionNumber,CurrentMinorVersionNumber,CurrentBuild
```

Windows Server Base Images

windows

servercore

nanoserver

iotcore

Windows Base Images

Using `windows` tag

Desktop version

Contains full set of Windows APIs and system services

Required for some apps such as SharePoint Server 2019

Windows Server Core Base Images

Using servercore tag

- **Headless**
- **Smaller image**
- **Suited for both VMs and containers**
- **Contains a subset of the Windows Server APIs**
- **Full .NET framework**
- **Includes most server roles**

Nano Server Base Images

Using nanoserver tag

- **Headless**
- **Smallest image**
- **Designed for containers (only available as a container base image in the Semi-Annual Channel)**
- **Optimized for .NET Core applications**
- **PowerShell Core, .NET Core, and WMI are not included by default**

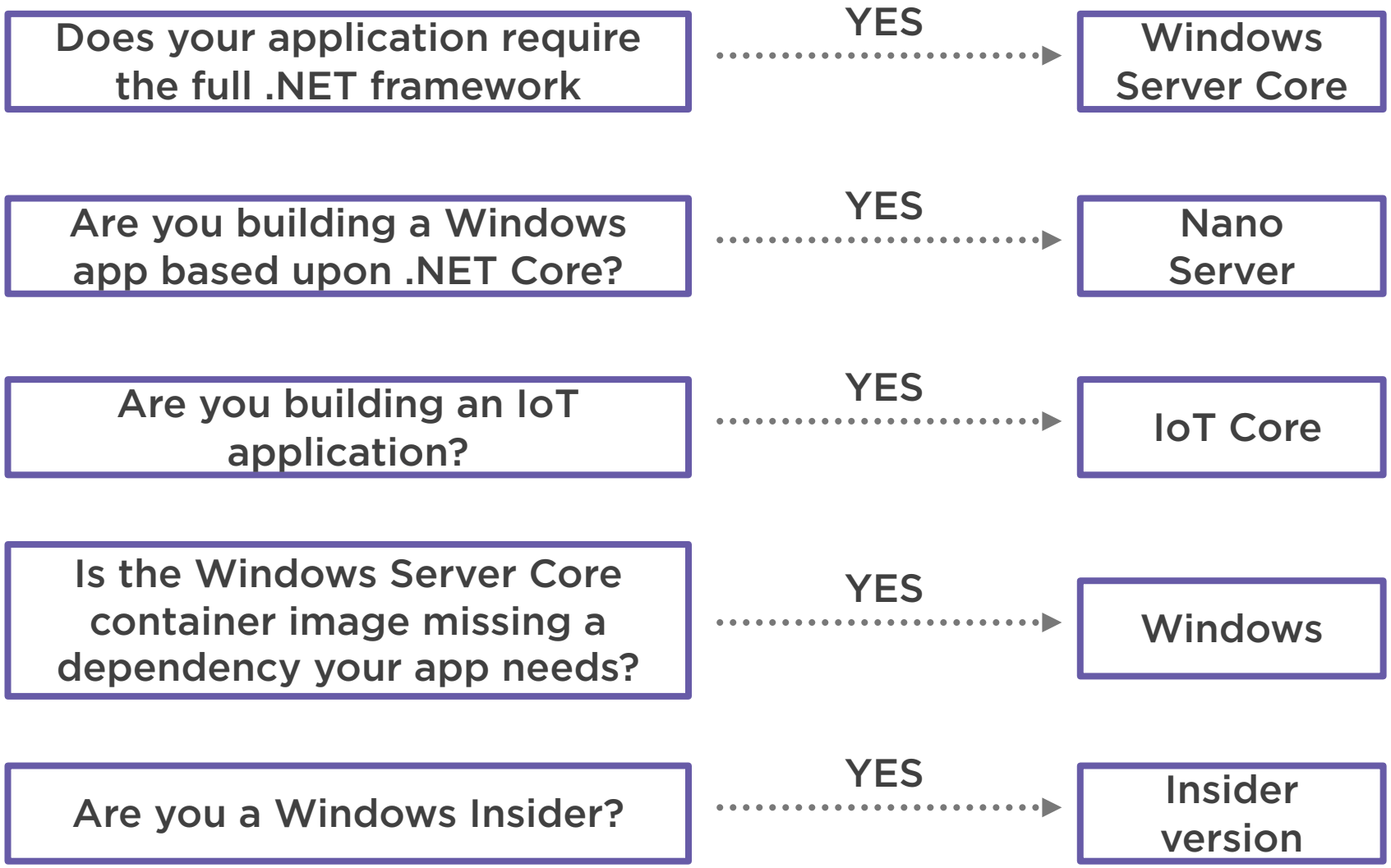
Windows 10 IoT Core Base Images

Using `iotcore` tag

Used for Internet of Things devices

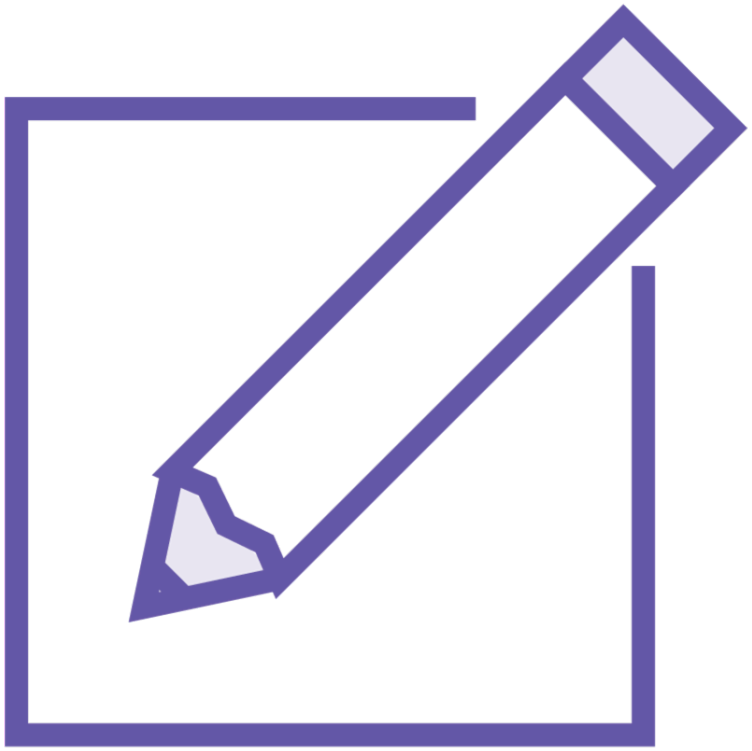
Supports ARM and x64 processors

Choosing a Base Image



Other Base Images

- Dotnet
- IIS
- azure-functions



Licensing:

- Container images may be used with properly licensed Windows host software
- The Semi-Annual Channel is available for cloud providers and volume-licensed customers

