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Current State of Storage in the Container World

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Today's Presenters

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@chadh0517

Agenda

- Overview of Containers
  - Virtual machines vs. Containers
  - Quick history, where we are now
  - How Docker containers work
  - Why containers are compelling
- Storage for Containers
  - Persistent and non-persistent
  - Options for Containers
  - NAS vs. SAN
- Future Considerations

Virtual Machine vs. Container

A Brief History of On-premises Technologies

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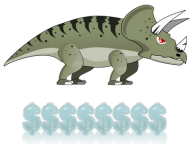
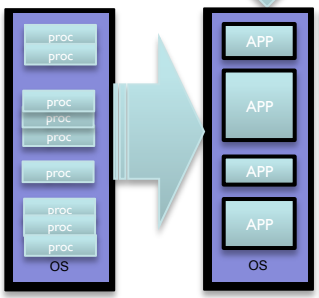
DEC

IBM



Mainframe



Zones

Projects

Fair Share

Timesharing

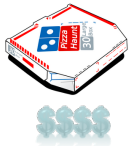
Unix ®

"App per Machine"

$O_{(1)}$

2x2x2

2x4x2



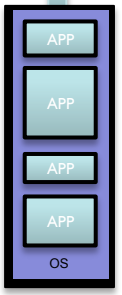
Linux / Windows

"App per Virtual Machine"

KVM Xen

ESX Hyper-V

Hypervisor



namespaces

cgroups

Completely Fair Share

Container

Multi-core

Mass-produced

Multi-processor

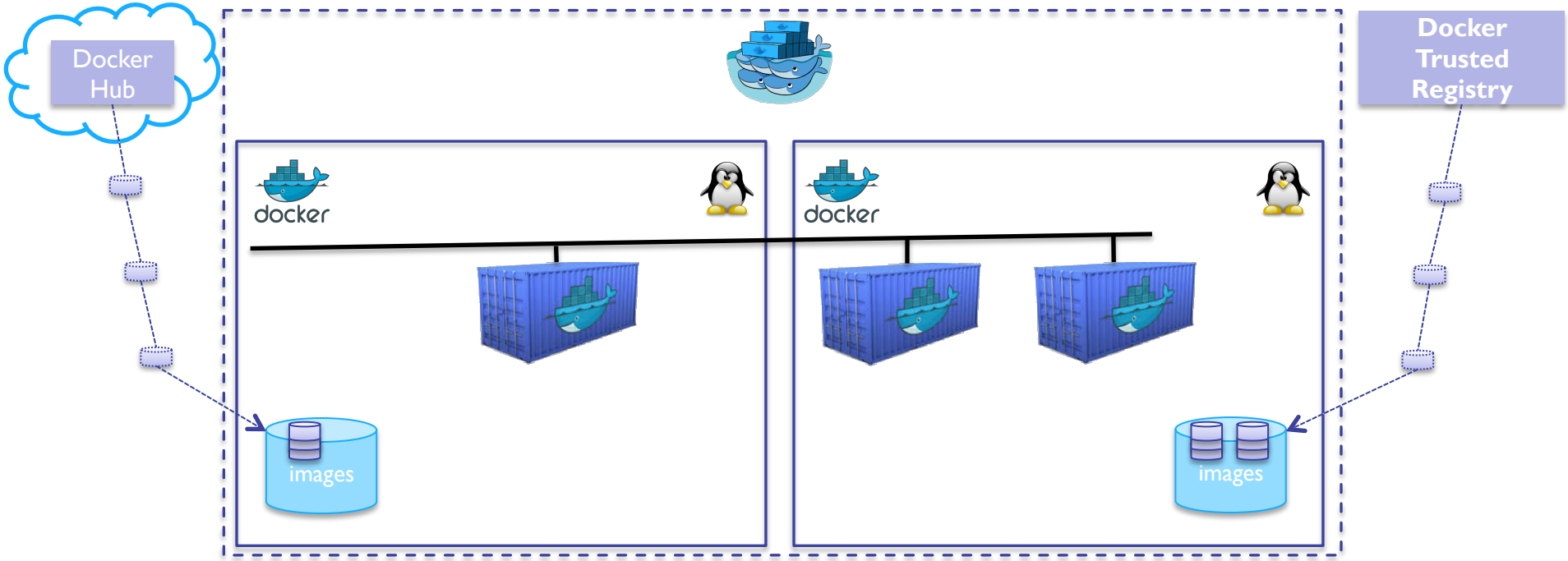
Why Containers are Compelling

- Operating System level isolation
  - Uses **cgroups and namespaces** in the Linux Kernel
  - Native Windows Containers in Windows Server 2016
    - Two types: Windows Server Container & Hyper-V Container
- Containers are about **applications**
  - **Define application needs** – the infrastructure will build it
  - Agility and consistency **in the software supply chain**
- Gives **Developers and Operations Teams** common interface
  - **Developers** care about **software** dependencies for **their app**
  - Operations care about **reliability, availability and performance**
- Docker **builds, ships and runs** applications everywhere

