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Introduction to Container Technology

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Container Technology

Containers

- "Linux Containers" is a Linux kernel feature to contain a group of processes in an independent execution environment.
- Linux kernel provides an independent application execution environment for each container including:
  - Independent filesystem
  - Independent network interface and IP address.
  - Usage limit for memory and CPU time.
- Linux containers are realized with integrating many existing Linux features. There are multiple container management tools such as lxctools, libvirt and docker. They may use different parts of these features.

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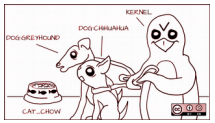
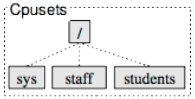
Container History

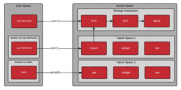
2000:
JAILS ADDED
TO FREEBSD



2003:
SELINUX ADDED TO
LINUX MAINLINE



2006:
GENERIC PROCESS
CONTAINERS



2008:
KERNEL AND USER
NAMESPACES

2013:
RED HAT
ENTERPRISE LINUX

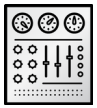
OPENSHIFT by Red Hat
RED HAT ATOMIC ENTERPRISE PLATFORM

2015:
RHT CONTAINER
PLATFORMS

Linux VServer

2001:
LINUX -VSERVER
PROJECT

2005:
FULL RELEASE OF
SOLARIS ZONES



2007:
GPC RENAMED
CONTROL GROUPS

2013:
DOT CLOUD PYCON
LIGHTNING TALK

2014:
GOOGLE
KUBERNETES

2015:
STANDARDS VIA OCI
AND CNCF

2000
2005
2010
2015

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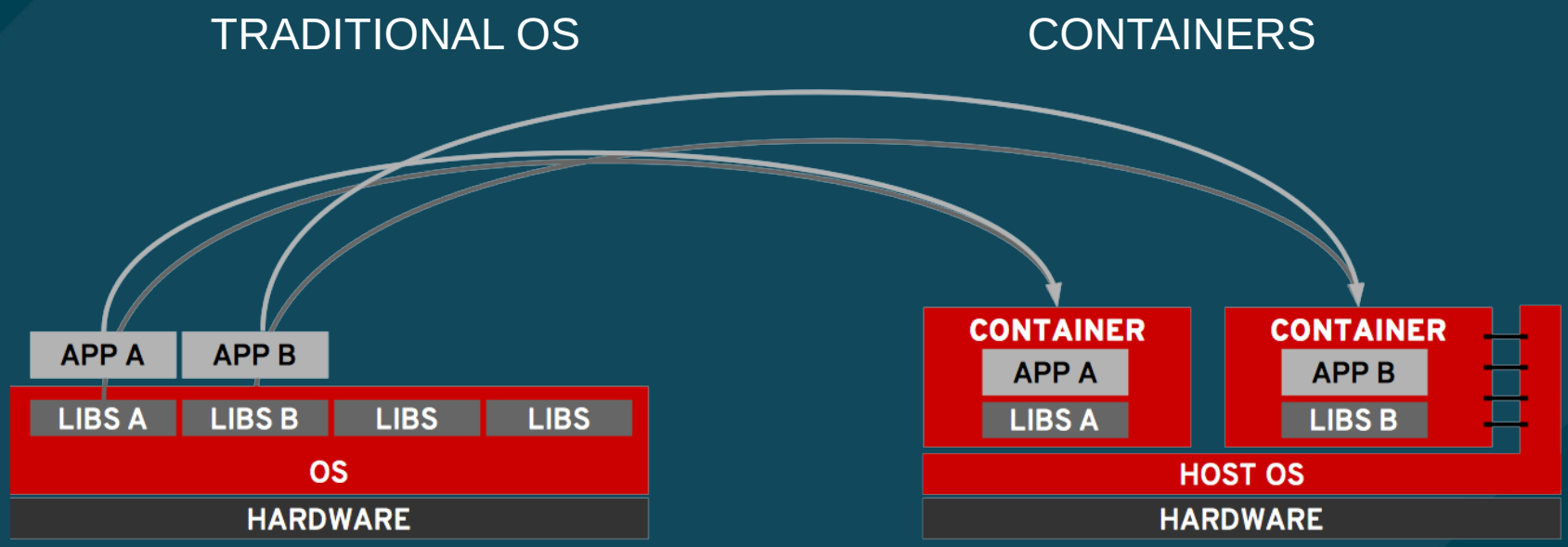
CONTAINERS
≠
VIRTUALIZATION


