Container without Docker

Jaehong Jung | WING SENIOR | 2023.03

Reference

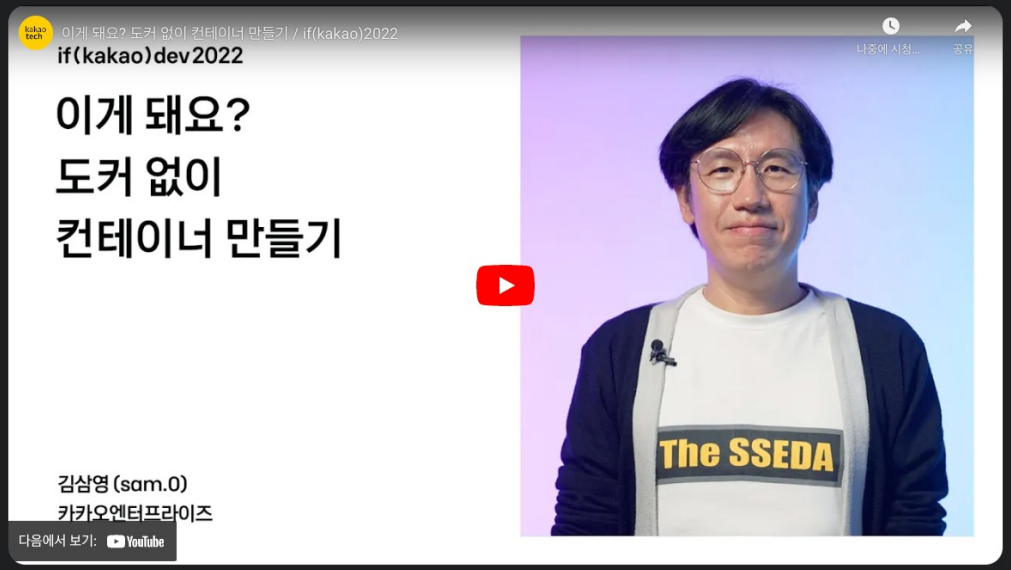
if(kakao) dev 2022

이게 돼요? 도커 없이 컨테이너 만들기

카카오엔터프라이즈 | 기술세션 클라우드

2022.12.09

공유하기



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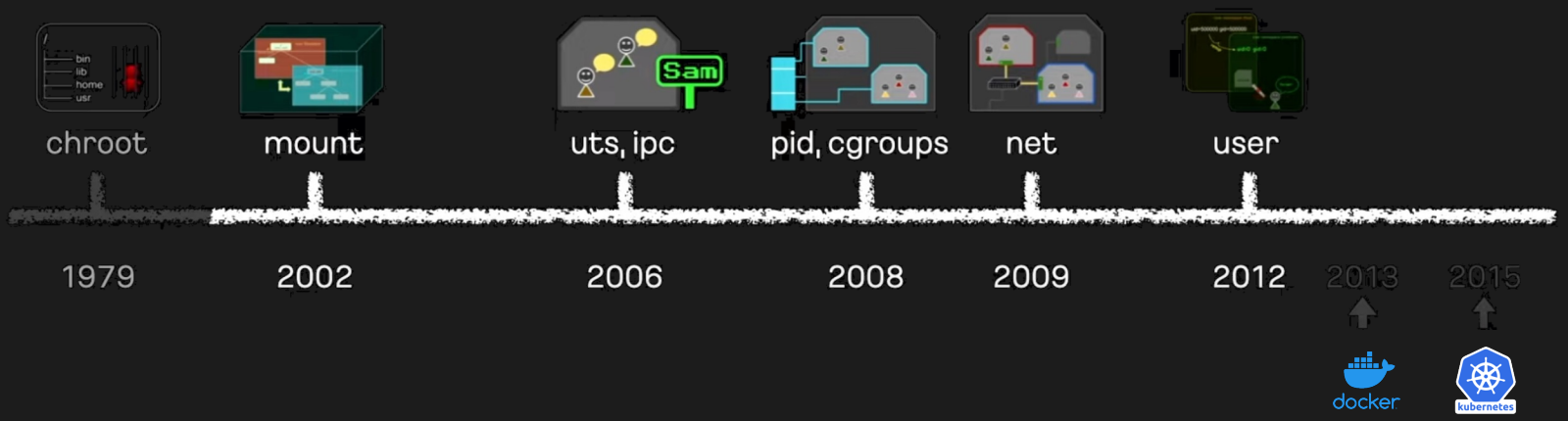
Timeline

Q. Is Docker a completely new technology?



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WING

“2,000,000,000”

Containers in 2014 every week

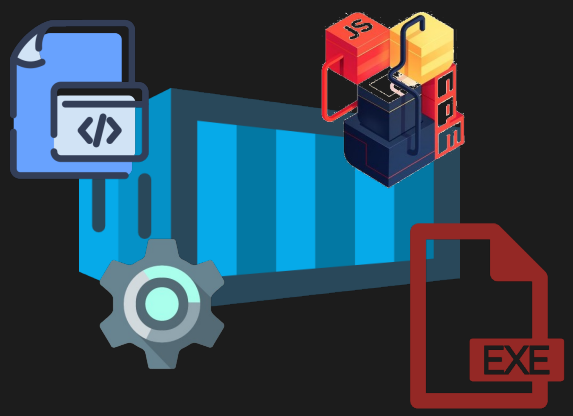
Google is using containers to run everything in their clusters, starting **over 2 billion of them per week**

Introduction

What is Docker and Why Docker?

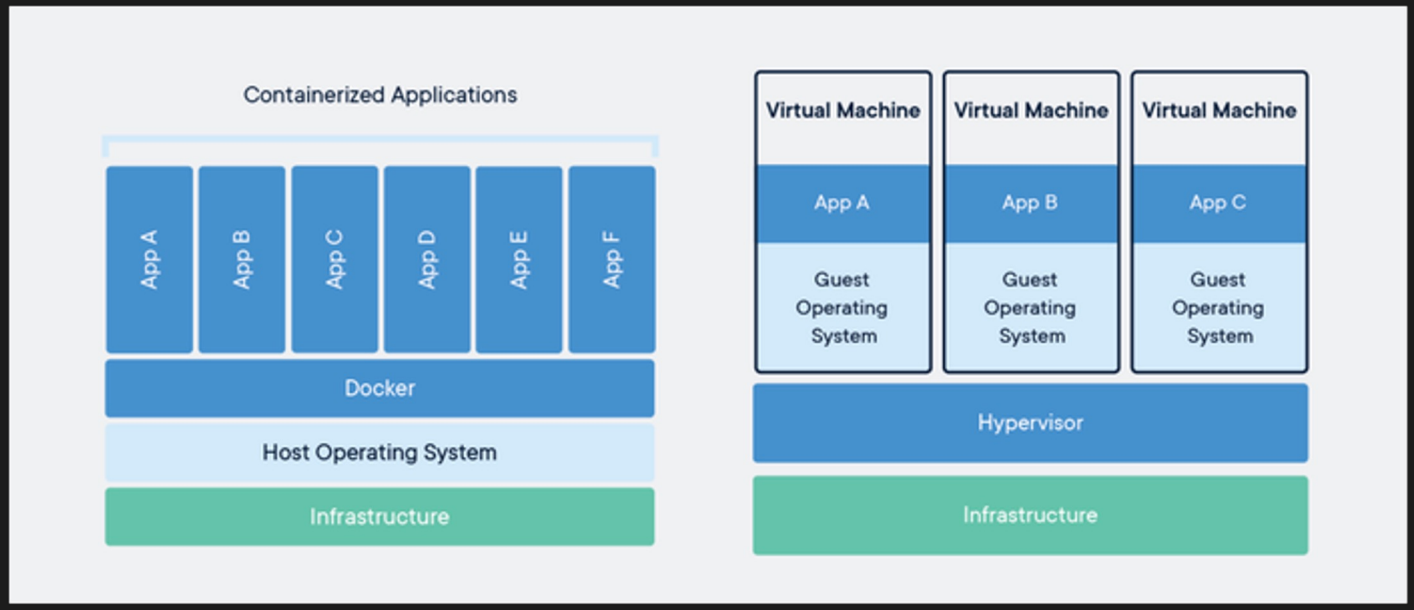
Many Application
Leads to high maintenance cost

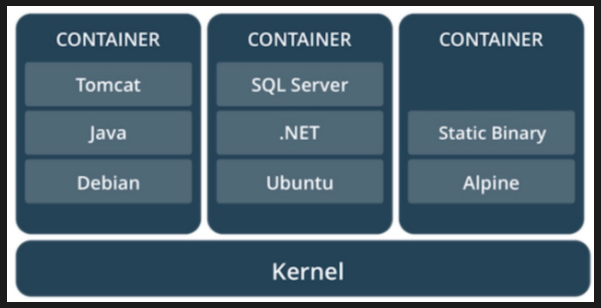
1. All-in-one **packaging**
2. **Isolation** (such as process)
3. Application **resource allocation**

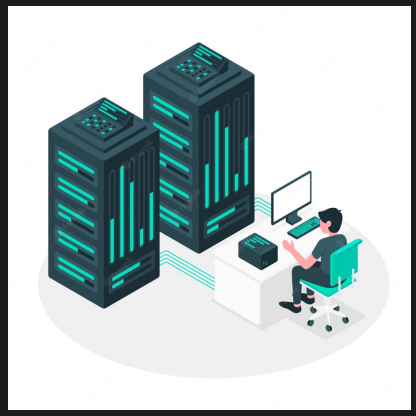


Introduction

What is Docker and Why Docker?







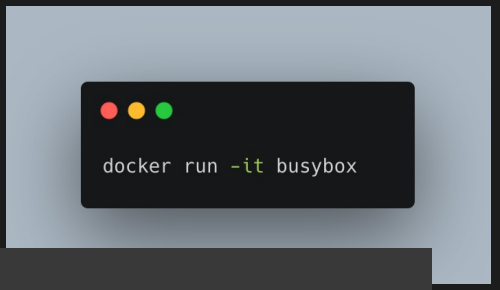
Prerequisites

```
sudo apt-get -y install gcc make pkg-config libseccomp-dev tree jq bridge-utils

sudo apt-get install -y \
    ca-certificates \
    curl \
    gnupg \
    lsb-release \
    gnupg2 \
    pass

curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo gpg --dearmor -o
/usr/share/keyrings/docker-archive-keyring.gpg

echo \
"deb [arch=amd64 signed-by=/usr/share/keyrings/docker-archive-keyring.gpg]
https://download.docker.com/linux/ubuntu \
$(lsb_release -cs) stable" | sudo tee /etc/apt/sources.list.d/docker.list > /dev/null

sudo apt-get update
sudo apt-get install -y docker-ce docker-ce-cli containerd.io

sudo -Es
```

Host vs Container

root directory

Host(up), Container(down)



root@ip-172-26-8-43: / (ssh)

```
root@ip-172-26-8-43:/# ls
bin   home            lib64       opt   sbin  tmp       vmlinuz.old
boot  initrd.img      lost+found  proc  snap  usr
dev   initrd.img.old  media       root  srv   var
etc   lib             mnt         run   sys   vmlinuz
root@ip-172-26-8-43:/#
```

root@ip-172-26-8-43: / (ssh)

```
/ # ls
bin    etc    lib    proc   sys    usr
dev    home   lib64  root   tmp    var
/ #
```

Host vs Container

root directory

Host(up), Container(down)

```
docker run -it busybox
df -h
```

root@ip-172-26-8-43: / (ssh)

```
root@ip-172-26-8-43:/# df -h
Filesystem      Size  Used Avail Use% Mounted on
udev            229M     0  229M   0% /dev
tmpfs            48M  840K   48M   2% /run
/dev/xvda1       20G  2.1G   18G  11% /
tmpfs           240M     0  240M   0% /dev/shm
tmpfs           5.0M     0  5.0M   0% /run/lock
tmpfs           240M     0  240M   0% /sys/fs/cgroup
/dev/loop0       88M   88M     0 100% /snap/core/5328
/dev/loop1       13M   13M     0 100% /snap/amazon-ssm-agent/495
tmpfs            48M     0   48M   0% /run/user/1000
overlay          20G  2.1G   18G  11% /var/lib/docker/overlay2/bc4e4308bc68352c47350086a27c84f7e94312b1
0bc5db72132dfed30bdb25b7/merged
root@ip-172-26-8-43:/#
```

root@ip-172-26-8-43: / (ssh)

```
/ # df -h
Filesystem                Size      Used Available Use% Mounted on
overlay                  19.3G      2.0G     17.3G  10% /
tmpfs                    64.0M         0     64.0M   0% /dev
tmpfs                   240.0M         0    240.0M   0% /sys/fs/cgroup
shm                      64.0M         0     64.0M   0% /dev/shm
/dev/xvda1               19.3G      2.0G     17.3G  10% /etc/resolv.conf
/dev/xvda1               19.3G      2.0G     17.3G  10% /etc/hostname
/dev/xvda1               19.3G      2.0G     17.3G  10% /etc/hosts
tmpfs                   240.0M         0    240.0M   0% /proc/acpi
tmpfs                    64.0M         0     64.0M   0% /proc/kcore
tmpfs                    64.0M         0     64.0M   0% /proc/keys
tmpfs                    64.0M         0     64.0M   0% /proc/timer_list
tmpfs                    64.0M         0     64.0M   0% /proc/sched_debug
```

Host vs Container

process

Host(up), Container(down)

root@ip-172-26-8-43: / (ssh)

```
root     15436  0.0  1.0  23028  5032 pts/0    S    15:54   0:00 /bin/bash
root     15644  0.0  0.0      0     0 ?        I    15:56   0:00 [kworker/0
root     15654  0.0  1.4 107988  7236 ?        Ss   15:57   0:00 sshd: ubun
ubuntu   15729  0.0  0.7 107988  3620 ?        S    15:57   0:00 sshd: ubun
ubuntu   15730  0.0  1.0  23164  5124 pts/1    Ss   15:57   0:00 -bash
root     15769  0.0  0.0      0     0 ?        I    15:58   0:00 [kworker/u
root     15847  0.0  0.8  68312  4268 pts/1    S    15:58   0:00 sudo -Es
root     15848  0.0  1.0  23028  5004 pts/1    S    15:58   0:00 /bin/bash
root     15992  0.0  4.8 1186888 23608 pts/0   Sl+  16:01   0:00 docker run
```

root@ip-172-26-8-43: / (ssh)

```
/ # ps aux
PID   USER     TIME  COMMAND
    1 root      0:00 sh
   12 root      0:00 ps aux
/ #
```

Host vs Container
network

Host(up), Container(down)

root@ip-172-26-8-43: / (ssh)

```
root@ip-172-26-8-43:/# ip link
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN mode DEFAULT group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9001 qdisc fq_codel state UP mode DEFAULT group default qlen 1000
    link/ether 02:07:39:a7:61:80 brd ff:ff:ff:ff:ff:ff
3: docker0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP mode DEFAULT group default
    link/ether 02:42:d7:04:94:68 brd ff:ff:ff:ff:ff:ff
9: veth0e8e947@if8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master docker0 state UP mode DEFAULT
    link/ether ae:37:40:0c:39:32 brd ff:ff:ff:ff:ff:ff link-netnsid 0
root@ip-172-26-8-43:/#
```

root@ip-172-26-8-43: / (ssh)

```
/ # ip link
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
8: eth0@if9: <BROADCAST,MULTICAST,UP,LOWER_UP,M-DOWN> mtu 1500 qdisc noqueue
    link/ether 02:42:ac:11:00:02 brd ff:ff:ff:ff:ff:ff
/ #
```

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Container File System

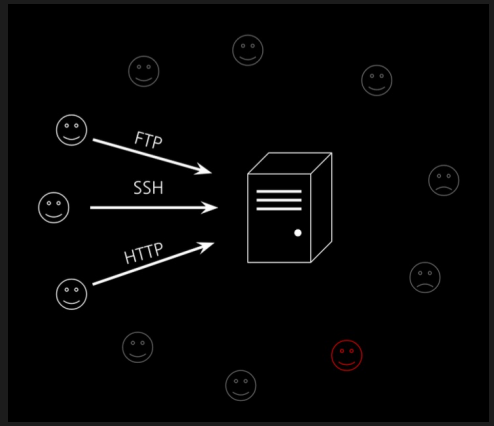
1. Isolating Process
2. Prevent breaking out chroot
3. Prevent duplicated resources