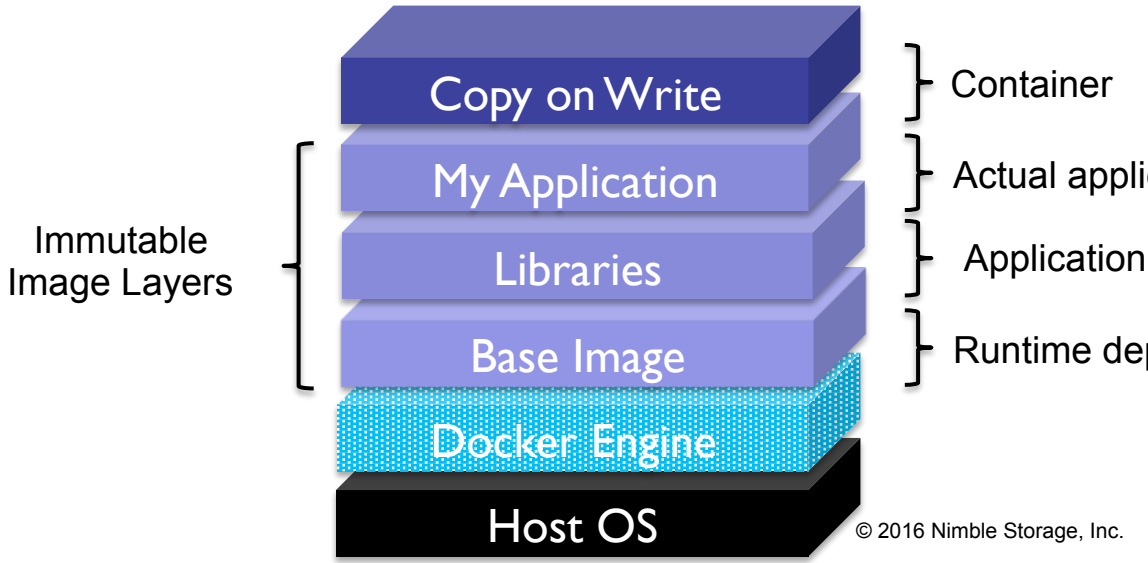
Orchestration

- Distributed Cluster
- Container Scheduler
- Examples
  - Docker Swarm
  - Kubernetes
  - Apache Mesos
  - Nomad

Docker Environment Overview

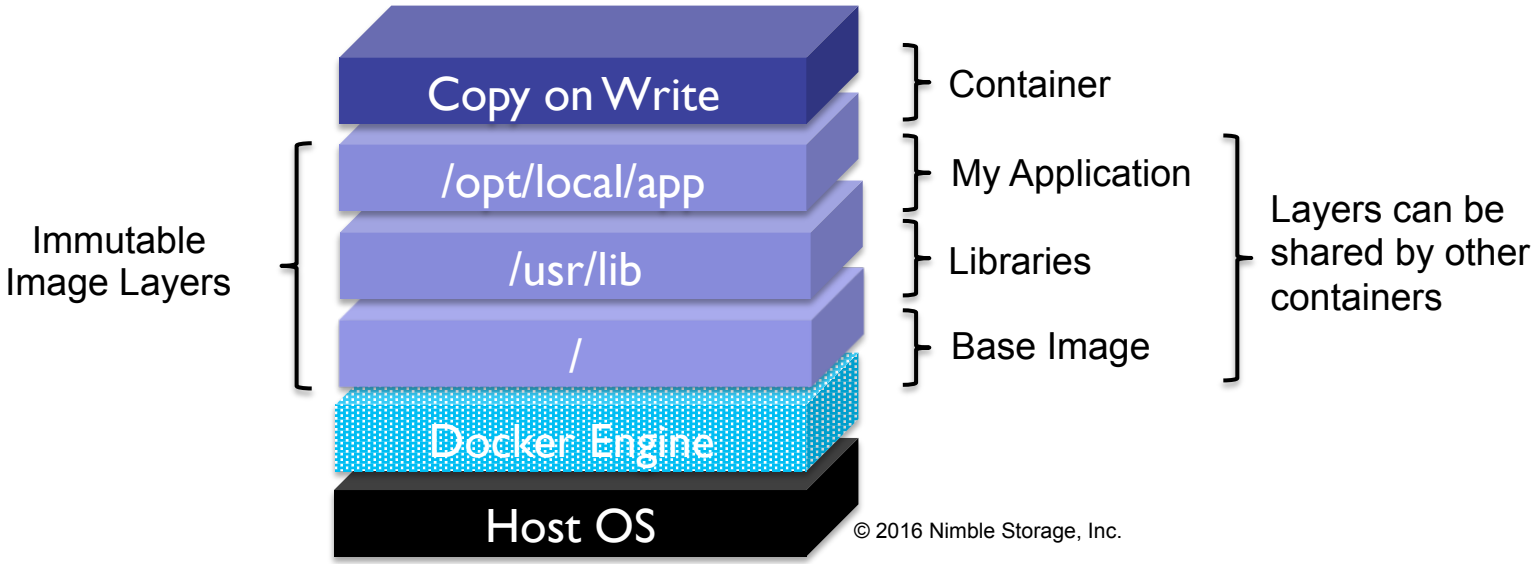


Docker Image File System Model



- Layers are composed by a union file system
- Changes are stored with the particular container instance image (COW)
- Data stored in the container post-creation is only suitable for transient content

Docker Image File System Model



- Layers are identified using cryptographic hashes of the layer's content
- Graph driver stacks the layers which provides the unified view from the container
- When the container is deleted, so are the changes in the Copy on Write layer