TRADITIONAL OS
CONTAINERS
APP A
APP B
LIBS A
LIBS B
LIBS
LIBS
OS
HARDWARE
CONTAINER
APP A
LIBS A
CONTAINER
APP B
LIBS B
HOST OS
HARDWARE

Underlying Technology

Enabling Technology in Linux has been present for many years

- Namespaces
  - Process
  - Network
  - Filesystem
  - User
  - IPC
  - UTS (UNIX Technology Services)
- cgroups - Control Groups
- Union (overlay) Filesystems

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Namespaces

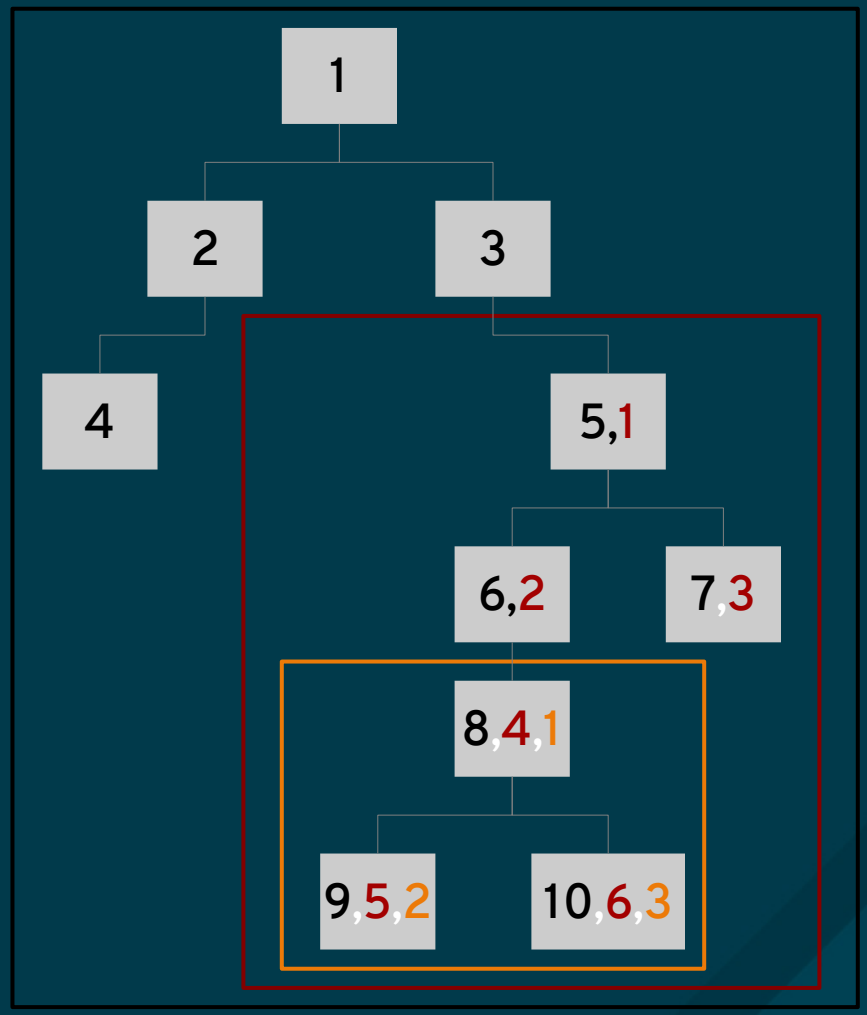
Process Namespaces

Original UNIX Process Tree

- First process is PID 1
- Process tree rooted at PID 1
- PIDs with appropriate privilege may inspect or kill other processes in the tree