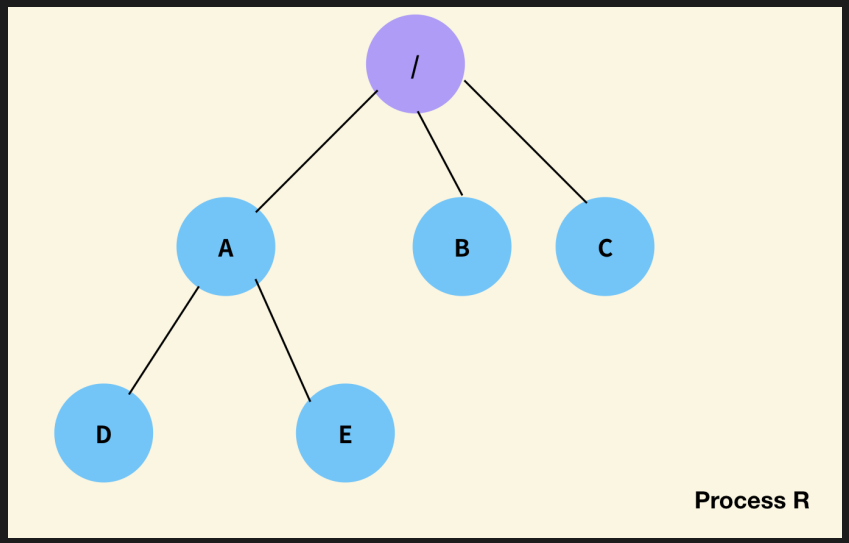
Isolating Process

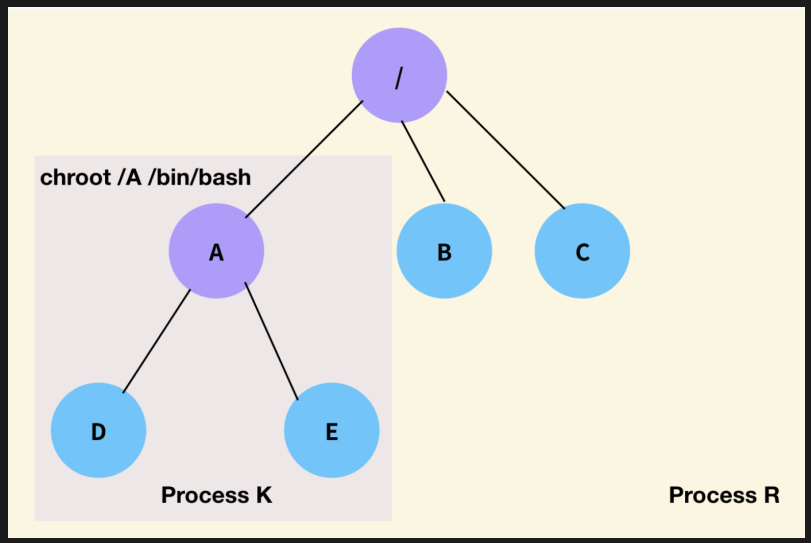
chroot (1973)

```
ubuntu@ip-172-26-8-43:~$ chroot --version
chroot (GNU coreutils) 8.28
Copyright (C) 2017 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>.
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.

Written by Roland McGrath.
```







chroot

```
mkdir myroot

chroot myroot /bin/sh
# Error
# Why?

# copy sh
which sh # /bin/sh
ldd /bin/sh
mkdir -p myroot/bin
cp /bin/sh myroot/bin/
mkdir -p myroot/{lib64,lib/x86_64-linux-gnu}
cp /lib/x86_64-linux-gnu/libc.so.6 myroot/lib/x86_64-linux-gnu/
cp /lib64/ld-linux-x86-64.so.2 myroot/lib64

# copy ls
which ls
ldd /bin/ls
cp /bin/ls myroot/bin/
cp /lib/x86_64-linux-
gnu/{libselinux.so.1,libc.so.6,libpcre.so.3,libdl.so.2,libpthread.so.0} myroot/lib/x86_64-
linux-gnu/
cp /lib64/ld-linux-x86-64.so.2 myroot/lib64/
```

chroot

Cannot get out of **myroot** using `ls`

root@ip-172-26-8-43: /tmp (ssh)

```
root@ip-172-26-8-43:~# cd /tmp
root@ip-172-26-8-43:/tmp# ls
myroot
snap-private-tmp
systemd-private-a5d1b3db81c84dd3ab356eb0e8f5be2a-systemd-resolved.service-E6CL5F
systemd-private-a5d1b3db81c84dd3ab356eb0e8f5be2a-systemd-timesyncd.service-ORryr7
root@ip-172-26-8-43:/tmp#
```

root@ip-172-26-8-43: /tmp (ssh)

```
root@ip-172-26-8-43:/tmp# chroot myroot /bin/sh
# ls
bin  lib  lib64
# cd ../../../
# ls
bin  lib  lib64
#
```

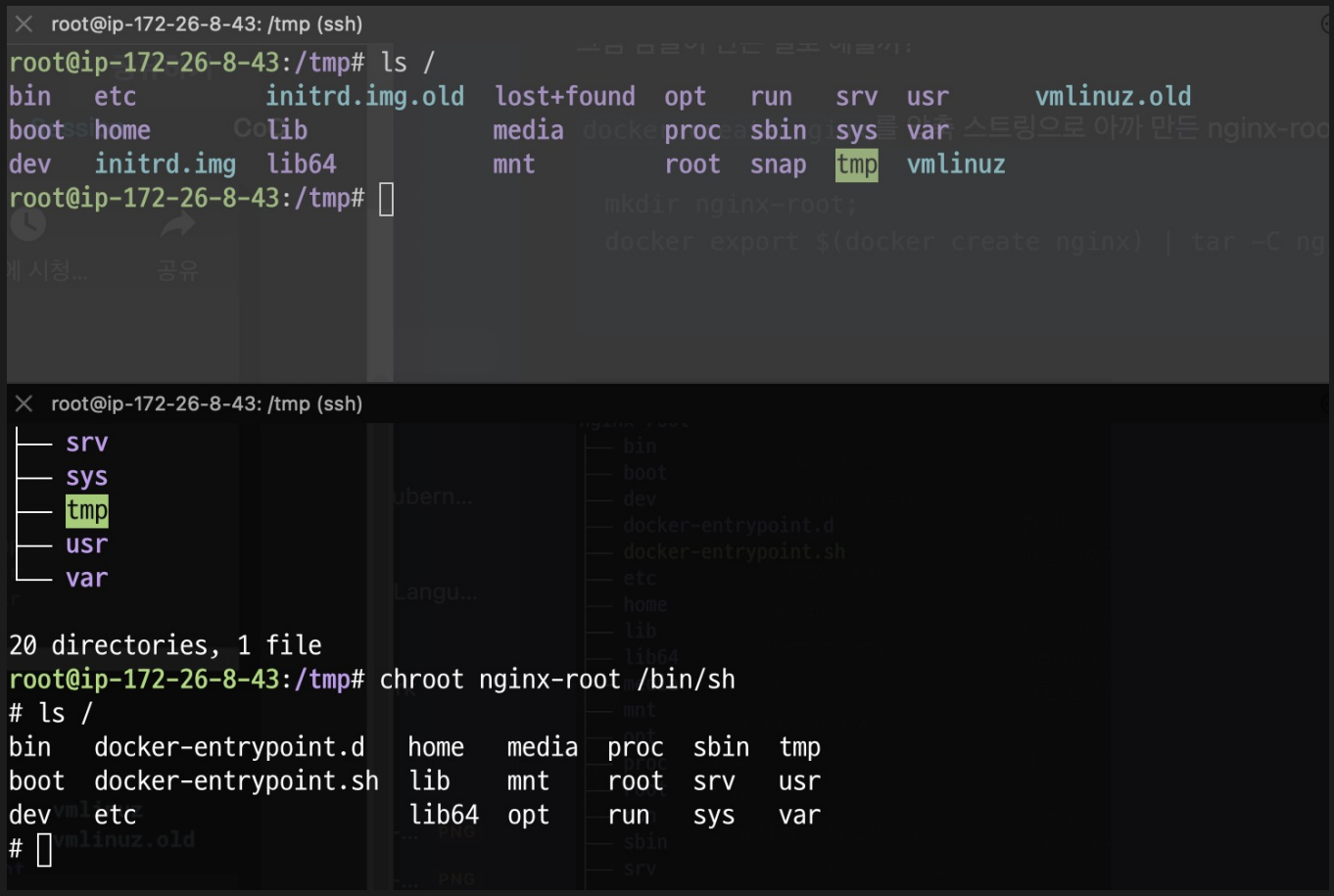
chroot (nginx)

```
mkdir nginx-root;
docker export $(docker create nginx)
| tar -C nginx-root -xvf -;
```

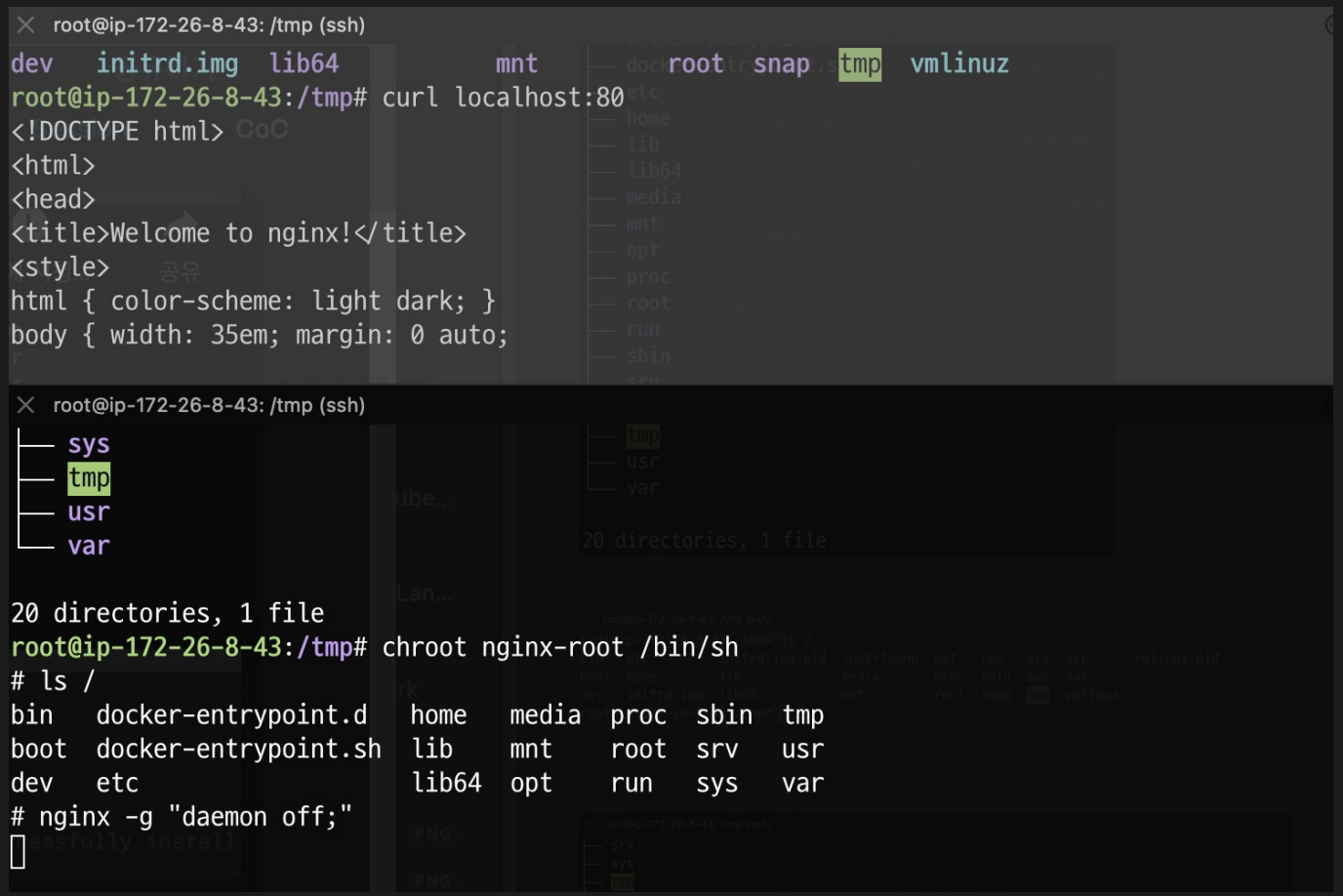
```
root@ip-172-26-8-43:/tmp# tree -L 1 nginx-root
nginx-root
├── bin
├── boot
├── dev
├── docker-entrypoint.d
├── docker-entrypoint.sh
├── etc
├── home
├── lib
├── lib64
├── media
├── mnt
├── opt
├── proc
├── root
├── run
├── sbin
├── srv
├── sys
├── tmp
├── usr
└── var

20 directories, 1 file
```

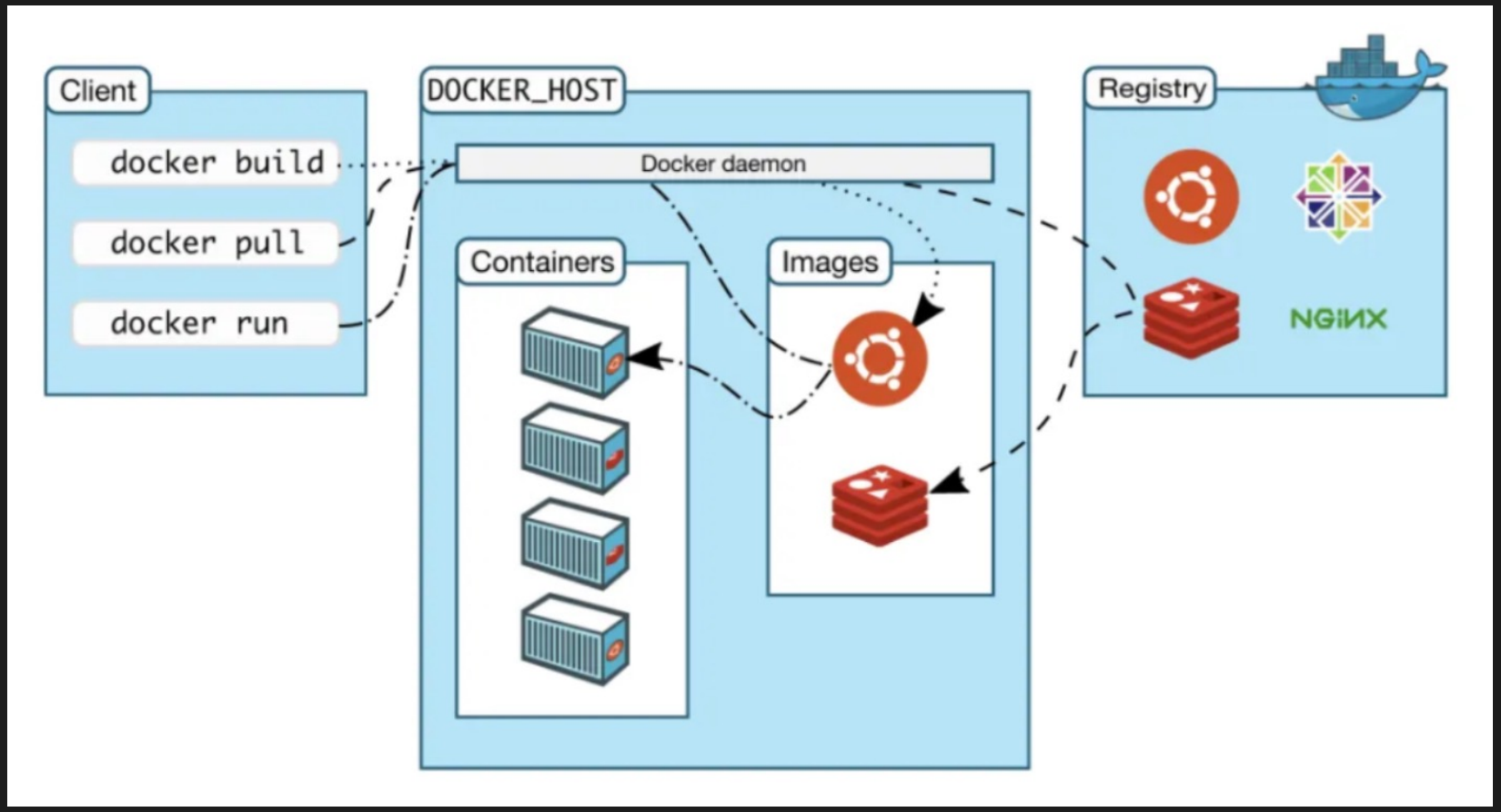
chroot (nginx)



chroot (nginx)



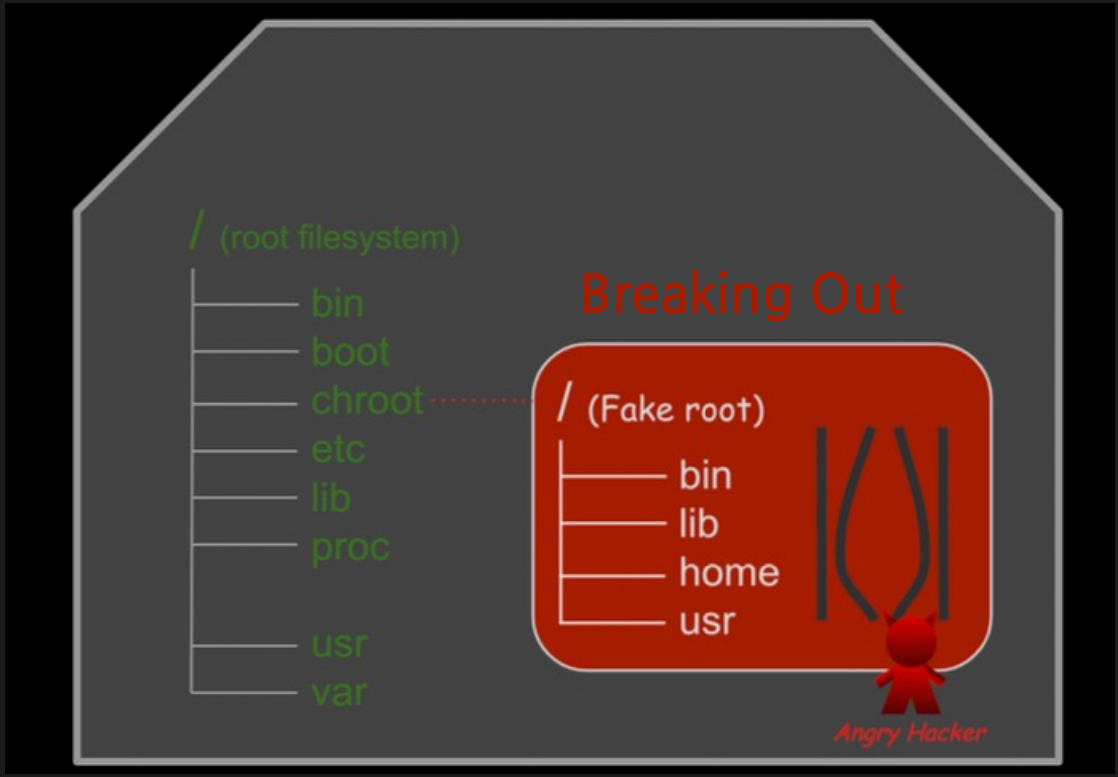
chroot


Client
docker build
docker pull
docker run
DOCKER_HOST
Docker daemon
Containers
Images
Registry
NGINX