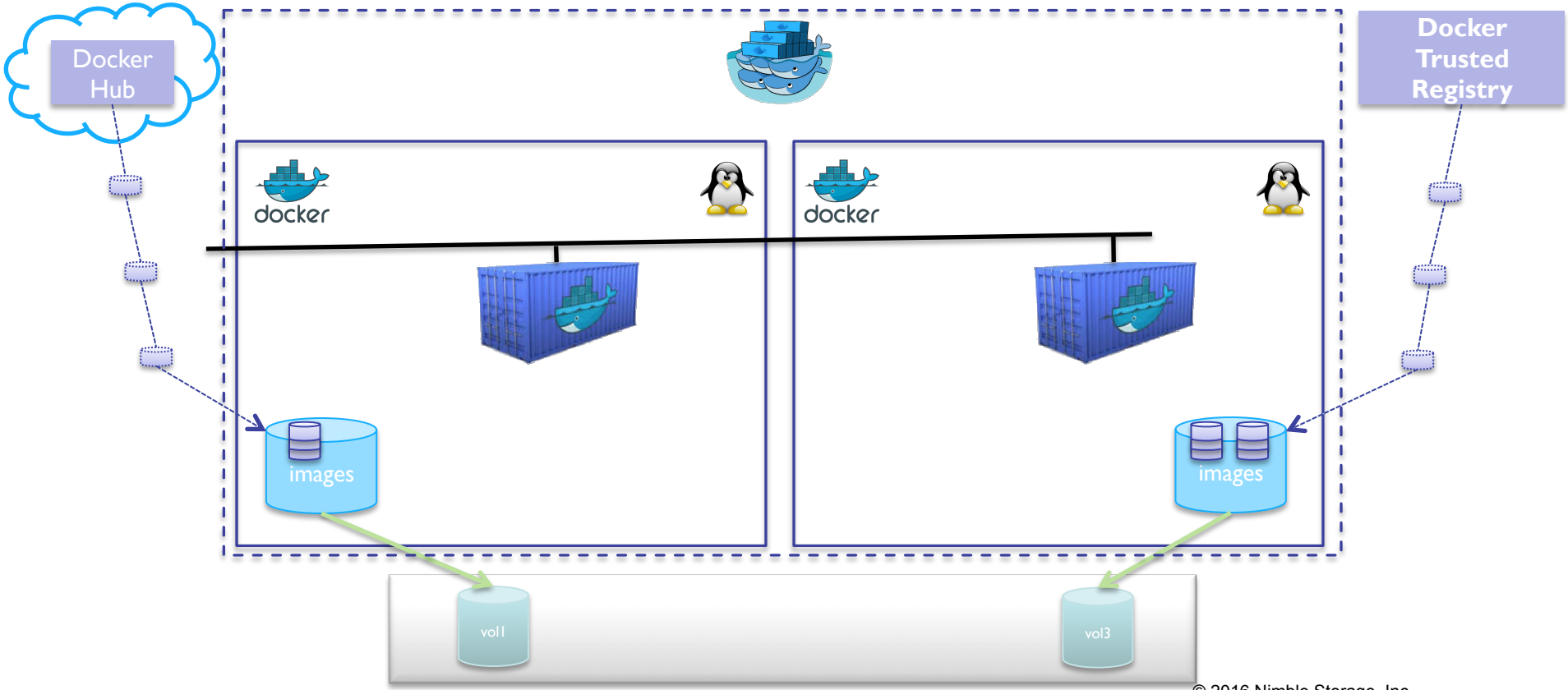
Graph Drivers

- Provides a local registry of images and layers
- Provides the Copy-On-Write functionality
- Allows for Layer creation
- Selection recommendations
  1. Use the default driver for your distribution*
  2. If implementation is within the limitations of Overlay2, use it
  3. If using the Commercially Supported Docker Engine, check Docker's compatibility matrix

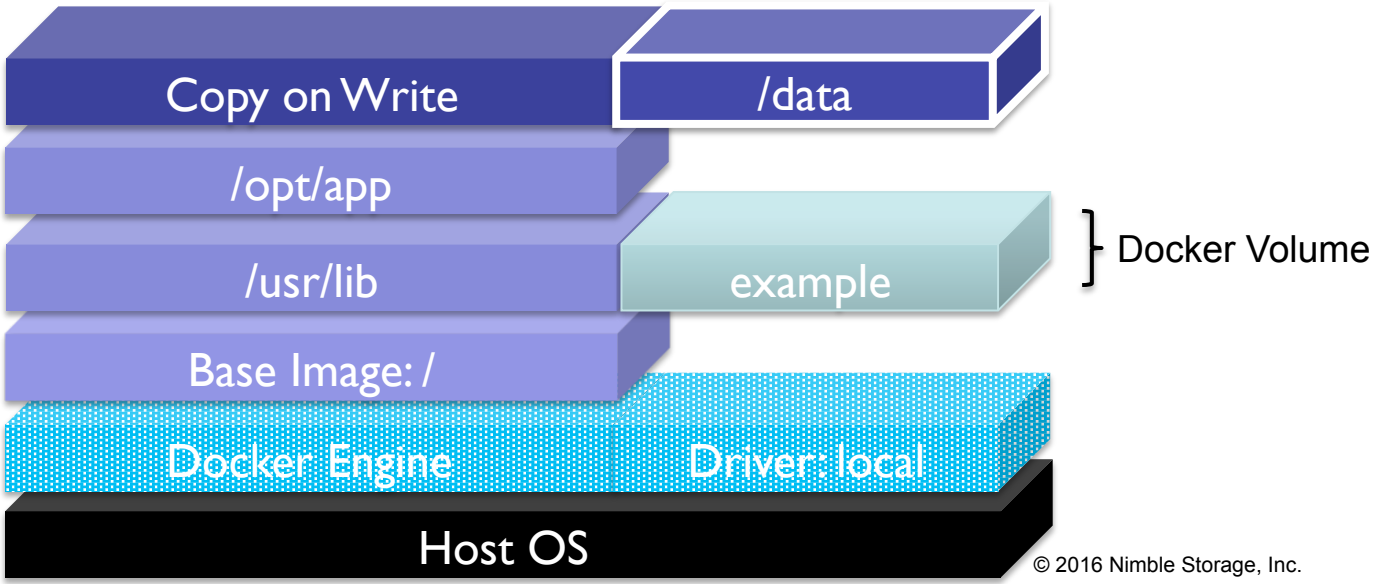
- OverlayFS
- AUFS
- Btrfs
- Device Mapper
- VFS
- ZFS

*Do not use the Device Mapper driver in loopback mode in production

Locate Node Registry on External Storage



Docker Volume



- Provides local persistence
- Bypass Copy-On-Write (COW) layer
- Presents a directory inside the container
- Persist after container is destroyed
- Docker on Linux supports mount options
- Docker on Windows (currently) supports no options
- Docker Volumes are separate, named, and reusable entities

