Current State of Storage in the Container World

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Agenda

概述容器
- 虚拟机 vs. 容器
- 快速历史，我们现在
- Docker 容器如何工作
- 容器为什么具有吸引力

存储容器
- 坚固和非持久
- 容器的选项
- NAS vs. SAN

未来考虑
Virtual Machine vs. Container
A Brief History of On-premises Technologies

Mainframe

IBM

DEC

Unix®

Zones

Projects

Fair Share

Timesharing

"App per Machine"

O(1)

2x2x2

2x4x2

Linux / Windows

"App per Virtual Machine"

KVM

Xen

ESX

Hyper-V

Hypervisor

Container

Namespaces

cgroups

Completely Fair Share

Multi-core

Mass-produced

Multi-processor

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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 Hub

Docker Trusted Registry

images

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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
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

*Do not use the Device Mapper driver in loopback mode in production
Locate Node Registry on External Storage

- Docker Hub
- Docker Trusted Registry

Vol1

Vol3

Images
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
```

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

<table>
<thead>
<tr>
<th>DRIVER</th>
<th>VOLUME NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>local</td>
<td>example</td>
</tr>
</tbody>
</table>

No volume named example
/var/lib/docker/volumes/example

```bash
$ docker volume ls
```

```bash
$ docker volume ls
```

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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

Docker Mount

- Copy on Write
- /opt/app
- /usr/lib
- Base Image: /
- Docker Engine
- Host OS: /usr/local/games

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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>
```
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

$ 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

Host OS

Docker Volume

- Copy on Write
- /data
- /opt/app
- /usr/lib
- Base Image: /
- Docker Engine
- Driver: nimble

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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",
        "PerfPolicy": "DockerDefault",
        "ThinlyProvisioned": true,
        "VolSizeMiB": 10240,
        "VolumeName": "example.docker"
    },
    "Labels": {},
    "Scope": "global"
}
Plug-in Driven Docker Volume Creation

Using the vanilla Docker client:

```bash
$ 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:

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

Using Docker Compose:

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

```yaml
# 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

```
images
/vimble/example

images
```

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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-projects

- Cloud Native Computing Foundation
  - 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

❖ 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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