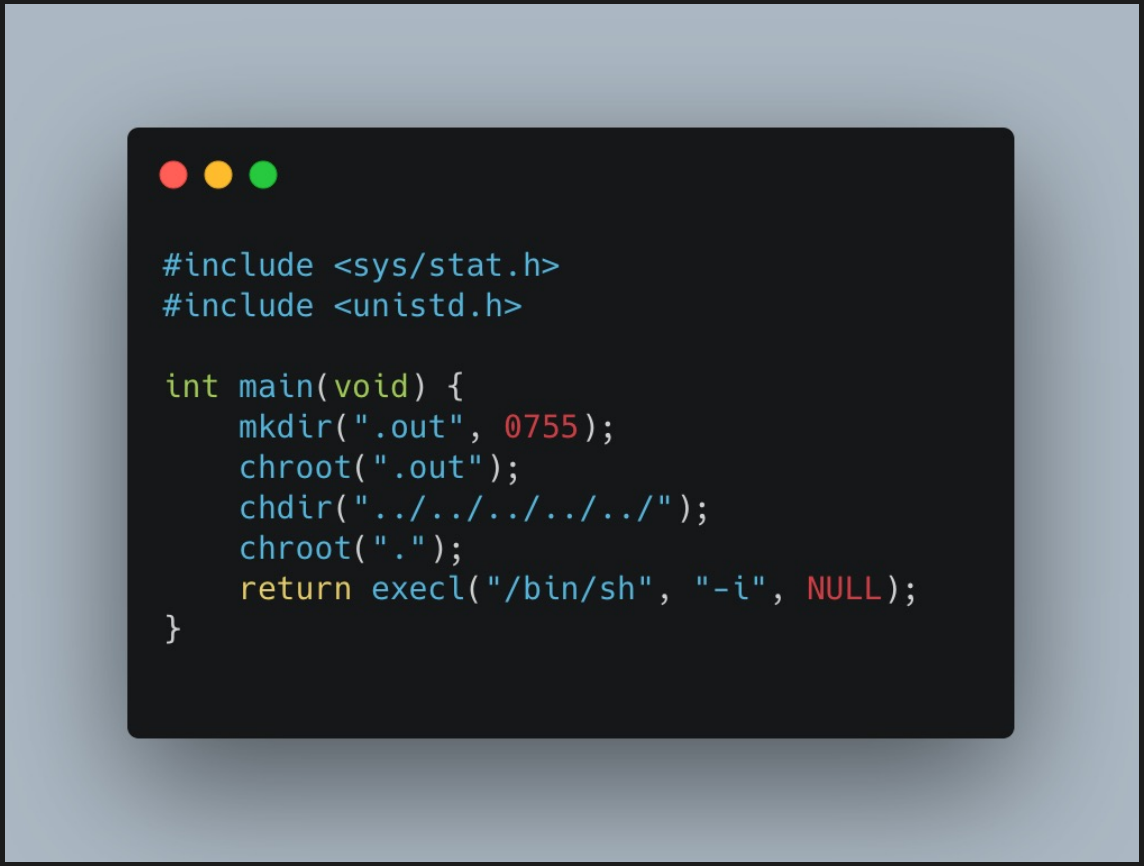
chroot

1. Packaging
2. Isolation

Breaking out from chroot



Breaking out from chroot



```c
#include <sys/stat.h>
#include <unistd.h>

int main(void) {
    mkdir(".out", 0755);
    chroot(".out");
    chdir("../../../../../");
    chroot(".");
    return execl("/bin/sh", "-i", NULL);
}
```

Breaking out from chroot

```
root@ip-172-26-8-43:/tmp# chroot myroot /bin/sh
# ls /
bin  escape_chroot  lib  lib64  proc  usr
# cd ../../
# ls
bin  escape_chroot  lib  lib64  proc  usr
# ./escape_chroot
# ls /
bin   etc        initrd.img.old  lost+found  opt   run   srv  usr      vmlinuz.old
boot  home       lib             media       proc  sbin  sys  var
dev   initrd.img  lib64          mnt         root  snap  tmp  vmlinuz
# 
```

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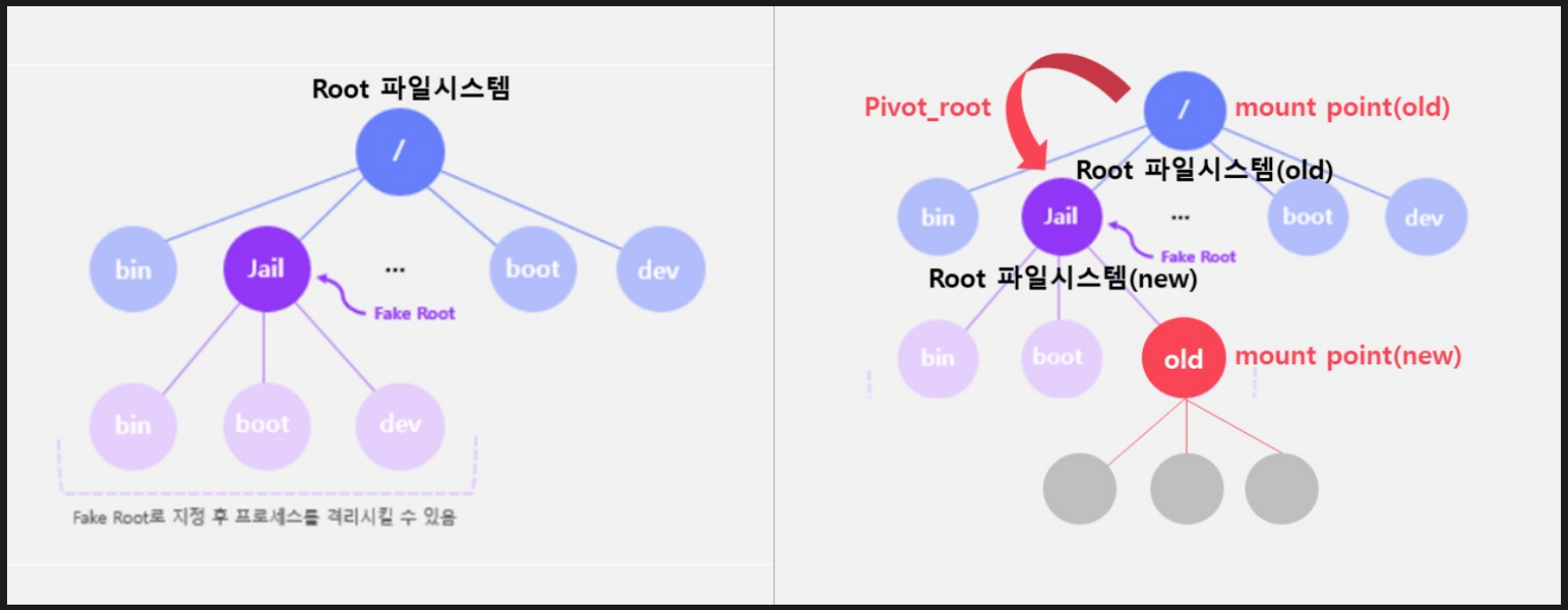
pivot_root

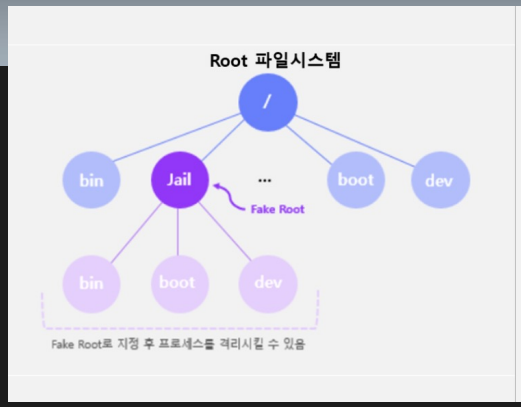


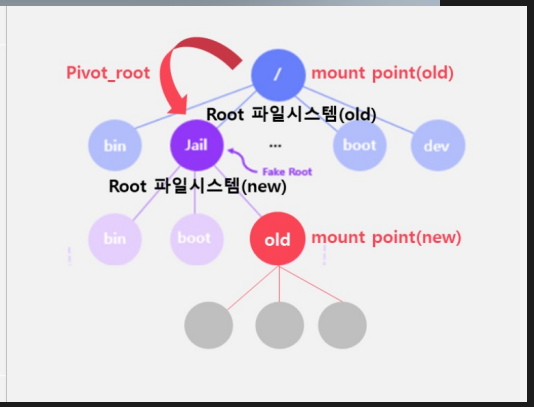
Reference: https://velog.io/@_gyullbb/1-2.-%EC%BB%A8%ED%85%8C%EC%9D%B4%EB%84%88-%EA%B2%A9%EB%A6%ACpivotroot

pivot_root

```
mkdir jail
docker export $(docker create nginx:latest) | tar -C jail -xvf -

chroot jail /bin/sh
./escape_chroot
```



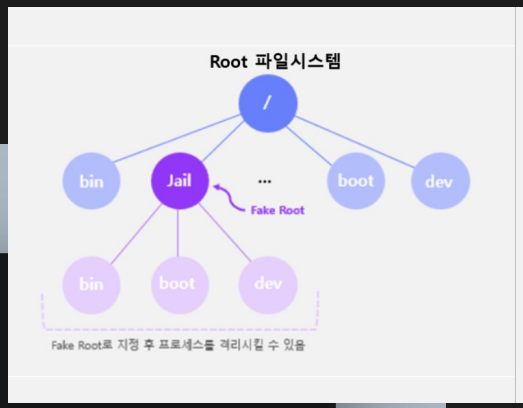


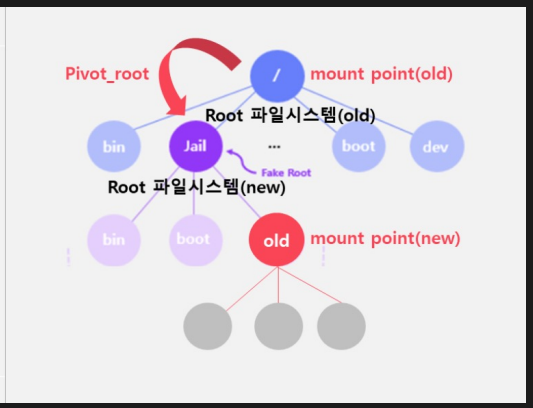
pivot_root

```
mkdir new_jail
mount -n -t tmpfs -o size=800M none ./new_jail/
df -h /new_jail
---
Filesystem      Size  Used Avail Use% Mounted on
none            800M     0  800M   0% /new_jail
---
```

```
mount | grep new_jail
---
none on /new_jail type tmpfs (rw,relatime,size=819200k)
---
```

pivot_root






```
cp -r jail/* ./new_jail/
mkdir ./new_jail/old_jail

tree -L 1 ./new_jail/
---
./new_jail/
├── bin
...
├── escape_chroot
...
├── old_jail
...
└── var
```

pivot_root

Q. If the root file system is pivoted,
will it have an **impact on the host**?

A. **Yes**, it will definitely have an impact.

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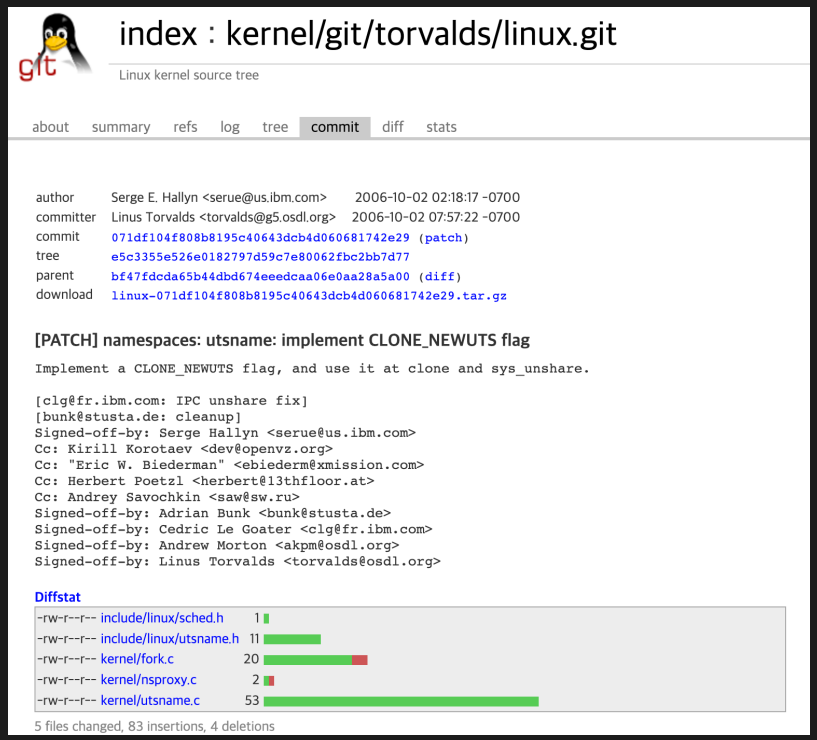
WING

Namespace (2002)

Feature of the Linux kernel that allow for creating **isolated environments**,
for different system resources, such as process IDs, network interfaces, file systems, and more



4-1 Mount namespace

4-2 UTS namespace

4-3 IPC namespace

4-4 cgroup namespace

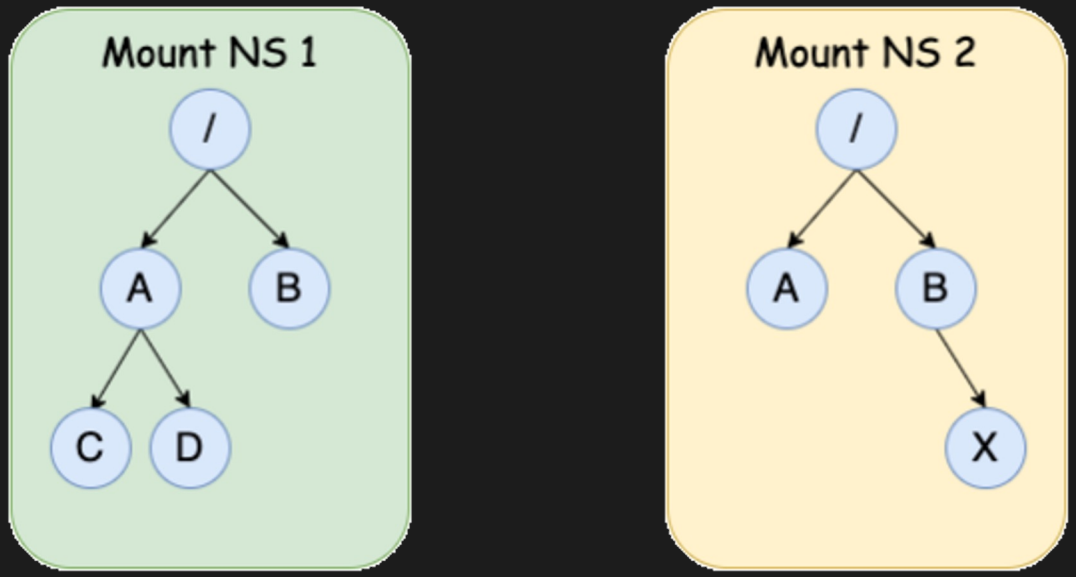
4-5 Network namespace

4-6 USER namespace

Mount namespace

Isolates file systems, so that each namespace

has its own unique view of the file system tree.