Local Docker Volume


```
$ docker volume create --name example
example
$ docker volume inspect example
    {
        "Name": "example",
        "Driver": "local",
        "Mountpoint": "/var/lib/docker/volumes/example/_data",
        "Labels": {},
        "Scope": "local"
    }
```

```
$ docker run --name myContainer -v example:/data alpine date
$ docker inspect myContainer
<snip>
 "Mounts": [
            {
                "Name": "example",
                "Source": "/var/lib/docker/volumes/example/_data",
                "Destination": "/data",
                "Driver": "local",
                "Mode": "z",
                "RW": true,
</snip>
```

Docker Volume Behaviors

- When the image has data in the directory where the volume is to be mounted, and the volume is empty, the content of the directory is copied to the volume
- A Docker Volume cannot be removed if it is referenced by a container

Create a volume and show it is empty:

```
$ docker volume create --name example
example
$ ls -l /var/lib/docker/volumes/example/_data
total 0
```

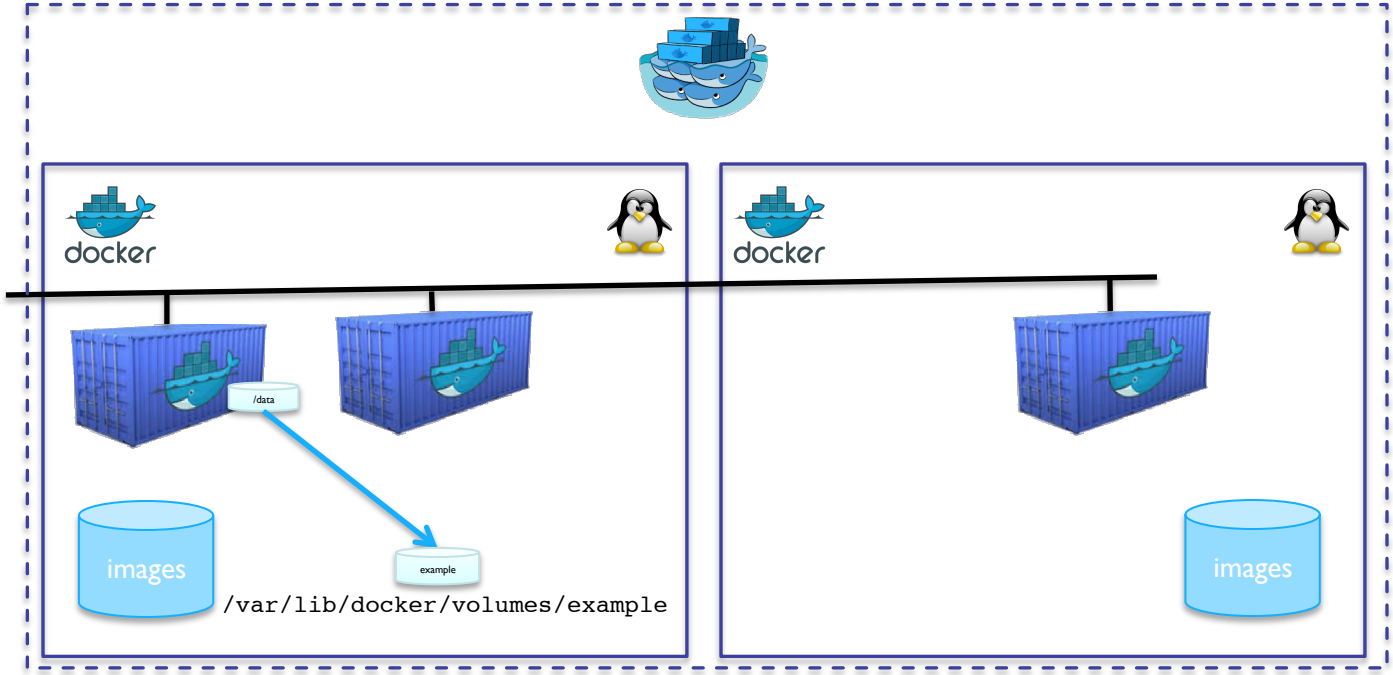
Run a container and show that the directories from the image have been copied to the volume:

```
$ docker run -it -v example:/var/lib alpine date
$ ls -l /var/lib/docker/volumes/example/_data
total 0
drwxr-xr-x 2 root root 6 Oct 18 11:58 apk
drwxr-xr-x 2 root root 6 Oct 18 11:58 misc
drwxr-xr-x 2 root root 6 Oct 18 11:58 udhcpd
```

Unable to remove a volume that is referenced by a container:

```
$ docker volume rm example
Error response from daemon: Unable to remove volume, volume still in use:
remove example: volume is in use - [a41a33563358b75ae483a595659fa433d34ea7761f05bd09f3151e43fd28870f]
```