Linux Namespaces

- Multiple, nested process trees
- Nested trees cannot see parent tree
- Process has multiple PIDs
  - One for each namespace it is a member of



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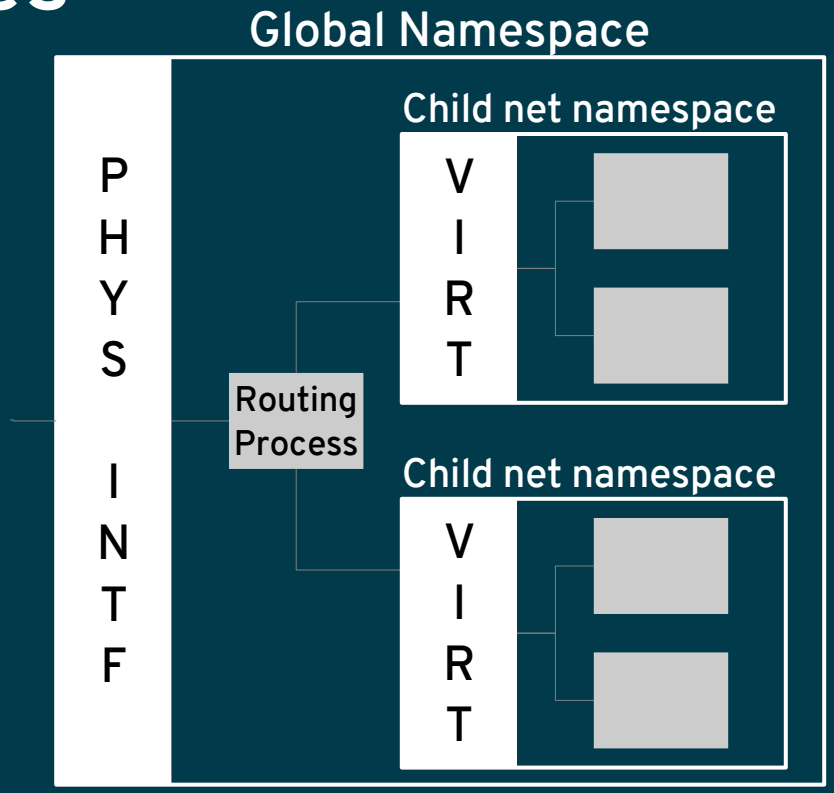
Network Namespaces

Presents an entirely separate set of network interfaces to each namespace

- All interfaces including loopback are virtualized
- Ethernet bridges may be created
  - `ip link add name veth0 type veth peer name veth1 netns <pid>`
- Routing process in global namespace to route packets




```
Original Namespace:
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: enp4s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP mode DEFAULT group default qlen 1000
    link/ether 00:24:8c:a1:ac:e7 brd ff:ff:ff:ff:ff:ff

New Namespace:
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN mode DEFAULT group default
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
```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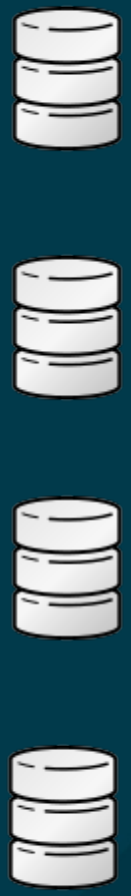
Filesystem Namespaces

Clone / Replace list of mounted filesystems

- Similar to `chroot`
- Allows isolation of all mount points, not just root
- Atrributes can be changed between namespaces (read only, for instance)
- Used properly, avoids exposing anything about underlying system



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User Namespaces

Replace / Extend UID / GID

- Delete unneeded UID / GID from container
- Add / change UID / GID map inside container
- Use: root privilege in container, user privilege in base OS

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IPC Namespaces

Similar to network namespaces

- Separate interprocess communications resources
  - Sys V IPC
  - POSIX messaging

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UTS Namespaces

UTS : UNIX Technology Services

- Change inside container:
  - Hostname
  - Domain

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Feature availability

- Filesystem separation
- Hostname separation
- IPC separation
- User (UID/GID) separation
- Processtable separation
- Network separation
- Usage limit of CPU/Memory