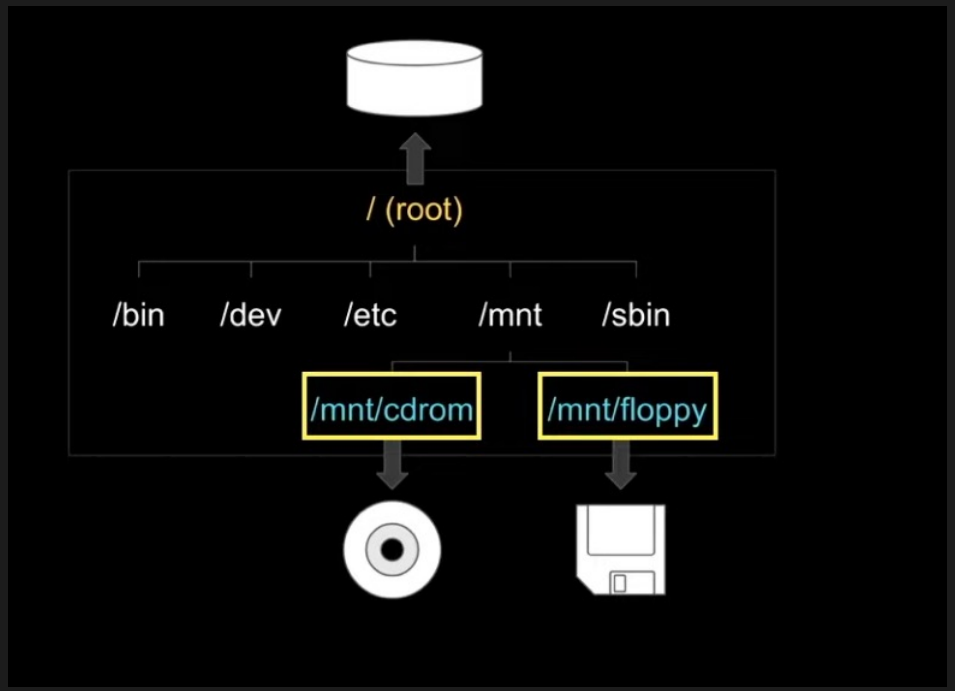


Mount

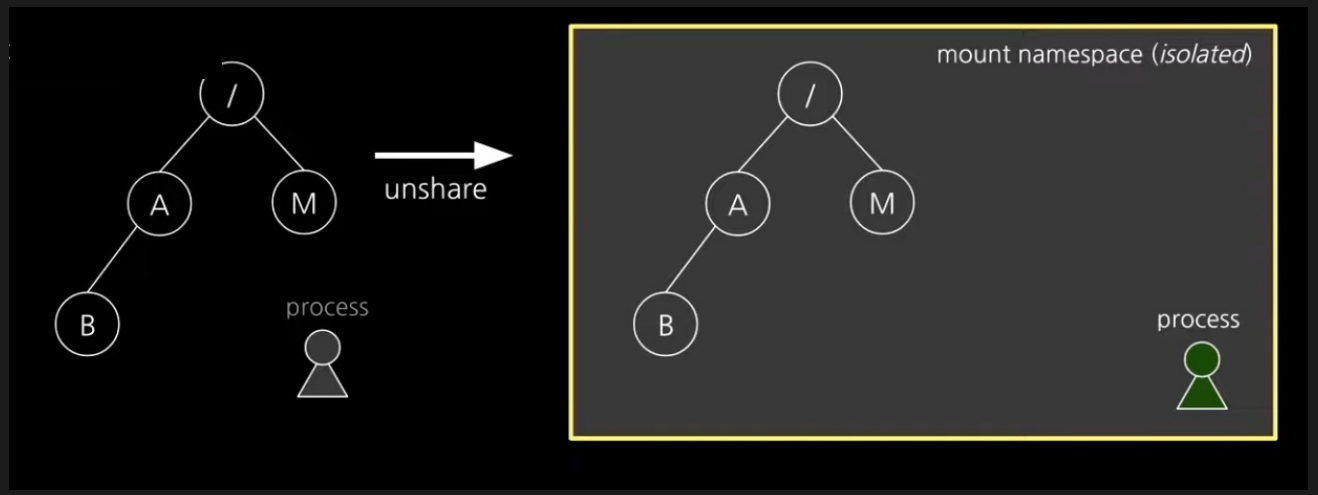
Process of making a **file system available for use**

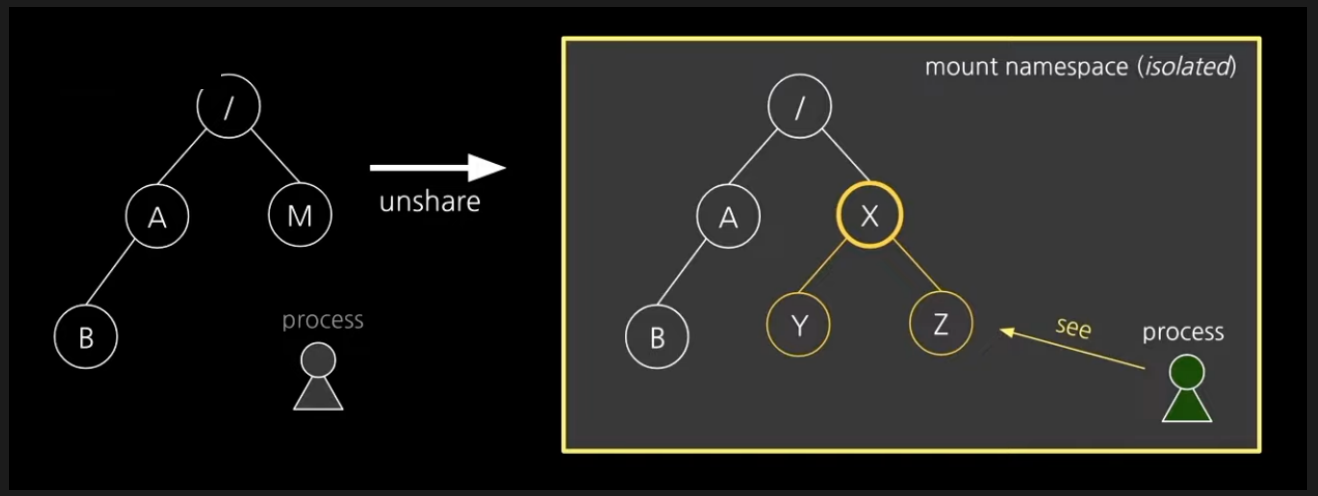
by the **operating system** and its **users**

Ex. external storage



Mount namespace





Mount namespace

Seems identical in initial state

ubuntu@ip-172-26-8-43: ~ (ssh)

```
Last login: Fri Mar 17 16:58:16 2023 from 203.230.52.5
ubuntu@ip-172-26-8-43:~$ df -h
Filesystem      Size  Used Avail Use% Mounted on
udev            222M     0  222M   0% /dev
tmpfs            48M  800K   47M   2% /run
/dev/xvda1       20G  3.0G   17G  16% /
tmpfs           236M     0  236M   0% /dev/shm
tmpfs           5.0M     0  5.0M   0% /run/lock
tmpfs           236M     0  236M   0% /sys/fs/cgroup
/dev/loop0      117M  117M     0 100% /snap/core/14784
/dev/loop1       56M   56M     0 100% /snap/core18/2708
/dev/loop2       25M   25M     0 100% /snap/amazon-ssm-agent/6312
/dev/loop3       13M   13M     0 100% /snap/amazon-ssm-agent/495
/dev/loop4       56M   56M     0 100% /snap/core18/2714
tmpfs            48M     0   48M   0% /run/user/1000
ubuntu@ip-172-26-8-43:~$
```

root@ip-172-26-8-43: /tmp (ssh)

```
root@ip-172-26-8-43:/# cd /tmp
root@ip-172-26-8-43:/tmp# clear
root@ip-172-26-8-43:/tmp# unshare --mount /bin/sh
# df -h
Filesystem      Size  Used Avail Use% Mounted on
/dev/xvda1       20G  3.0G   17G  16% /
udev            222M     0  222M   0% /dev
tmpfs           236M     0  236M   0% /dev/shm
tmpfs            48M  792K   47M   2% /run
tmpfs           5.0M     0  5.0M   0% /run/lock
tmpfs            48M     0   48M   0% /run/user/1000
tmpfs           236M     0  236M   0% /sys/fs/cgroup
/dev/loop0      117M  117M     0 100% /snap/core/14784
/dev/loop1       56M   56M     0 100% /snap/core18/2708
/dev/loop2       25M   25M     0 100% /snap/amazon-ssm-agent/6312
/dev/loop3       13M   13M     0 100% /snap/amazon-ssm-agent/495
/dev/loop4       56M   56M     0 100% /snap/core18/2714
#
```

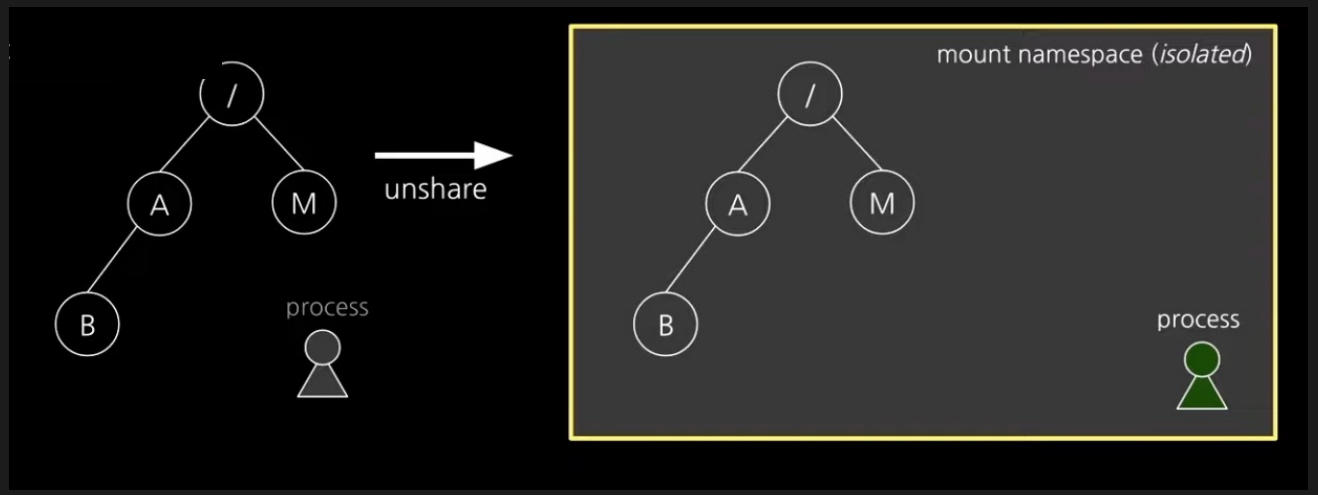
Mount namespace

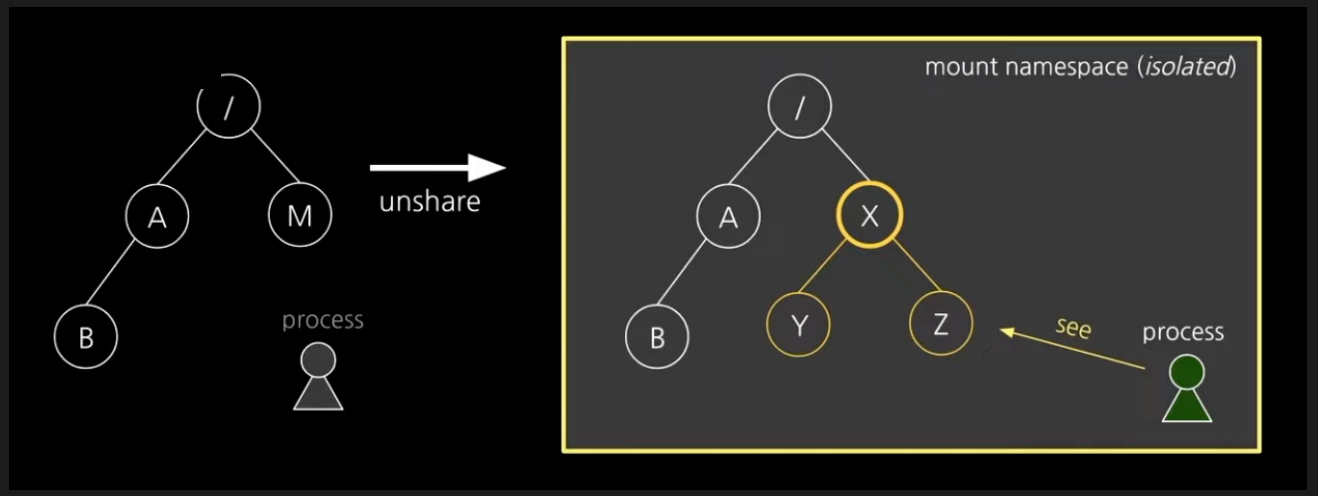
mount *new_root* can only be seen in mount namespace

```
ubuntu@ip-172-26-8-43: /tmp (ssh)
ubuntu@ip-172-26-8-43:/tmp$ ls
chroot_ps.sh
escape_chroot.c
myroot
new_root
nginx-root
snap-private-tmp
systemd-private-a5d1b3db81c84dd3ab356eb0e8f5be2a-systemd-resolved.service-E6CL5F
systemd-private-a5d1b3db81c84dd3ab356eb0e8f5be2a-systemd-timesyncd.service-ORryr7
ubuntu@ip-172-26-8-43:/tmp$ mount ¦ grep new_root
ubuntu@ip-172-26-8-43:/tmp$
```

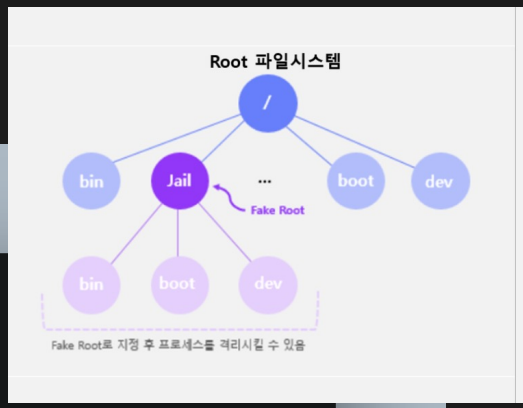
```
root@ip-172-26-8-43: /tmp (ssh)
/dev/loop3       13M   13M     0 100% /snap/amazon-ssm-agent/495
/dev/loop4       56M   56M     0 100% /snap/core18/2714
# mkdir new_root
# mount -t tmpfs none new_root
# df -h ¦ grep new_root
none            236M     0  236M   0% /tmp/new_root
# ls
chroot_ps.sh
escape_chroot.c
myroot
new_root
nginx-root
snap-private-tmp
systemd-private-a5d1b3db81c84dd3ab356eb0e8f5be2a-systemd-resolved.service-E6CL5F
systemd-private-a5d1b3db81c84dd3ab356eb0e8f5be2a-systemd-timesyncd.service-ORryr7
# mount ¦ grep new_root
none on /tmp/new_root type tmpfs (rw,relatime)
#
```

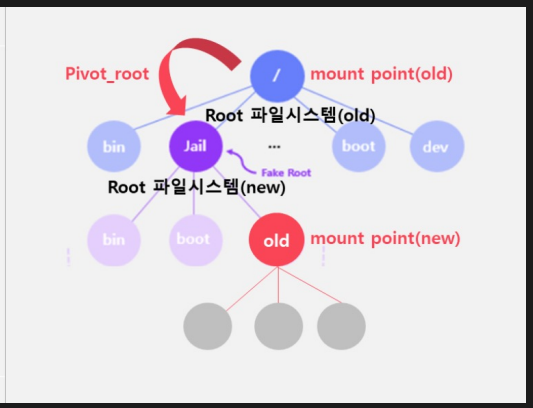
Mount namespace





pivot_root






```
cp -r jail/* ./new_jail/
mkdir ./new_jail/old_jail

tree -L 1 ./new_jail/
---
./new_jail/
├── bin
...
├── escape_chroot
...
├── old_jail
...
└── var
```

pivot_root

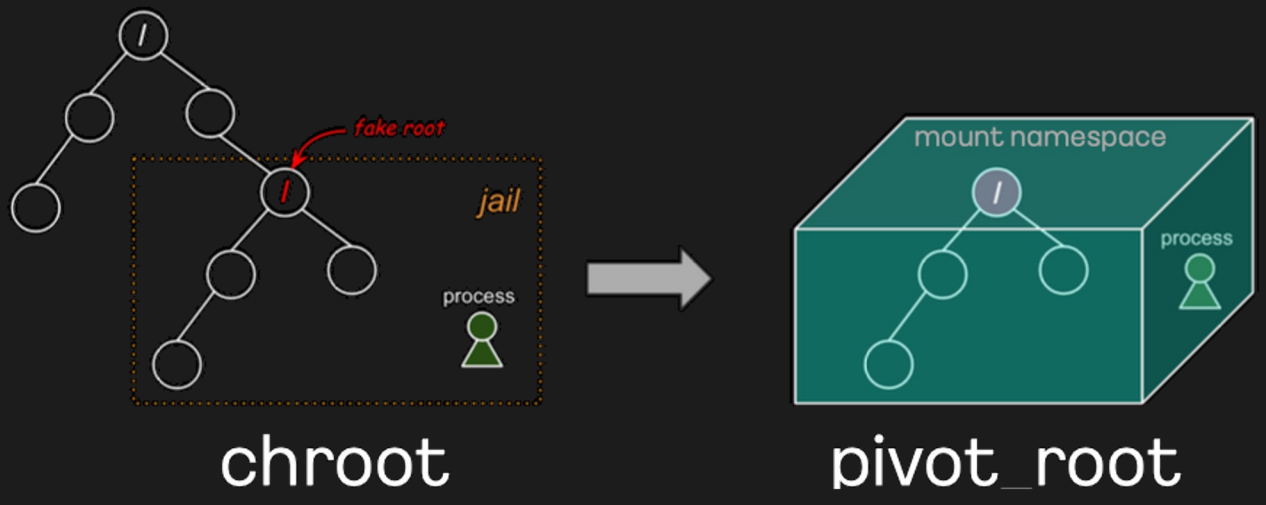
```
cd ./new_jail/
# mount namespace
unshare -m

pivot_root . old_jail

# try to escape
./escape_chroot

cd /
ls
---
bin   docker-entrypoint.d   etc   lib64  old_jail  root  srv  usr
boot  docker-entrypoint.sh  home  media  opt       run   sys  var
dev   escape_chroot         lib   mnt    proc      sbin  tmp
```

pivot_root


/
fake root
/
jail
process
mount namespace
/
process
chroot
pivot_root

Mount namespace

1. Isolated Environment (as own root filesystem)
2. Safe in security manner
3. Can change mount freely and expand filesystem also