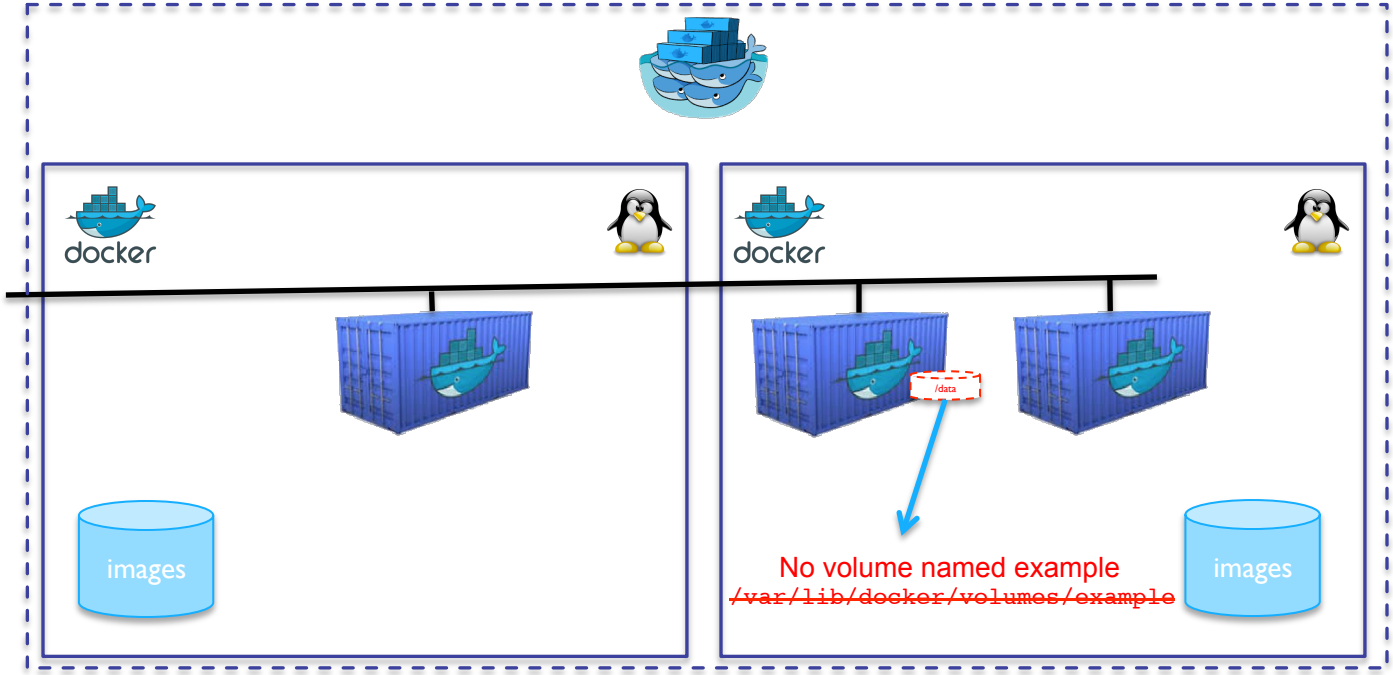
Local Persistent Storage




```
$ docker volume ls
DRIVER              VOLUME NAME
local               example
```

```
$ docker volume ls
DRIVER              VOLUME NAME
```

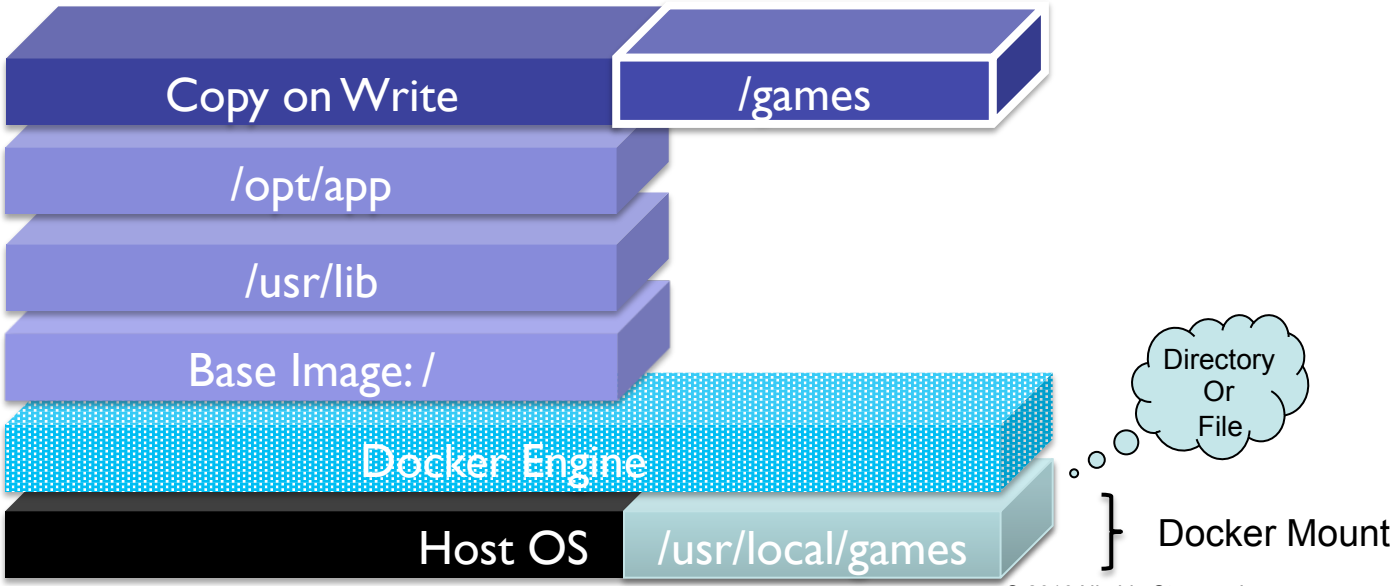
Local Persistent Storage




```
$ docker volume ls
DRIVER              VOLUME NAME
local               example
```

```
$ docker volume ls
DRIVER              VOLUME NAME
```

Host Directory/File Exposed to Container



- Provides local persistence
- Presents a directory from the host into the container
- Bypass Copy-On-Write (COW) layer
- **Not a Docker Volume**: Docker Volume Behaviors Don't Apply