- Mount namespace (kernel 2.4.19)
- UTS namespace (kernel 2.6.19)
- IPC namespace (kernel 2.6.19)
- User namespace (kernel 2.6.23 ~ kernel 3.8)
- PID namespace (kernel 2.6.24)
- Network Namespace (kernel 2.6.24)
- Control groups

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Namespaces Summary

Isolation / Modification of Container processes from host

- PIDs
- Network
- Filesystems
- UID/GID
- IPC
- Hostname / Domain

See documentation on clone() system call for more complete details on functionality (Warning: systems programmer jargon territory)

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cgroups

cgroups

- Way to allocate resources to processes running on a system
- Hierarchical and can be dynamically added, changed and removed
- Made up of several subsystems also called Resource Controllers

- Part of RHEL 6 & 7 Kernel
- Upstream since 2.6.24
- You must install userspace tools
  - Install libcgroup

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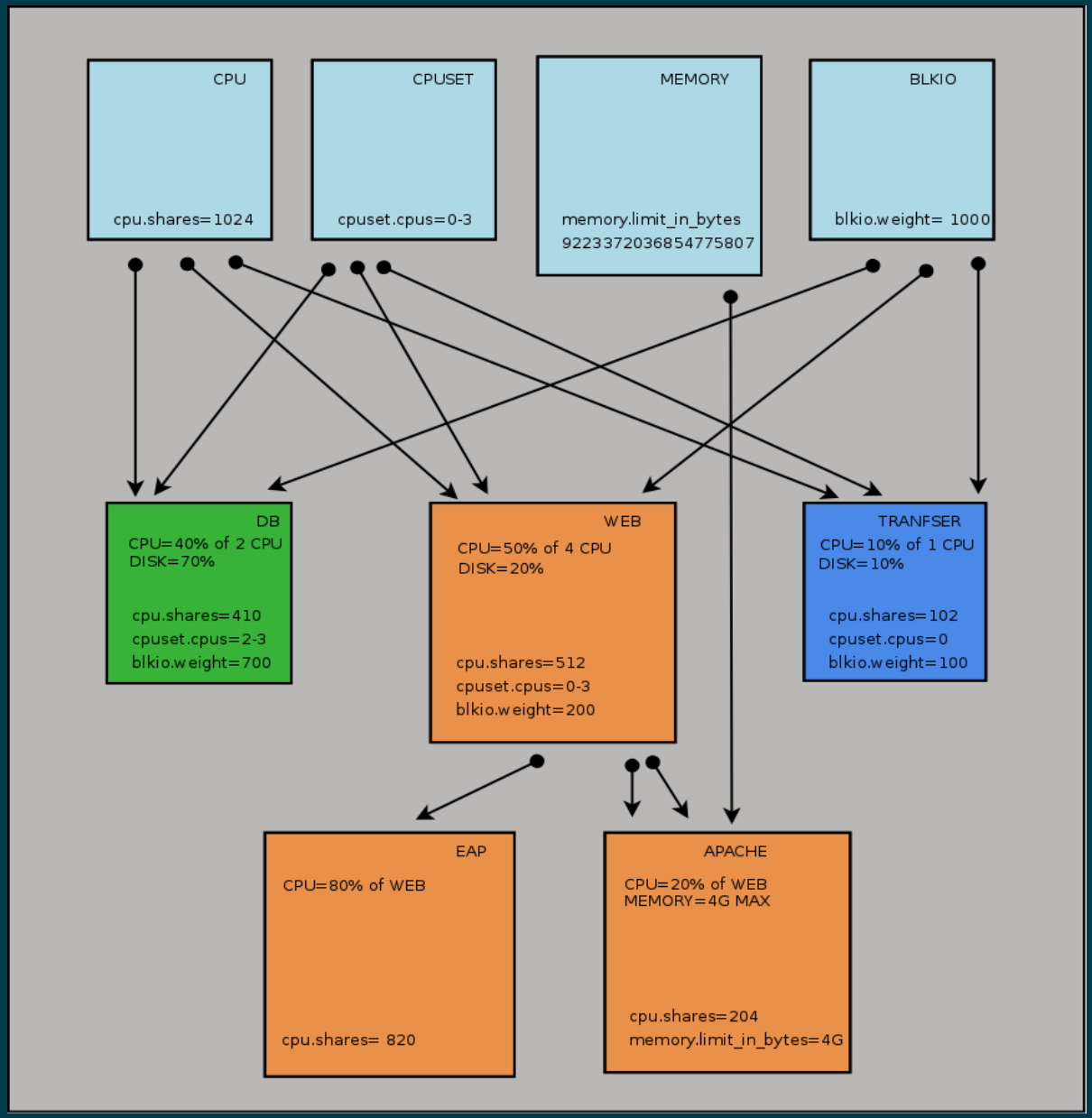
CPU
cpu.shares=1024
CPUSET
cpuset.cpus=0-3
MEMORY
memory.limit_in_bytes
9223372036854775807
BLKIO
blkio.weight= 1000
DB
CPU=40% of 2 CPU
DISK=70%
cpu.shares=410
cpuset.cpus=2-3
blkio.weight=700
WEB
CPU=50% of 4 CPU
DISK=20%
cpu.shares=512
cpuset.cpus=0-3
blkio.weight=200
TRANFSER
CPU=10% of 1 CPU
DISK=10%
cpu.shares=102
cpuset.cpus=0
blkio.weight=100
EAP
CPU=80% of WEB
cpu.shares= 820
APACHE
CPU=20% of WEB
MEMORY=4G MAX
cpu.shares=204
memory.limit_in_bytes=4G