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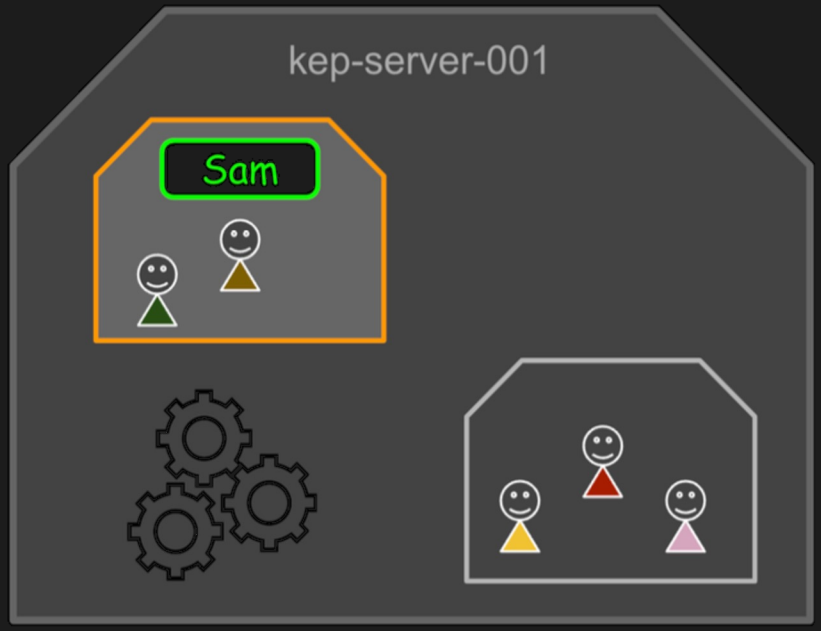
WING

UTS (Unix Time Sharing) namespace

Namespace that isolates

two system identifiers related to the system hostname



UTS (Unix Time Sharing) namespace

```
hostname
---
ubuntu
```

```
unshare --uts /bin/bash

hostname jaehong21
hostname
---
jaehong21
```

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WING

IPC (Inter-Process Communication)
namespace

1. Pipe
2. Named-pipe
3. Message queue
4. Shared Memory
5. Memory map
6. Socket

IPC (Inter-Process Communication)
namespace

Host(up), Container(down)

```
ubuntu@ip-172-26-8-43:~$ sudo ipcmk -M 1000
Shared memory id: 3
ubuntu@ip-172-26-8-43:~$ sudo ipcs -m

------ Shared Memory Segments --------
key        shmid      owner      perms      bytes      nattch     status
0x00000000 0          root       644        80         2
0x00000000 1          root       644        16384      2
0x00000000 2          root       644        280        2
0xf58e45ec 3          root       644        1000       0
```

```
root@ip-172-26-8-43:/tmp# unshare --ipc /bin/bash
root@ip-172-26-8-43:/tmp# ipcmk -M 2000
Shared memory id: 0
root@ip-172-26-8-43:/tmp# ipcs -m

------ Shared Memory Segments --------
key        shmid      owner      perms      bytes      nattch     status
0xeb4b79db 0          root       644        2000       0
```

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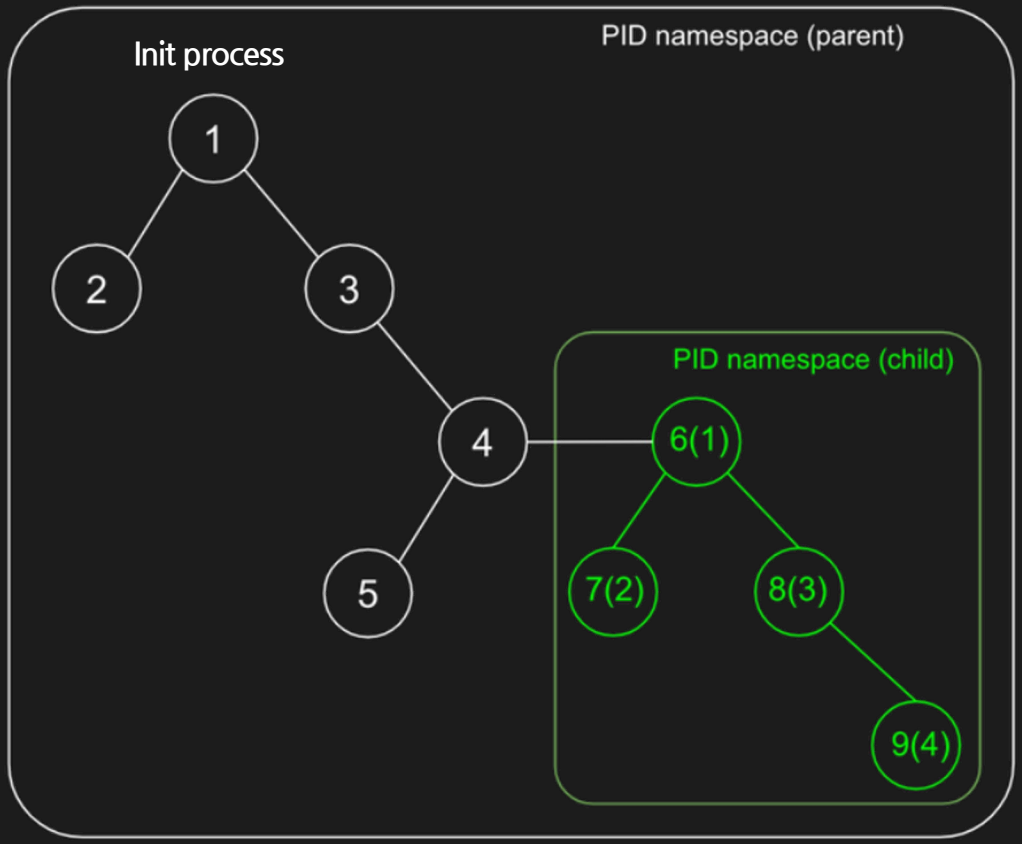
WING

PID (process id) namespace



PID (process id) namespace

```
unshare -fp --mount-proc /bin/sh

# -f: fork
# -p: pid namespace
# --mount-proc: proc filesystem mount
```

/proc

1. Memory-based virtual filesystem
2. System information that kernel manages
3. Used for System monitoring and analysis

PID (process id) namespace

```
root@ip-172-26-8-43:/tmp# echo $$
14466
root@ip-172-26-8-43:/tmp# unshare --pid --fork --mount-proc /bin/bash
root@ip-172-26-8-43:/tmp# echo $$
1
root@ip-172-26-8-43:/tmp# ps aux
USER         PID %CPU %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root           1  0.0  1.0  23028  4932 pts/0    S    15:21   0:00 /bin/bash
root           9  0.0  0.6  37804  3308 pts/0    R+   15:22   0:00 ps aux
```

```
ubuntu@ip-172-26-8-43:~$ ps aux | grep '/bin/bash'
root     14466  0.0  1.0  23028  4980 pts/0    S    15:20   0:00 /bin/bash
root     14476  0.0  0.1   7920   828 pts/0    S    15:21   0:00 unshare --pid --fork --mount-proc /bin/bash
root     14477  0.0  1.0  23028  4932 pts/0    S+   15:21   0:00 /bin/bash
ubuntu   14618  0.0  0.2  14860  1120 pts/1    S+   15:25   0:00 grep --color=auto /bin/bash
```

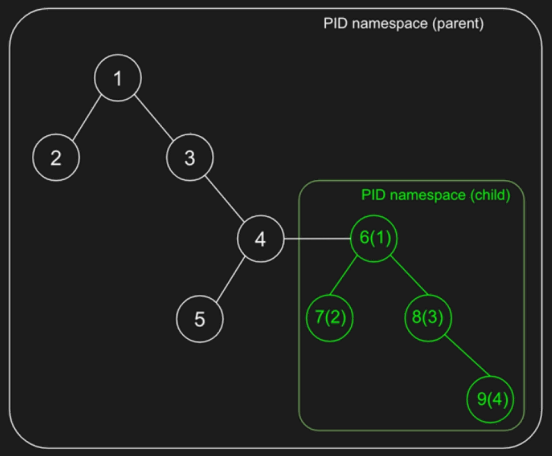
PID (process id) namespace

```
ubuntu@ip-172-26-8-43:~$ ps aux | grep '/bin/bash'
root       14466  0.0  1.0  23028  4980 pts/0    S    15:20   0:00 /bin/bash
root       14476  0.0  0.1   7920   828 pts/0    S    15:21   0:00 unshare --pid --fork --mount-proc /bin/bash
root       14477  0.0  1.0  23028  4932 pts/0    S+   15:21   0:00 /bin/bash
ubuntu     14618  0.0  0.2  14860  1120 pts/1    S+   15:25   0:00 grep --color=auto /bin/bash
```

```
readlink /proc/<target-pid>/ns/pid
```

```
root@ip-172-26-8-43:~# readlink /proc/14768/ns/pid
pid:[4026532224]
```

```
root@ip-172-26-8-43:/tmp# readlink /proc/1/ns/pid
pid:[4026532224]
```



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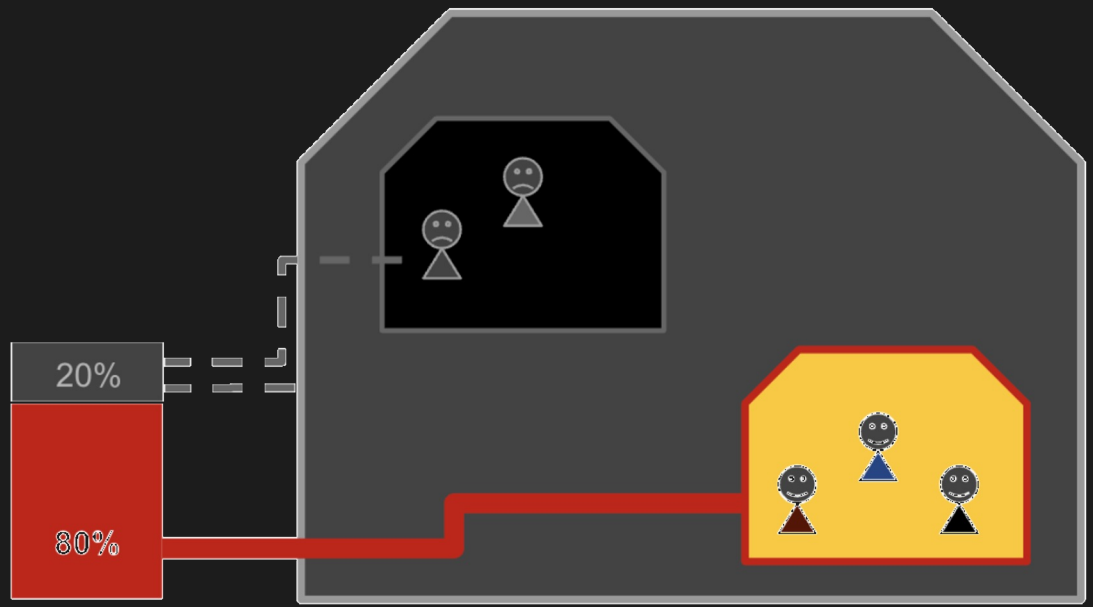
WING

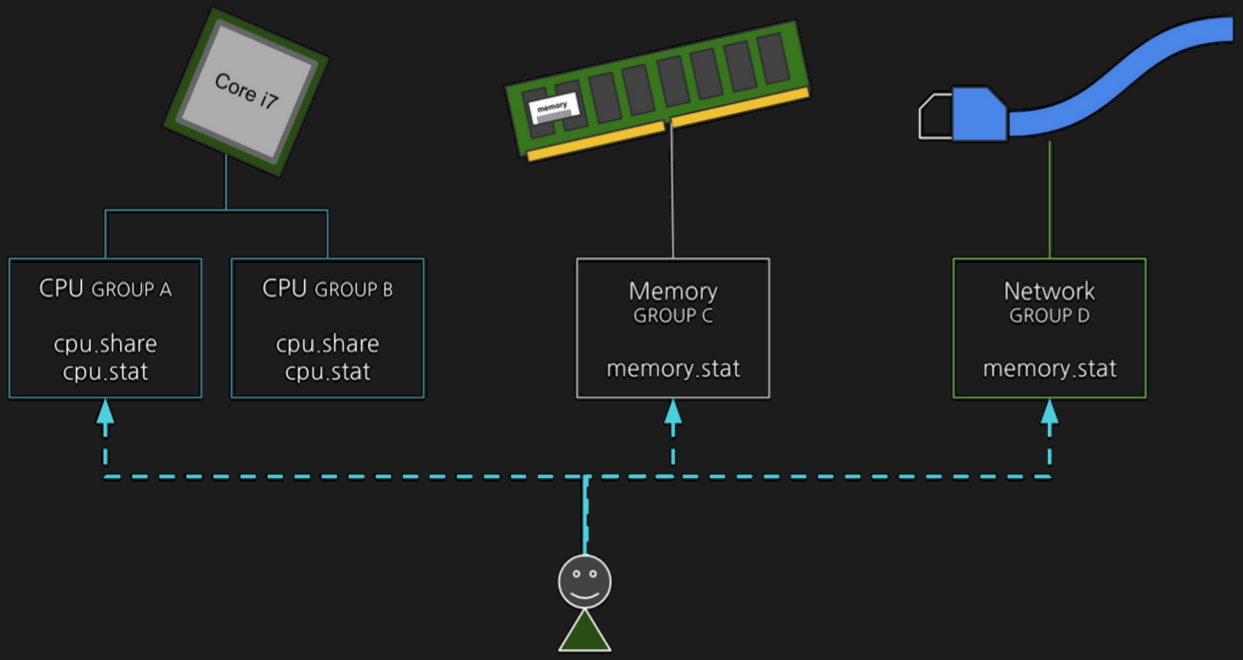
cgroup (control group)
namespace

Namespace isolates and manages system resources,
such as CPU, memory, disk I/O, and network bandwidth,
for different groups of processes



cgroup (control group)
namespace

Namespace isolates and manages system resources,
such as CPU, memory, disk I/O, and network bandwidth,
for different groups of processes



cgroup (control group)
namespace

cgroup filesystem: **/sys/fs/cgroup**

```
ubuntu@ip-172-26-8-43:~$ tree -L 1 /sys/fs/cgroup
/sys/fs/cgroup
├── blkio
├── cpu -> cpu,cpuacct
├── cpu,cpuacct
├── cpuacct -> cpu,cpuacct
├── cpuset
├── devices
├── freezer
├── hugetlb
├── memory
├── net_cls -> net_cls,net_prio
├── net_cls,net_prio
├── net_prio -> net_cls,net_prio
├── perf_event
├── pids
├── rdma
├── systemd
└── unified

17 directories, 0 files
```

cgroup (control group)
namespace

cgroup filesystem: **/sys/fs/cgroup**

```
ubuntu@ip-172-26-8-43:~$ tree -L 1 /sys/fs/cgroup/cpu
/sys/fs/cgroup/cpu
├── cgroup.clone_children
├── cgroup.procs
├── cgroup.sane_behavior
├── cpu.cfs_period_us
├── cpu.cfs_quota_us
├── cpu.shares
├── cpu.stat
├── cpuacct.stat
├── cpuacct.usage
├── cpuacct.usage_all
├── cpuacct.usage_percpu
├── cpuacct.usage_percpu_sys
├── cpuacct.usage_percpu_user
├── cpuacct.usage_sys
├── cpuacct.usage_user
├── notify_on_release
├── release_agent
├── system.slice
├── tasks
└── user.slice

2 directories, 18 files
```

cgroup (control group)
namespace

```
root@ip-172-26-8-43:~# cgcreate -a root -g cpu:jaehong21
root@ip-172-26-8-43:~# tree /sys/fs/cgroup/cpu/jaehong21
/sys/fs/cgroup/cpu/jaehong21
├── cgroup.clone_children
├── cgroup.procs
├── cpu.cfs_period_us
├── cpu.cfs_quota_us
├── cpu.shares
├── cpu.stat
├── cpu.uclamp.max
├── cpu.uclamp.min
├── cpuacct.stat
├── cpuacct.usage
├── cpuacct.usage_all
├── cpuacct.usage_percpu
├── cpuacct.usage_percpu_sys
├── cpuacct.usage_percpu_user
├── cpuacct.usage_sys
├── cpuacct.usage_user
├── notify_on_release
└── tasks

0 directories, 18 files
root@ip-172-26-8-43:~#
root@ip-172-26-8-43:~# cgset -r cpu.cfs_quota_us=30000 jaehong21
```