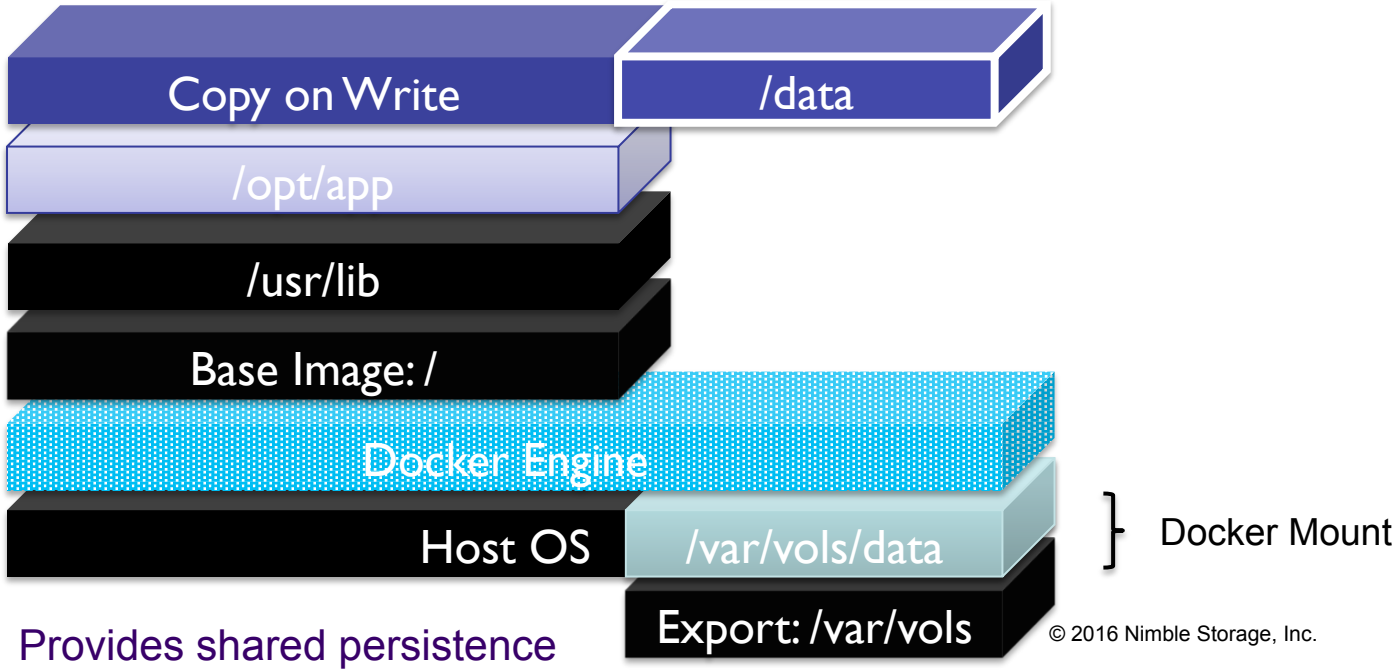
Host Directory/File Exposed to Container

- Directories need not be created manually
  - Docker engine silently creates the directory if missing
  - Docker engine bind mounts the directory into the container (hiding existing content)
  - Often used to expose read-only access

```
$ docker run --name myContainer -v /usr/local/games:/games:ro alpine date

$ docker inspect myContainer
<snip>
        "Mounts": [
            {
                "Source": "/usr/local/games",
                "Destination": "/games",
                "Mode": ”ro",
                "RW": false,
</snip>
```

Directory from NFS Mounted Filesystem



- Provides shared persistence
- Presents a directory from an NFS mounted export into the container
- Bypass Copy-On-Write (COW) layer
- **Not a Docker Volume**: Docker Volume Behaviors Don't Apply

Directory from NFS Mounted Filesystem

- Export should allow root access (no_root_squash)
- Mount should be present in /etc/fstab
- Directories need not be created manually
- Directory is bind mounted into the container (hiding existing content)
- No protection from accidental deletion of directory
- Little or no isolation between containers leads to noisy neighbor
  - Single “bucket” of capacity
  - Single filesystem/device providing IO

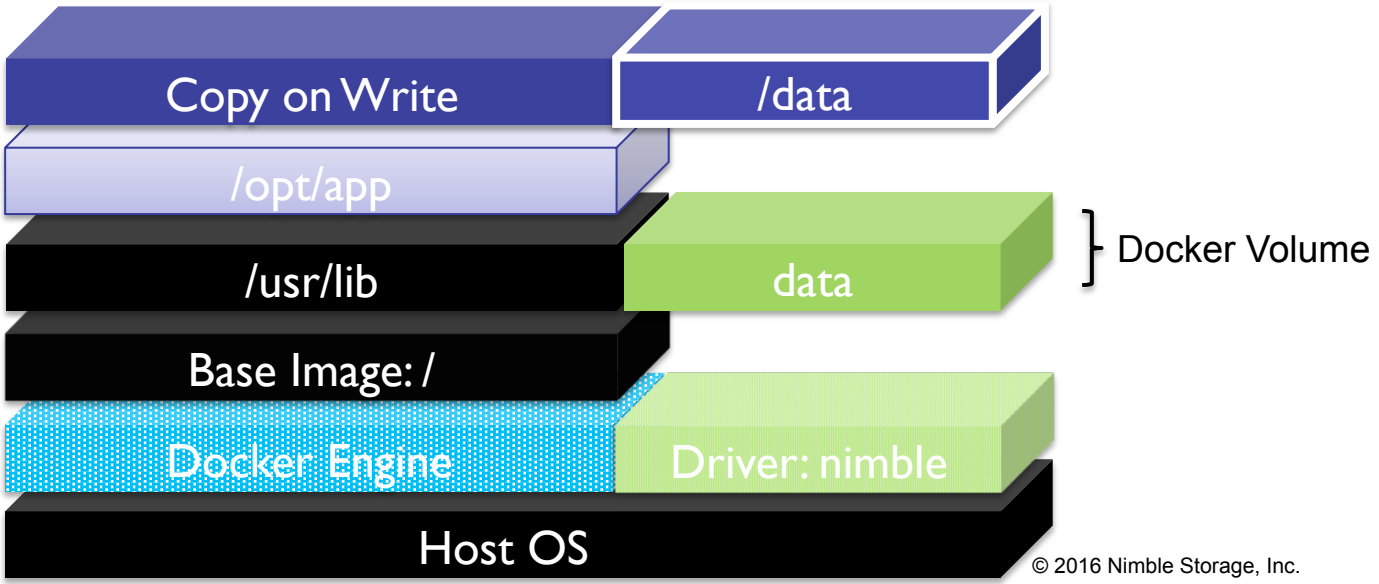
Anti-pattern

```
$ docker run --name myContainer -v /var/vols/data:/data alpine date
$ docker inspect myContainer
<snip>
            "Mounts": [
            {
                "Source": "/var/vols/data",
                "Destination": "/data",
                "Mode": "",
                "RW": true,
</snip>
```