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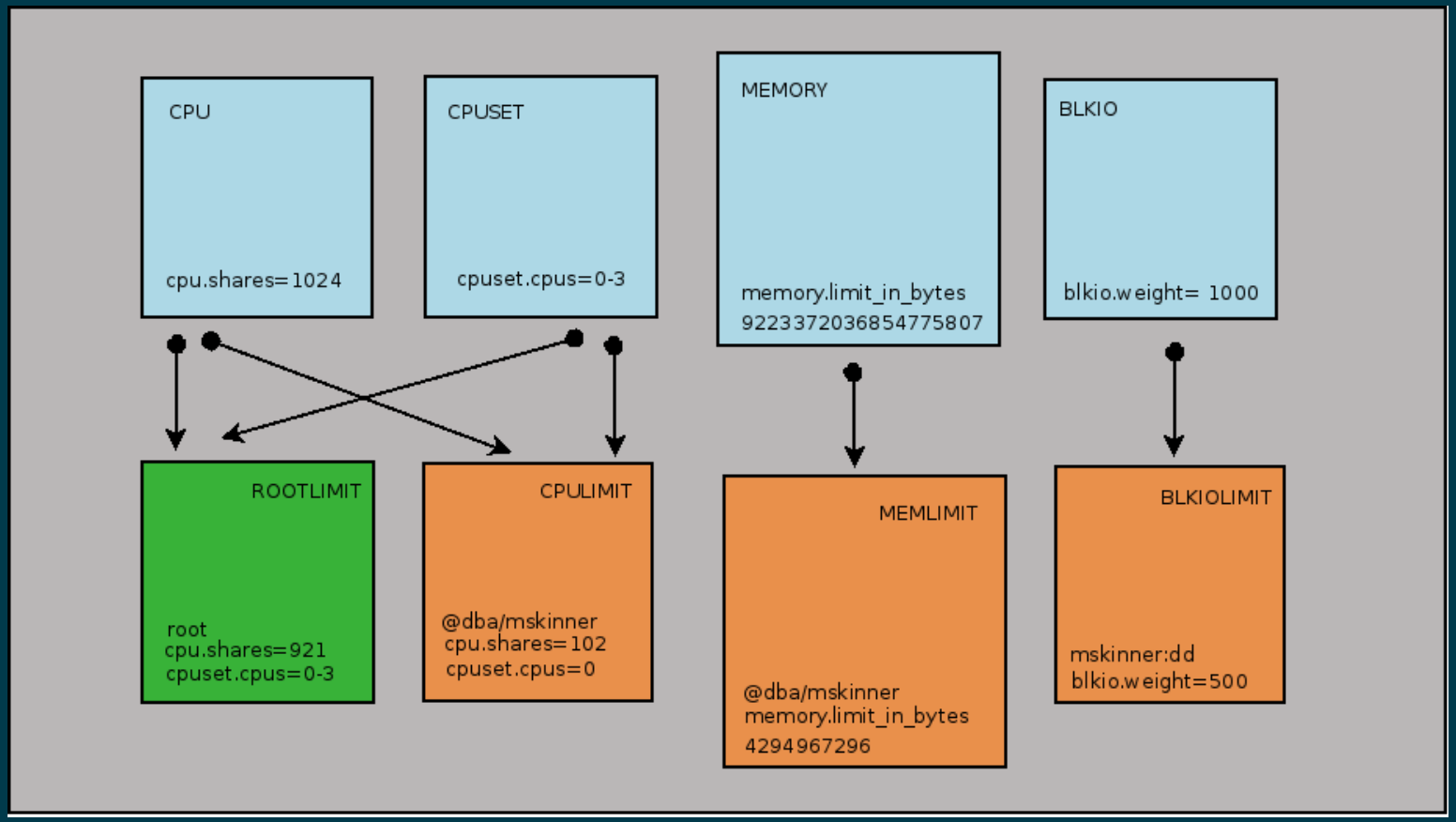
CPU
cpu.shares=1024
CPUSET
cpuset.cpus=0-3
MEMORY
memory.limit_in_bytes
9223372036854775807
BLKIO
blkio.weight= 1000
ROOTLIMIT
root
cpu.shares=921
cpuset.cpus=0-3
CPULIMIT
@dba/mskinner
cpu.shares=102
cpuset.cpus=0
MEMLIMIT
@dba/mskinner
memory.limit_in_bytes
4294967296
BLKIOLIMIT
mskinner:dd
blkio.weight=500