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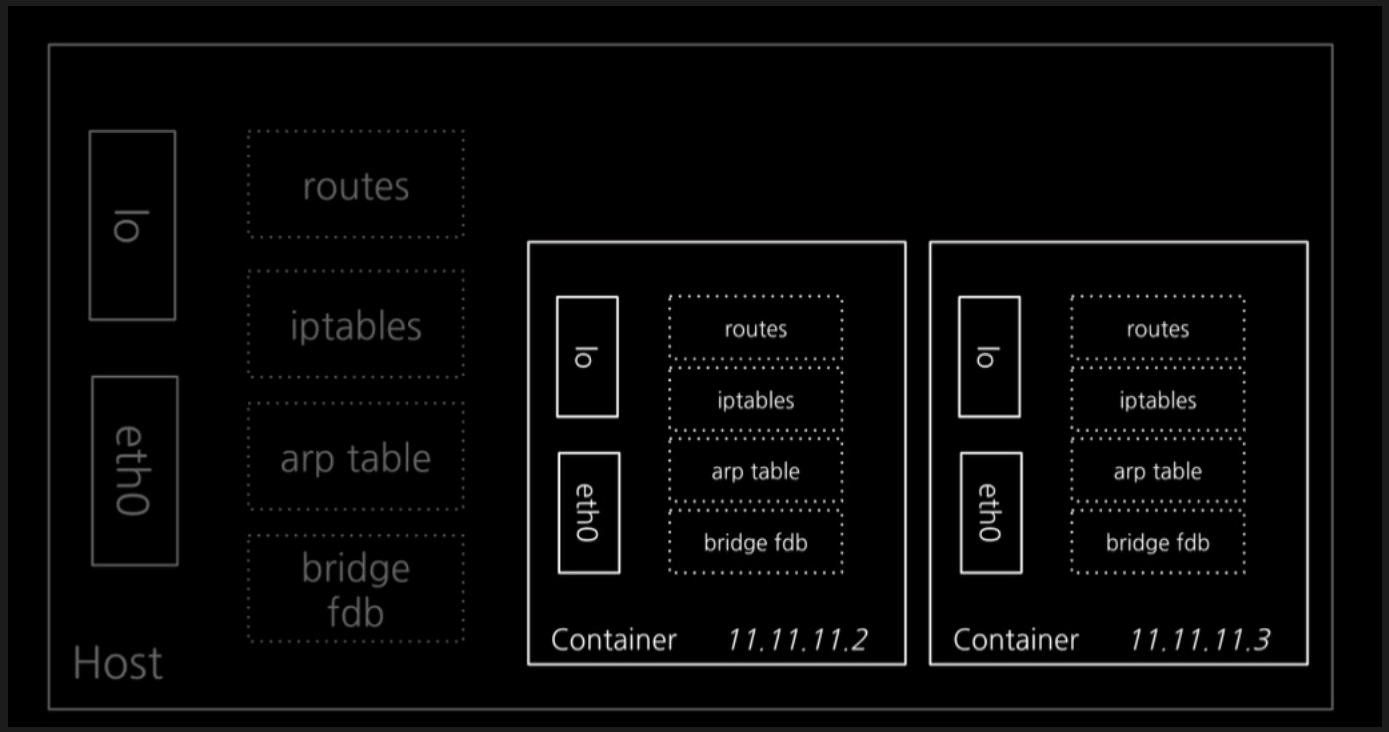
WING

Network namespace

Namespace provides an

isolated network stack for a group of processes.



Network namespace

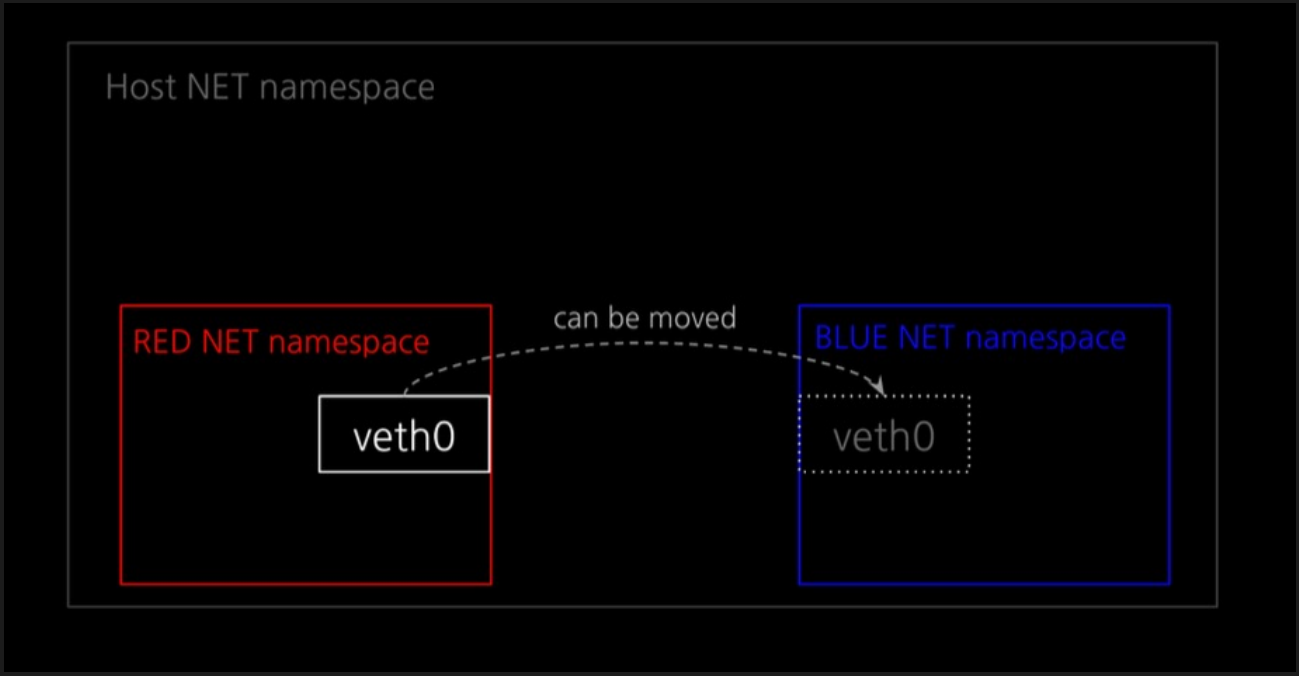
Namespace provides an

isolated network stack for a group of processes.

```
root@ip-172-26-8-43:~# ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9001 qdisc fq_codel state UP group default qlen 1000
    link/ether 02:07:39:a7:61:80 brd ff:ff:ff:ff:ff:ff
    inet 172.26.8.43/20 brd 172.26.15.255 scope global dynamic eth0
       valid_lft 2549sec preferred_lft 2549sec
    inet6 2406:da12:6ab:ee00:109e:caca:eef1:e04f/128 scope global dynamic noprefixroute
       valid_lft 437sec preferred_lft 127sec
    inet6 fe80::7:39ff:fea7:6180/64 scope link
       valid_lft forever preferred_lft forever
3: docker0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue state DOWN group default
    link/ether 02:42:12:ab:d4:51 brd ff:ff:ff:ff:ff:ff
    inet 172.17.0.1/16 brd 172.17.255.255 scope global docker0
       valid_lft forever preferred_lft forever
root@ip-172-26-8-43:~# unshare --net /bin/bash
root@ip-172-26-8-43:~# ip a
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
root@ip-172-26-8-43:~#
```

Network Interface

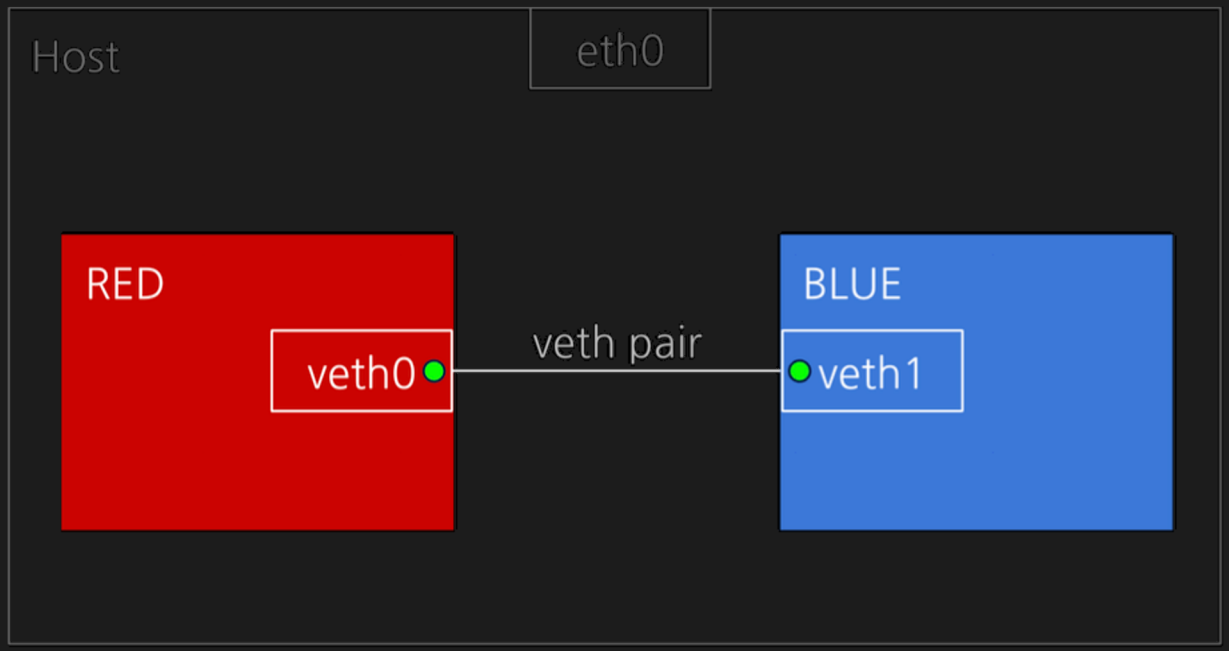
ex. **veth**, **bridge**, **vxlan**, ⋯



1. **Cannot** be present in multiple network namespaces
2. Can move to another network namespaces

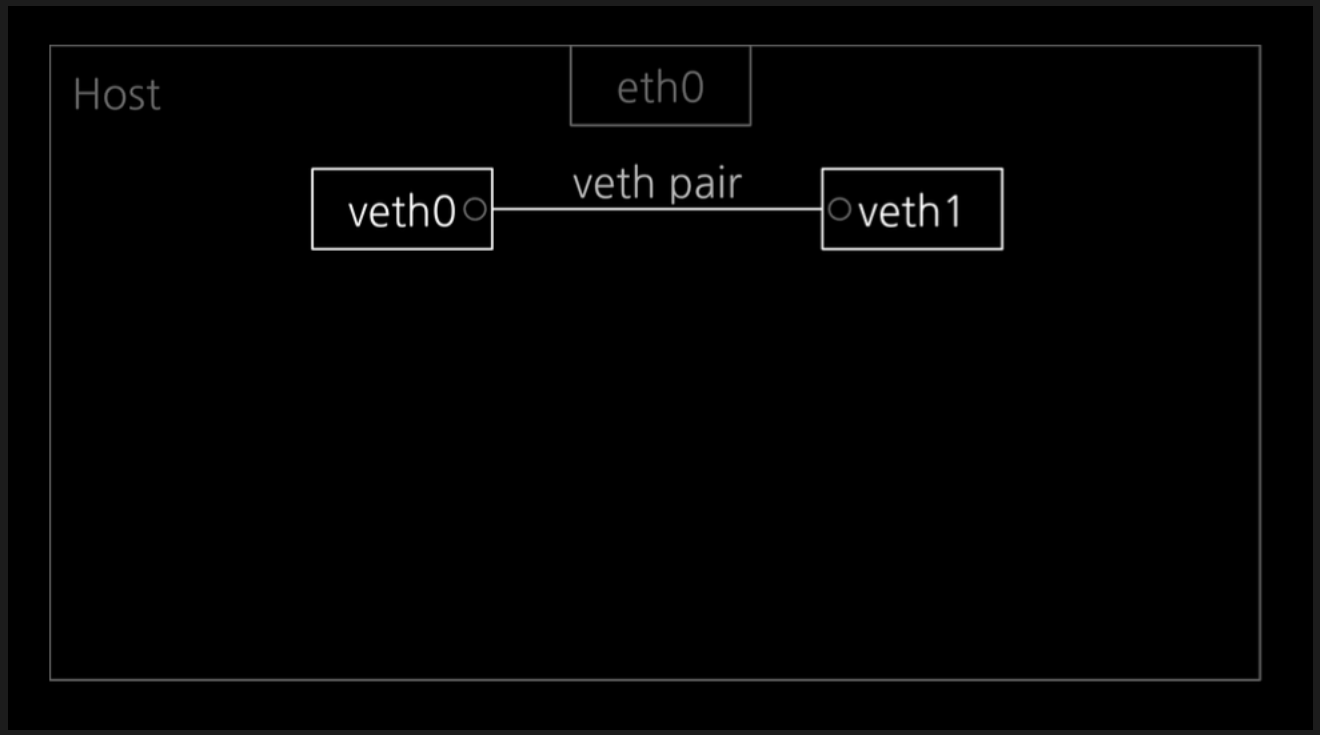
Network Interface

1. **Isolate Network namespaces**
2. Communication between RED & BLUE container



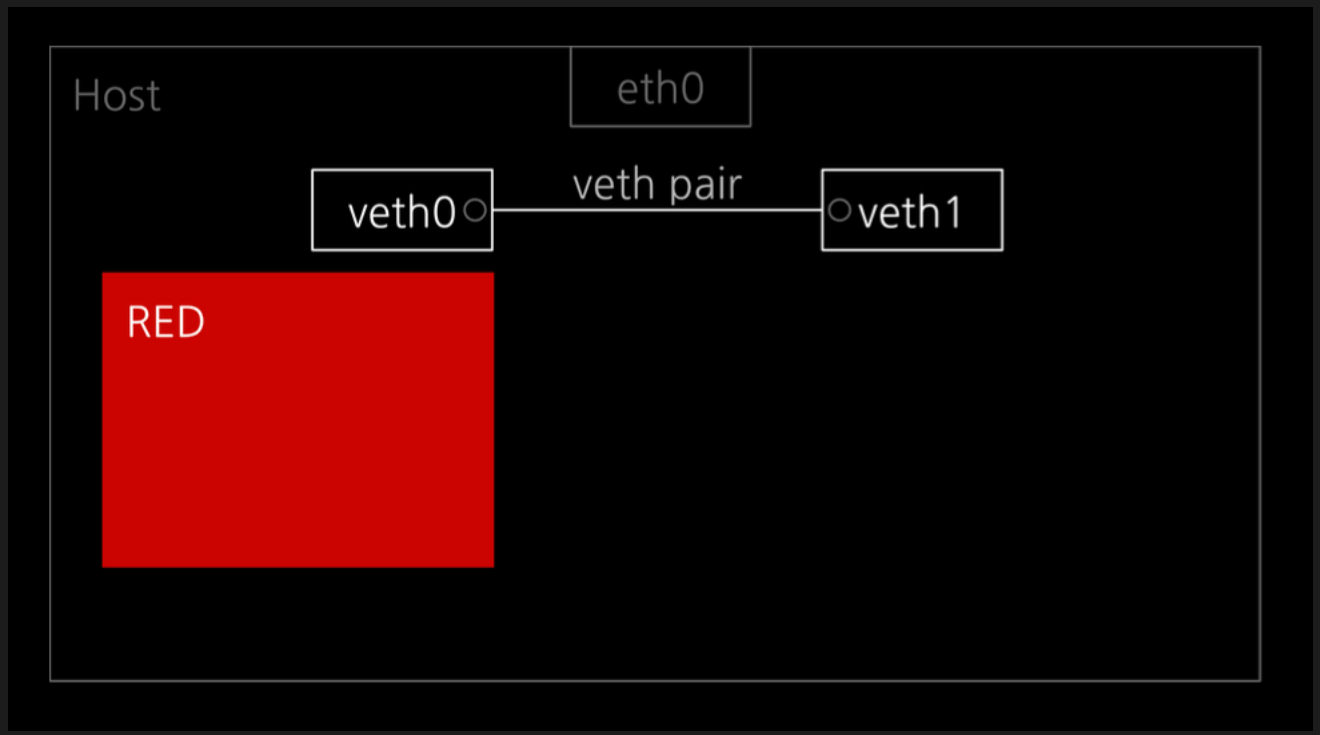
Network namespace

```
ip link add veth0 type veth peer name veth1
```