“Batteries Included But Swappable”

- Docker plug-in framework announced @ DockerCon 2015
  - Network plug-ins
  - Volume plug-ins
- Plug-ins allow 3rd parties to extend the capabilities of Docker
- Volume Plug-ins exist for both SAN and NAS solutions
- Volume Plug-ins allow
  - Local and global scope
  - Storage system capabilities to be exposed
  - High performance storage options for Docker Containers

Docker Volume Created by Plug-in



- Can provides locally or globally scoped persistence
- Docker Volumes are separate, named, and reusable entities
- Bypass Copy-On-Write (COW) layer
- Presents a directory or filesystem inside the container

Docker Volume Created by Plug-in

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```
$ docker volume create --name example --driver=nimble
example
$ docker volume inspect example
    {   "Name": ”example",
        "Driver": "nimble",
        "Mountpoint": "",
        "Status": {
            "Blocksize": 4096,
            "DedupeEnabled": true,
            "Description": "Docker knows this volume as example.",
            "EncryptionCipher": ”AES-256",
<lines removed />
            "PerfPolicy": "DockerDefault",
            "ThinlyProvisioned": true,
            "VolSizeMiB": 10240,
            "VolumeName": ”example.docker”
        },
        "Labels": {},
        "Scope": "global”
    }
```

Plug-in Driven Docker Volume Creation

- Using the vanilla Docker client:

```
$ docker volume create --driver=nimble –o sizeInGiB=50 --name myvol1
$ docker run -it -v myvol1:/data alpine /bin/sh
```

- Using Docker service with Docker SwarmKit:

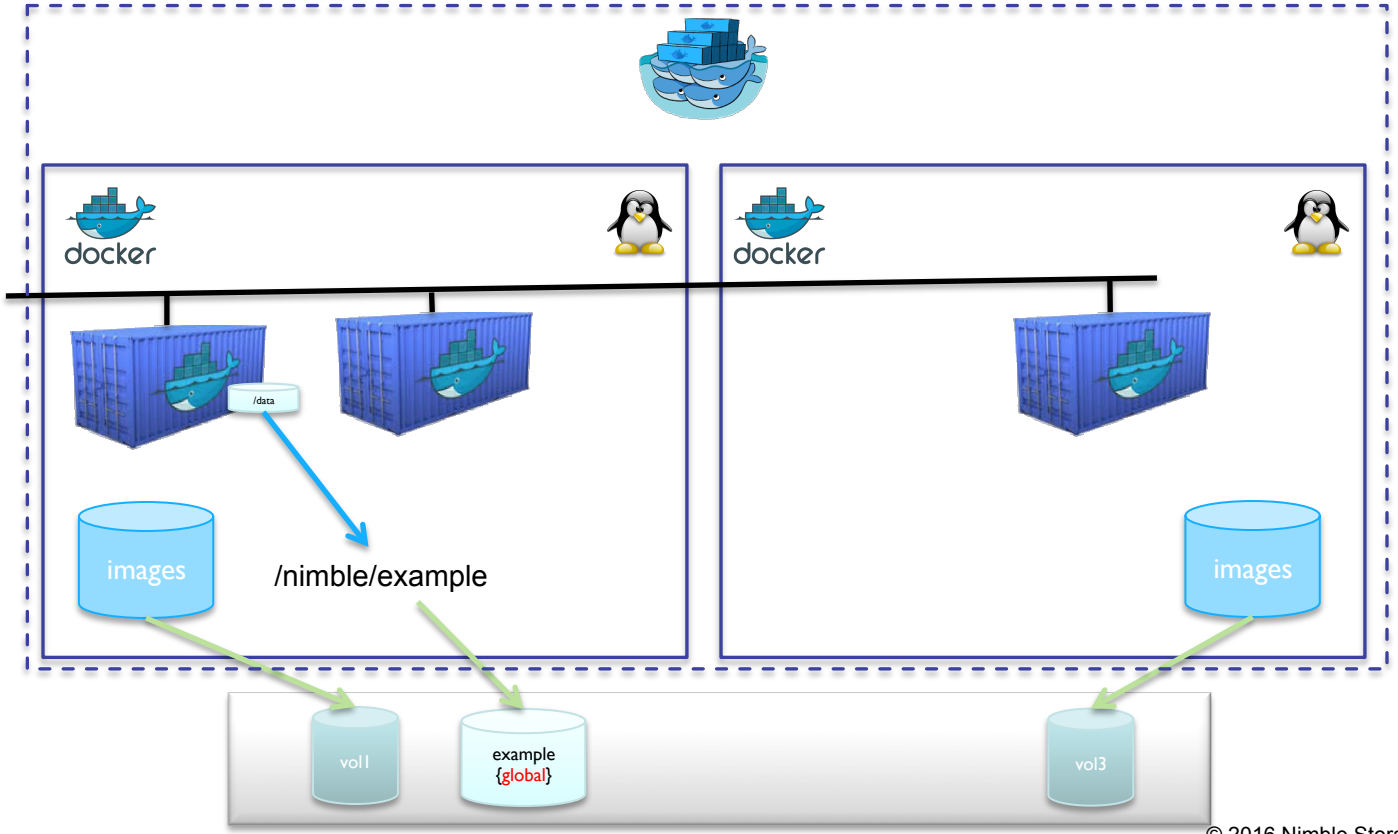
```
$ docker service create –mount type=volume,target=/usr/share/nginx/html,\
        source=myvol1,volume-driver=nimble,volume-opt=sizeInGiB=50 nginx
```

- Using Docker Compose:

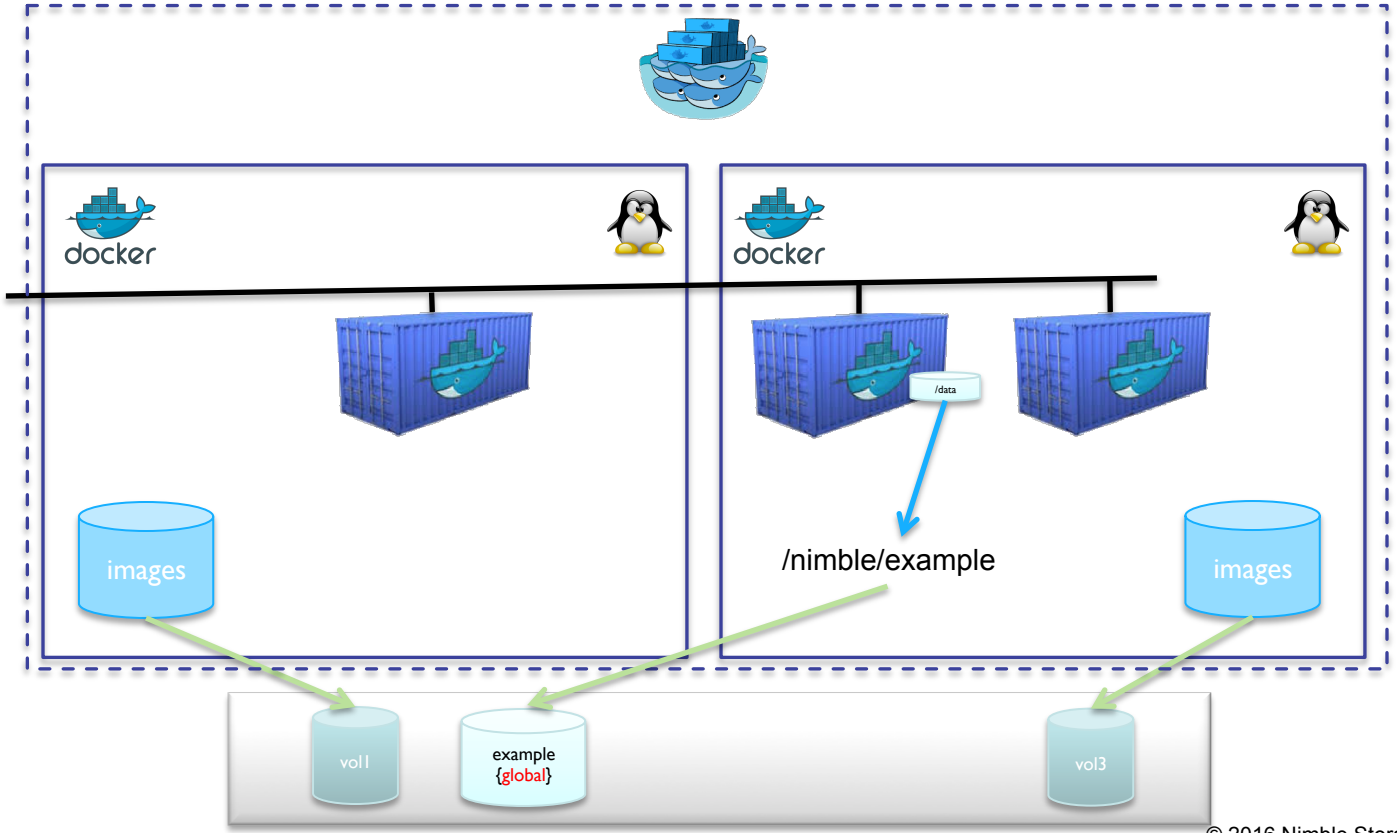
```
$ docker-compose -f web.yml –p web up –d
```

```
# web.yml
version: "2"
services:
  web:
    image: nginx:latest
    ports:
    - "8080:80"
    volumes:
    - myvol1:/usr/share/nginx/html
volumes:
  myvol1:
    driver: nimble
    driver_opts:
      sizeInGiB: 50
```

Persistent Shared Storage via Plug-in



Persistent Shared Storage via Plug-in



Future Considerations

- Storage for Central Image Registry
  - Performance
  - Protection
  - Scalability
  - Availability
- Orchestration
  - Plugging into other layers

Resources

- Docker Community
  - https://forums.docker.com/c/open-source-projectsCommunity
- Cloud Native Computing Foundataion
  - https://www.cncf.io/
- “Windows Containers” post by Taylor Brown
  - https://msdn.microsoft.com/en-us/virtualization/windowscontainers/about/about_overview
- Docker Documentation
  - https://docs.docker.com/
- Michael Mattsson’s blog
  - https://connect.nimblestorage.com/people/mmattsson/activity

More SNIA Webcasts on Containers

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- On-Demand: **Intro to Containers, Container Storage and Docker**
  https://www.brighttalk.com/webcast/663/217971

- Live December 7, 2016: **Containers: Best Practices and Data Management Services**
  https://www.brighttalk.com/webcast/663/227349

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