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Resource Controllers

- **blkio** — this subsystem sets limits on input/output access to and from block devices such as physical drives (disk, solid state, USB, etc.).
- **cpu** — this subsystem uses the scheduler to provide cgroup tasks access to the CPU.
- **cpuacct** — this subsystem generates automatic reports on CPU resources used by tasks in a cgroup.
- **cpuset** — this subsystem assigns individual CPUs (on a multicore system) and memory nodes to tasks in a cgroup.
- **devices** — this subsystem allows or denies access to devices by tasks in a cgroup.
- **freezer** — this subsystem suspends or resumes tasks in a cgroup.
- **memory** — this subsystem sets limits on memory use by tasks in a cgroup, and generates automatic reports on memory resources used by those tasks.
- **net_cls** — this subsystem tags network packets with a class identifier (classid) that allows the Linux traffic controller (tc) to identify packets originating from a particular cgroup task.
- **net_prio** — this subsystem provides a way to dynamically set the priority of network traffic per network interface.
- **ns** — the *namespace* subsystem.

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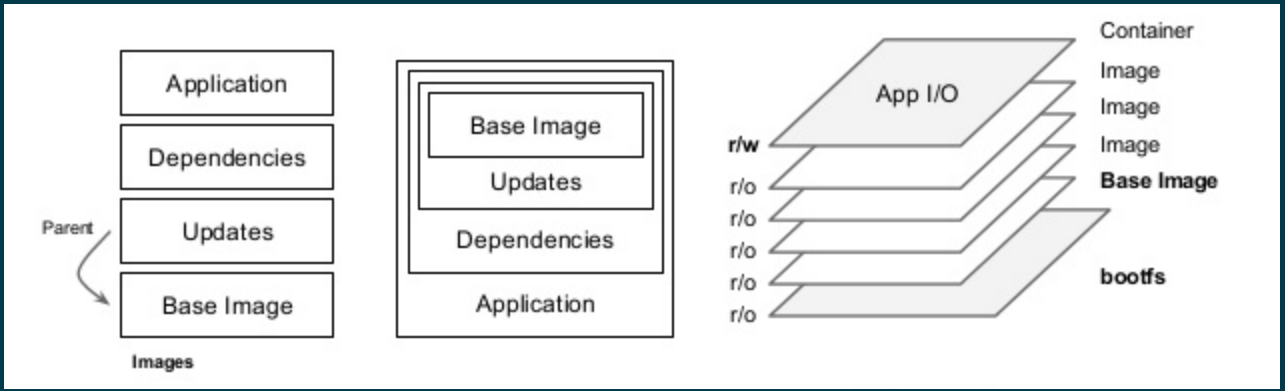
Union (overlay) Filesystems