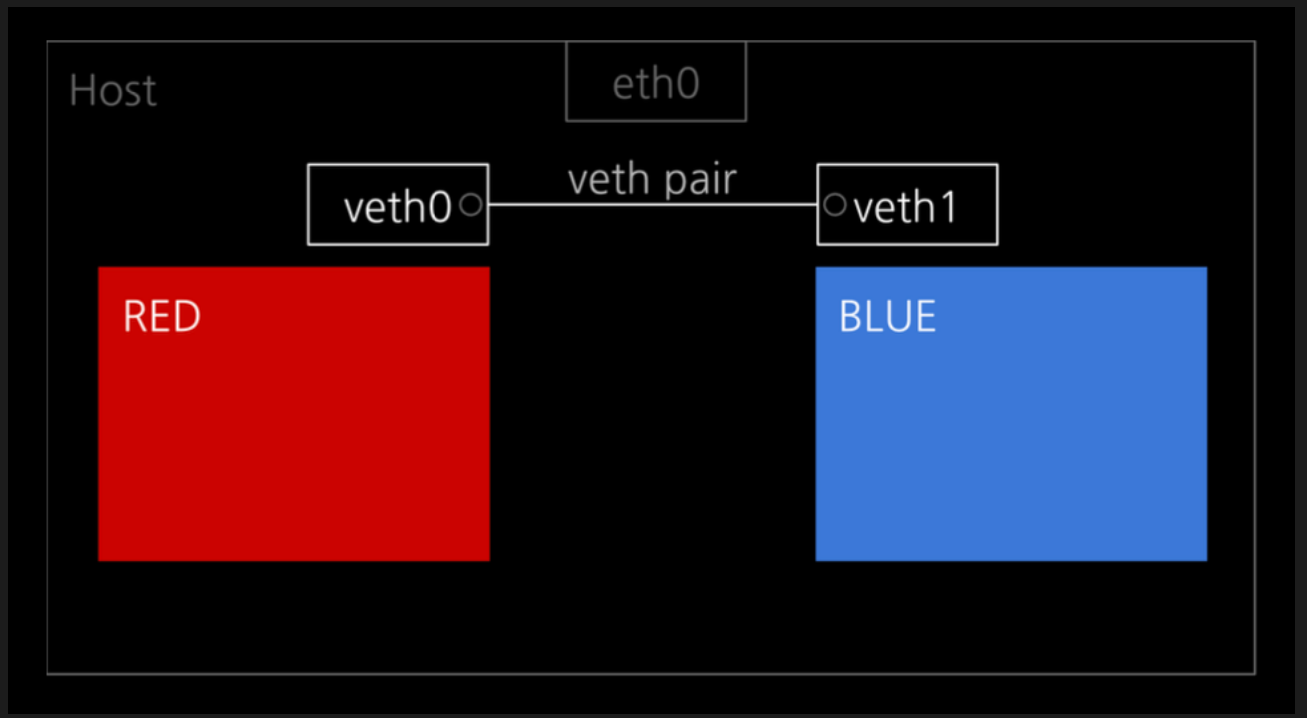
Network namespace

```
ip netns add RED
```



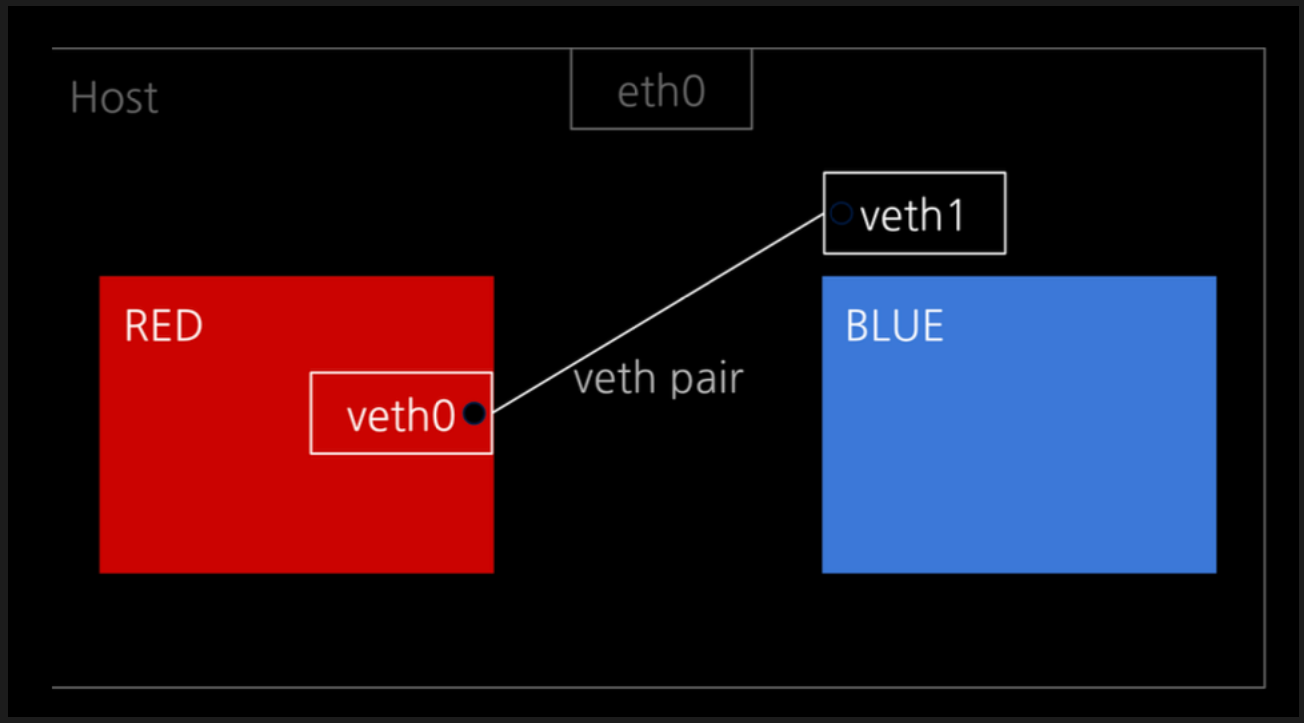
Network namespace

```
ip netns add BLUE
```



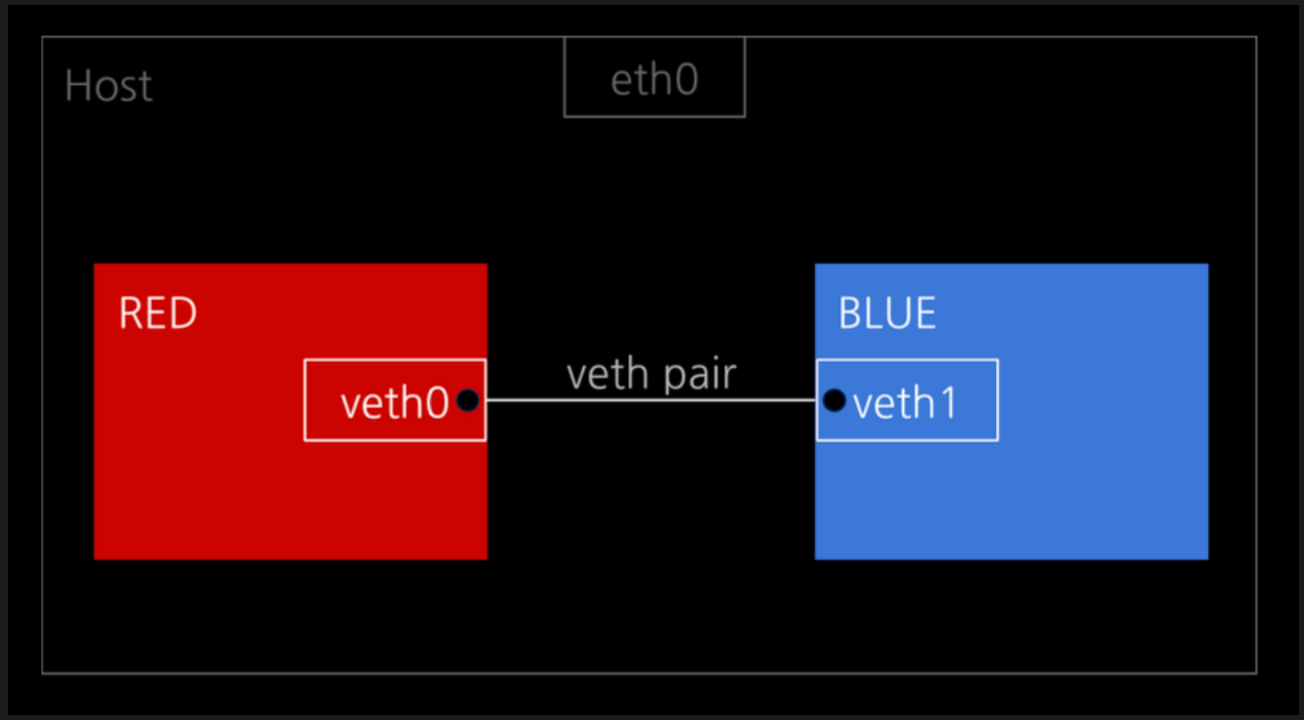
Network namespace

```
ip link set veth0 netns RED
```



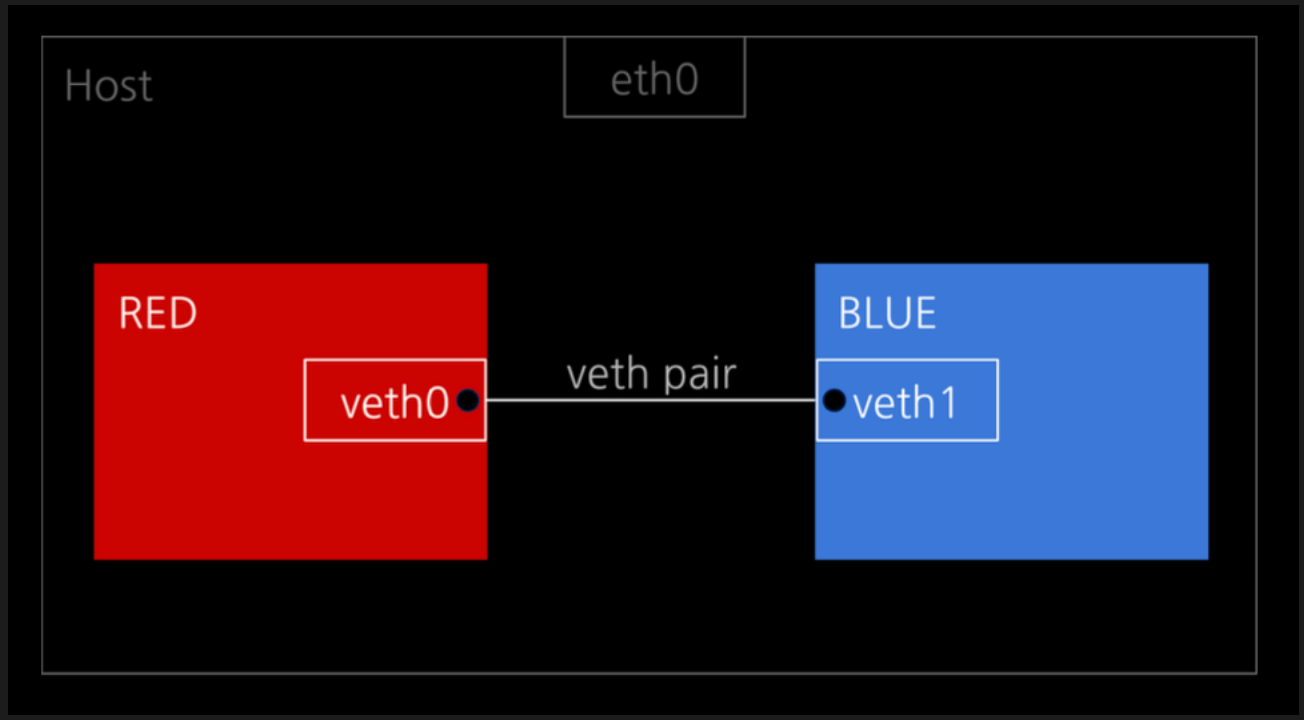
Network namespace

```
ip link set veth1 netns BLUE
```



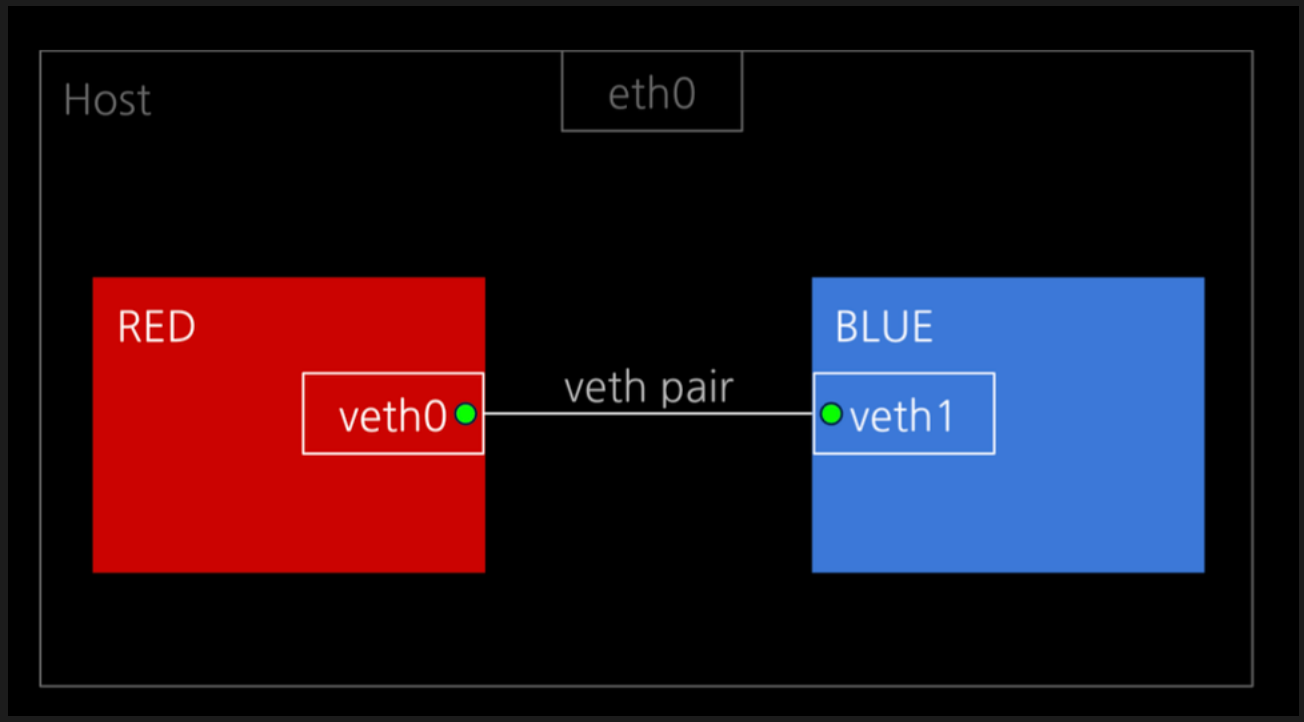
Network namespace

```
ip link set veth1 netns BLUE
```



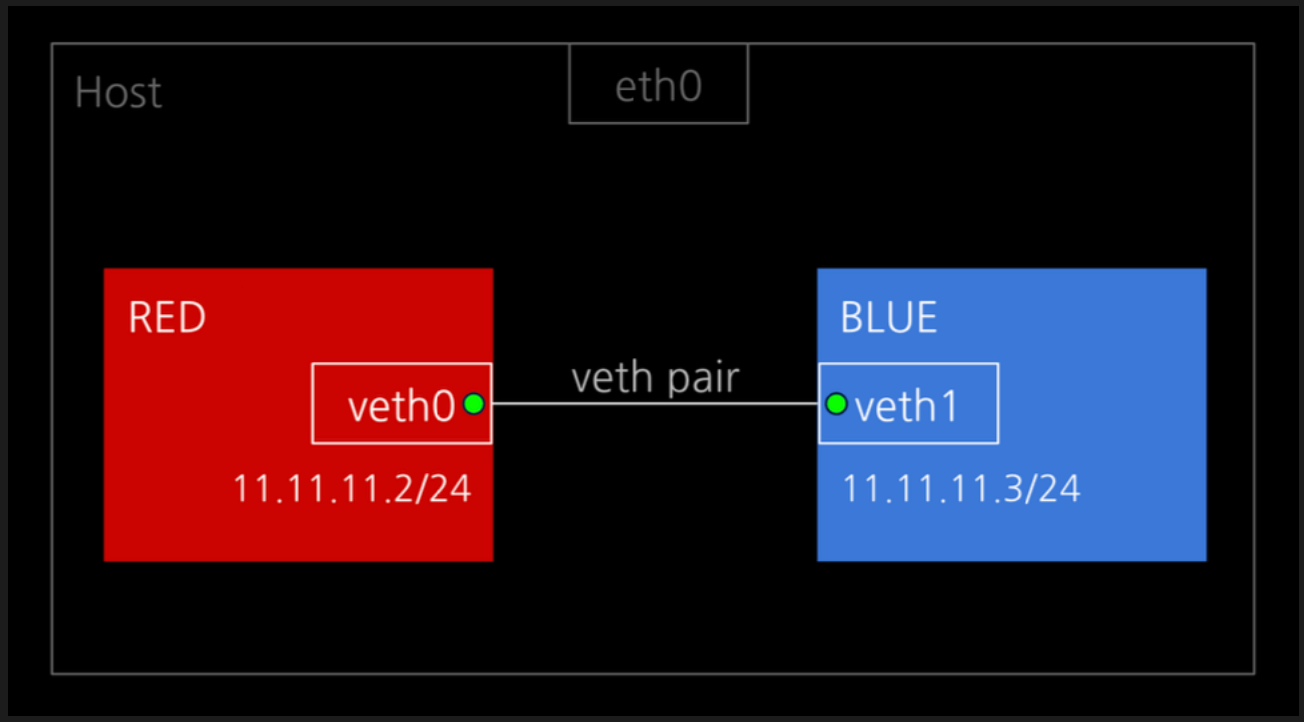
Network namespace

```
ip netns exec RED ip link set veth0 up
ip netns exec BLUE ip link set veth1 up
```