```
FROM mcr.microsoft.com/powershell:nanoserver-$SERVERCORE

SHELL ["pwsh", "-Command", "$ErrorActionPreference = 'Stop'; $ProgressPreference = 'SilentlyContinue';"]

COPY --from=builder /nodejs /nodejs

COPY ["app.js", "c:/web/"]

EXPOSE 8080

WORKDIR /web

CMD Start-Process -NoNewWindow -Wait -FilePath c:/nodejs/node.exe -ArgumentList c:/web/app.js
```

Powershell in Dockerfile

Source: https://github.com/rancher/rancher/blob/v2.5.3/tests/validation/tests/Dockerfiles/windows/metrics/Dockerfile

```
# escape=`

FROM mcr.microsoft.com/nanoserver

ARG VS_REMOTE_DEBUGGER_PATH

ARG VS_OUT_DIR

ADD $VS_REMOTE_DEBUGGER_PATH "c:\windows"

VOLUME $VS_OUT_DIR

WORKDIR $VS_OUT_DIR

ENTRYPOINT msvsmon.exe /noauth /anyuser /silent /nostatus /noclrwarn /nosecuritywarn /nofirewallwarn /nowowwarn
/timeout:36000
```

Shell Subset in Dockerfile

Source: https://github.com/microsoft/NanoServerTools/blob/v0.1/DevTools/ContainerDebug/dockerfile