Union Filesystems

- Stacked / Layered Storage
- Copy on write
- Many available underlying implementations
  - Aufs
  - OverlayFS
  - btrfs
  - LVM
  - Device mapper



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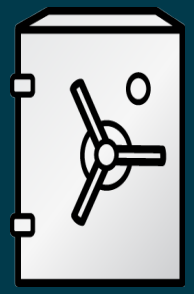
Container Security

CONTAINERS ARE NOT SECURE BY DEFAULT

Container Security



ISOLATION OF HOSTS

Host OS + SELinux maintained by trusted kernel engineers and frequently updated.

ARE SOURCES TRUSTED?

36% of Docker Hub official images contain high priority security vulnerabilities.*

WHAT'S INSIDE CONTAINERS

Red Hat + Black Duck = secure, trusted model for validating container contents.

TRUST IS TEMPORAL

New vulnerabilities are identified daily and containers become stale over time.

*Source: *Over 30% of Official Images in Docker Hub Contain High Priority Security Vulnerabilities*, Jayanth Gummaraju, Tarun Desikan, and Yoshio Turner, BanyanOps, May 2015 (http://www.banyanops.com/pdf/BanyanOps-AnalyzingDockerHub-WhitePaper.pdf)

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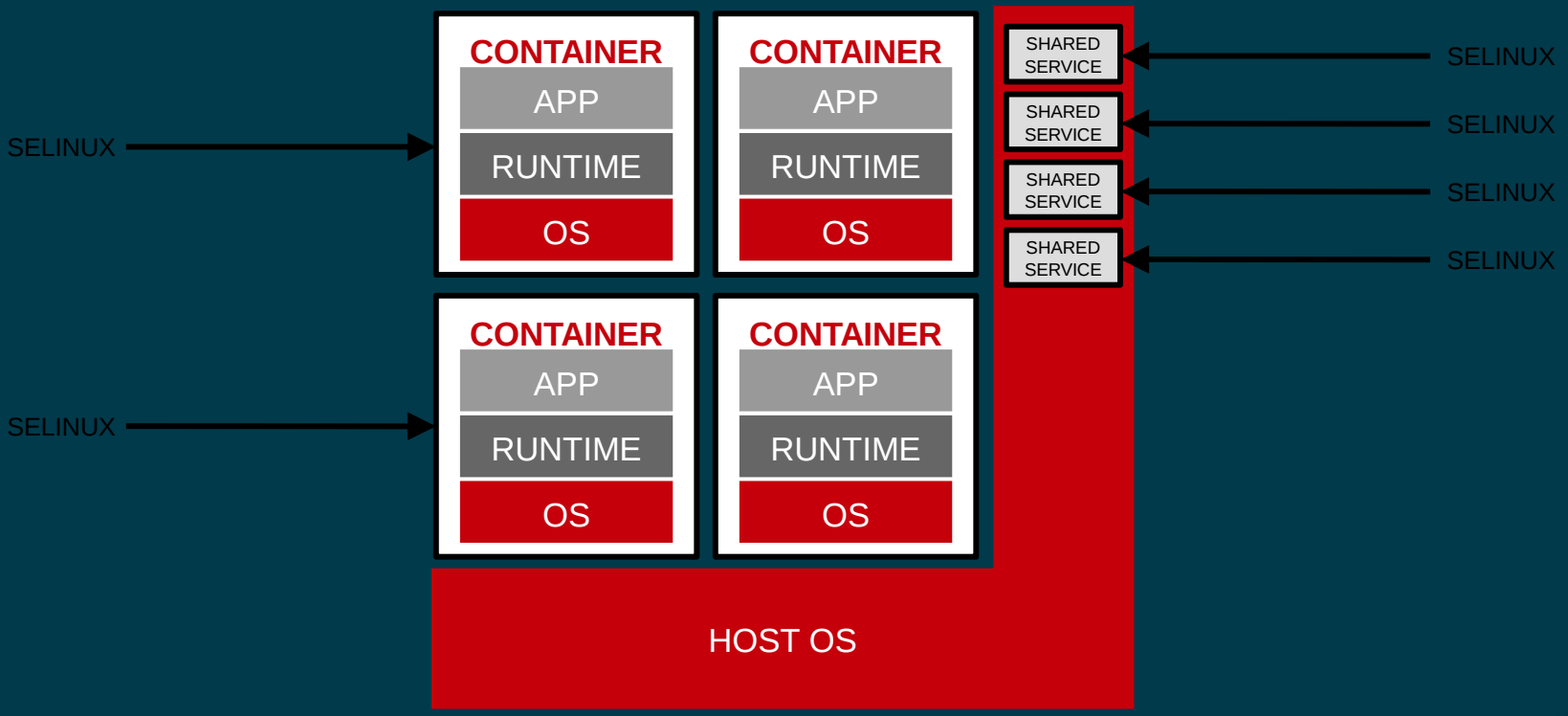
Container Isolation with SELinux



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Red Hat Container Technology

- Stock Red Hat Enterprise Linux (“RHEL”)
  - Full OS image
  - Docker packages added
  - All combinations of use
- Red Hat Enterprise Linux Atomic Host (“Atomic”)
  - Stripped down OS image
  - Pre-installed docker packages
  - Only for container deployment
    - Limited additional packages
    - Different upgrade / update process (no yum)
  - Optimized settings for container deployment
  - Separate subscription from RHEL subscription

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Atomic Formats

- Multiple environments available
  - Cloud image (qcow2)
  - RHEV (ova)
  - Hyper-V (vhd)
  - vSphere (ova)
  - Installer (iso)

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Installing Atomic on kvm

- Create overlay of image

```
qemu-img create -f qcow2 -o
backing_file=rhel-atomic-cloud-7.2-
12.x86_64.rhevm.qcow2  atomic-instance-
0.qcow2
```

- Set up VM
- Customize VM startup
  - meta-data & user-data files
    - Host IP addresses
    - Login credentials
- Start VM

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Register & Update Atomic

- Register Atomic

```
subscription-manager register —username=myid
subscription-manager attach
subscription-manager list
```

- Upgrade Atomic

```
atomic host upgrade
```

- Atomic upgrade status

```
atomic host status
```

- Recover from failed upgrade

```
atomic host rollback
```


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Using Docker

- Getting help

```
docker --help
```

- Information on docker install

```
docker info
docker network ls
```


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Using Docker Images

- Download an image

```
docker pull rhel7:latest
```

- Modify Dockerfile
  - Update MAINTAINER
- Build image

```
docker build -t webserver .
```

- Show images

```
docker images
```

- Remove an image

```
docker rmi myimage
```

- Show all images

```
docker images -a
```


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Using Containers

- Start a container

```
docker run -d -p 80:80 --name=myweb webserver
```

- Change content
- Start another container

```
docker run -d -p 80:80 --name=myweb webserver
```

- List containers

```
docker ps
```

- Stop container

```
docker stop myimage
```

- Restart container

```
docker restart myimage
```

- Remove container

```
docker rm myimage
```


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Reference Materials

- Atomic documentation
  https://access.redhat.com/documentation/en/red-hat-enterprise-linux-atomic-host?version=7/
- Atomic Download
  https://access.redhat.com/downloads/content/271/ver=/rhel---7/7.2.2-2/x86_64/product-software

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