Network namespace

```
ip netns exec RED ip addr add 11.11.11.2/24 dev veth0
ip netns exec BLUE ip addr add 11.11.11.3/24 dev veth1
```



Network namespace

```
ubuntu@ip-172-26-8-43:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9001 qdisc fq_codel state UP group default qlen 1000
    link/ether 02:07:39:a7:61:80 brd ff:ff:ff:ff:ff:ff
    inet 172.26.8.43/20 brd 172.26.15.255 scope global dynamic eth0
       valid_lft 1949sec preferred_lft 1949sec
    inet6 2406:da12:6ab:ee00:109e:caca:eef1:e04f/128 scope global dynamic noprefixroute
       valid_lft 417sec preferred_lft 107sec
    inet6 fe80::7:39ff:fea7:6180/64 scope link
       valid_lft forever preferred_lft forever
3: docker0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue state DOWN group default
    link/ether 02:42:12:ab:d4:51 brd ff:ff:ff:ff:ff:ff
    inet 172.17.0.1/16 brd 172.17.255.255 scope global docker0
       valid_lft forever preferred_lft forever
ubuntu@ip-172-26-8-43:~$ ip route
default via 172.26.0.1 dev eth0 proto dhcp src 172.26.8.43 metric 100
172.17.0.0/16 dev docker0 proto kernel scope link src 172.17.0.1 linkdown
172.26.0.0/20 dev eth0 proto kernel scope link src 172.26.8.43
172.26.0.1 dev eth0 proto dhcp scope link src 172.26.8.43 metric 100
```

Network namespace

```
root@ip-172-26-8-43:~# nsenter --net=/var/run/netns/RED
root@ip-172-26-8-43:~# ip a
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
5: veth0@if4: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether e2:c7:92:10:ad:d3 brd ff:ff:ff:ff:ff:ff link-netnsid 1
    inet 11.11.11.2/24 scope global veth0
       valid_lft forever preferred_lft forever
    inet6 fe80::e0c7:92ff:fe10:add3/64 scope link
       valid_lft forever preferred_lft forever
root@ip-172-26-8-43:~# ip route
11.11.11.0/24 dev veth0 proto kernel scope link src 11.11.11.2
root@ip-172-26-8-43:~#
```

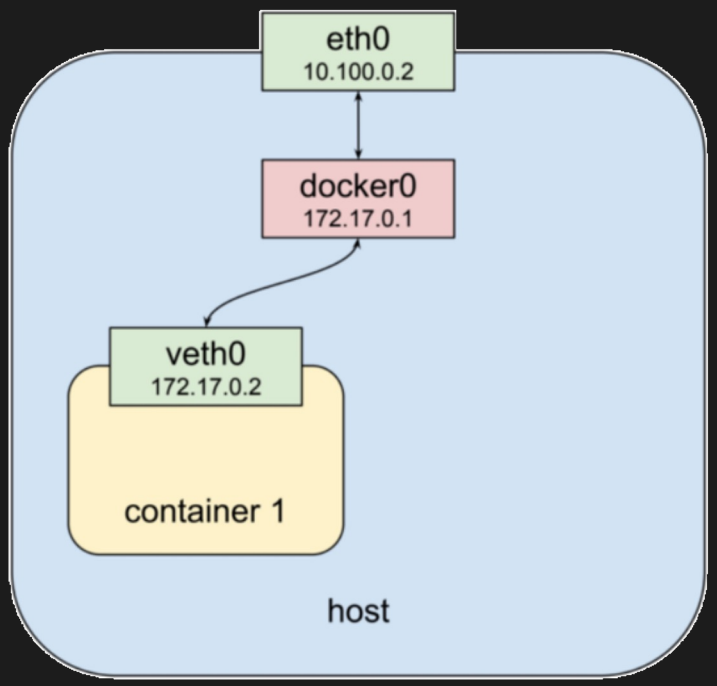
```
root@ip-172-26-8-43:~# nsenter --net=/var/run/netns/BLUE
root@ip-172-26-8-43:~# ip a
1: lo: <LOOPBACK> mtu 65536 qdisc noop state DOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
4: veth1@if5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether aa:68:e9:18:4c:7e brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 11.11.11.3/24 scope global veth1
       valid_lft forever preferred_lft forever
    inet6 fe80::a868:e9ff:fe18:4c7e/64 scope link
       valid_lft forever preferred_lft forever
root@ip-172-26-8-43:~# ip route
11.11.11.0/24 dev veth1 proto kernel scope link src 11.11.11.3
root@ip-172-26-8-43:~#
```

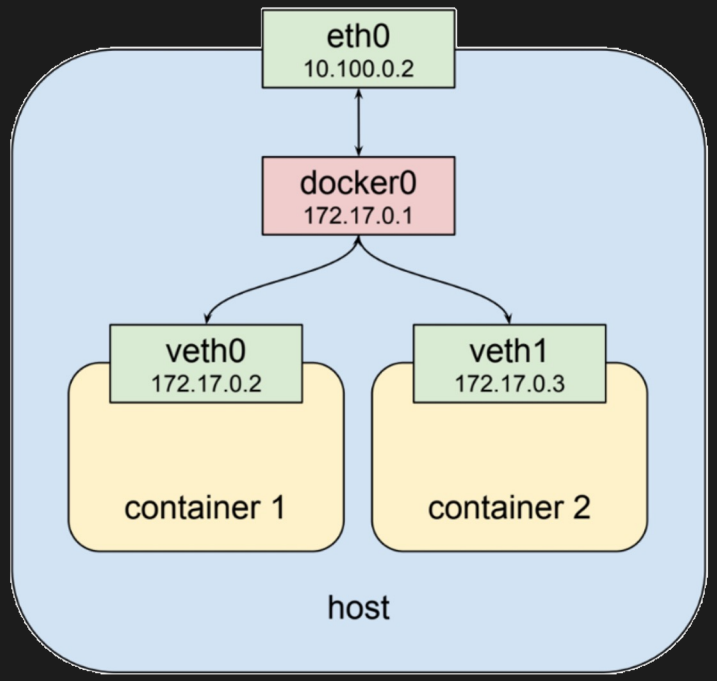
Network namespace

```
root@ip-172-26-8-43:~# ping 11.11.11.3
PING 11.11.11.3 (11.11.11.3) 56(84) bytes of data.
64 bytes from 11.11.11.3: icmp_seq=1 ttl=64 time=0.032 ms
64 bytes from 11.11.11.3: icmp_seq=2 ttl=64 time=0.044 ms
64 bytes from 11.11.11.3: icmp_seq=3 ttl=64 time=0.045 ms
^C
--- 11.11.11.3 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2050ms
rtt min/avg/max/mdev = 0.032/0.040/0.045/0.007 ms
```

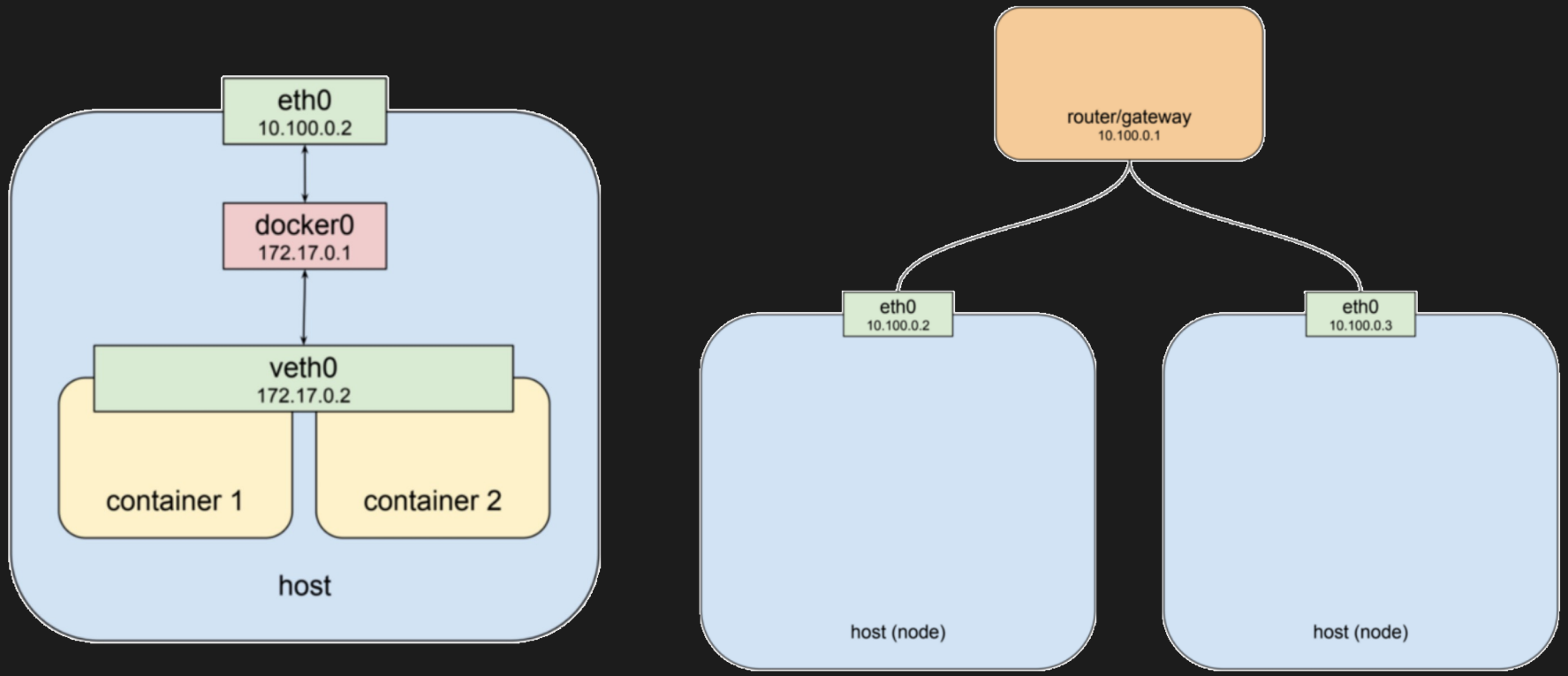
```
root@ip-172-26-8-43:~# tcpdump -li veth1
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on veth1, link-type EN10MB (Ethernet), capture size 262144 bytes
20:38:42.964454 IP 11.11.11.2 > 11.11.11.3: ICMP echo request, id 17264, seq 1, length 64
20:38:42.964473 IP 11.11.11.3 > 11.11.11.2: ICMP echo reply, id 17264, seq 1, length 64
20:38:43.990744 IP 11.11.11.2 > 11.11.11.3: ICMP echo request, id 17264, seq 2, length 64
20:38:43.990766 IP 11.11.11.3 > 11.11.11.2: ICMP echo reply, id 17264, seq 2, length 64
20:38:45.014749 IP 11.11.11.2 > 11.11.11.3: ICMP echo request, id 17264, seq 3, length 64
20:38:45.014772 IP 11.11.11.3 > 11.11.11.2: ICMP echo reply, id 17264, seq 3, length 64
20:38:48.214682 ARP, Request who-has 11.11.11.2 tell 11.11.11.3, length 28
20:38:48.214694 ARP, Request who-has 11.11.11.3 tell 11.11.11.2, length 28
20:38:48.214730 ARP, Reply 11.11.11.3 is-at aa:68:e9:18:4c:7e (oui Unknown), length 28
20:38:48.214726 ARP, Reply 11.11.11.2 is-at e2:c7:92:10:ad:d3 (oui Unknown), length 28
```

Network namespace





Network namespace



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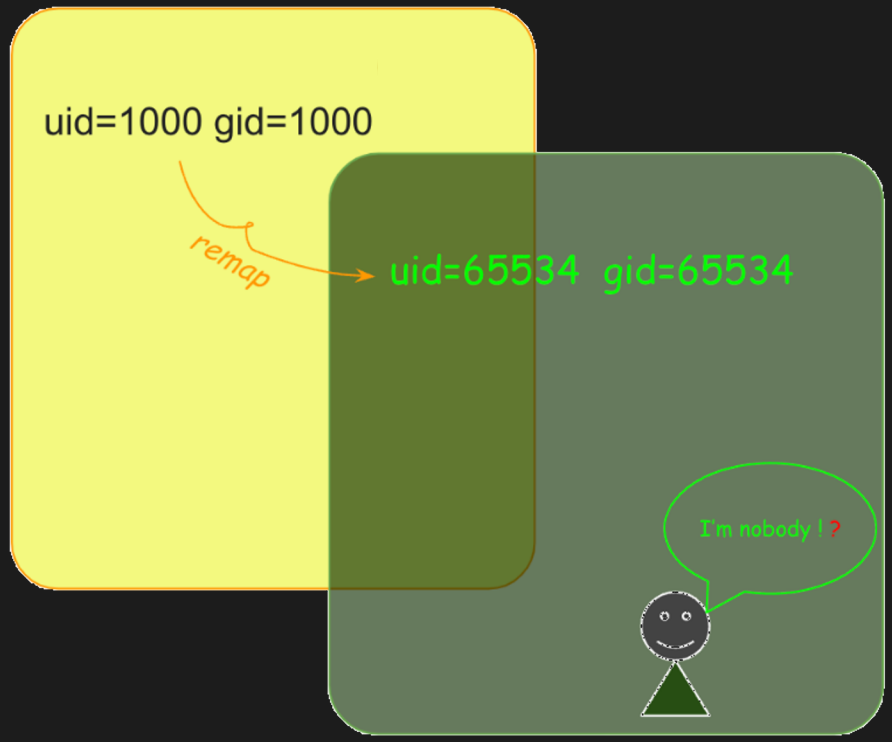
WING

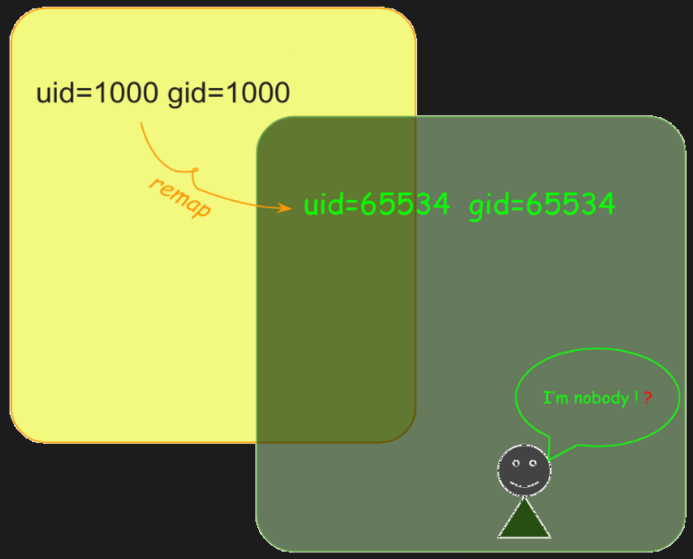
USER
namespace

Namespace provides an

isolated ID space for group of processes



USER namespace




```
ubuntu@ip-172-26-8-43:~$ sudo -Es
root@ip-172-26-8-43:~# id
uid=0(root) gid=0(root) groups=0(root)
```

```
ubuntu@ip-172-26-8-43:~$ id
uid=1000(ubuntu) gid=1000(ubuntu) groups=1000(ubuntu),4(adm),20(dialout),
24(cdrom),25(floppy),27(sudo),29(audio),30(dip),44(video),46(plugdev),108
(lxd),114(netdev),999(docker)
```

```
ubuntu@ip-172-26-8-43:~$ unshare --user /bin/bash
nobody@ip-172-26-8-43:~$ id
uid=65534(nobody) gid=65534(nogroup) groups=65534(nogroup)
```

USER namespace

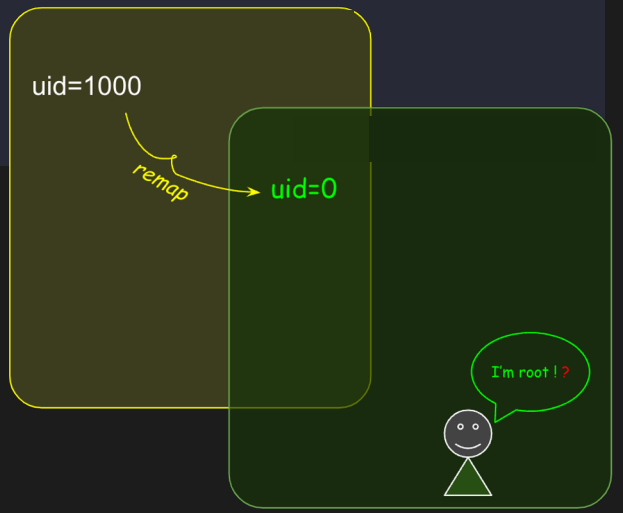
```
nobody@ip-172-26-8-43:~$ id
uid=65534(nobody) gid=65534(nogroup) groups=65534(nogroup)
nobody@ip-172-26-8-43:~$
nobody@ip-172-26-8-43:~$ unshare --uts /bin/bash
unshare: unshare failed: Operation not permitted
nobody@ip-172-26-8-43:~$
nobody@ip-172-26-8-43:~$ capsh --print | grep Current
Current: =
nobody@ip-172-26-8-43:~$
nobody@ip-172-26-8-43:~$ echo $$
18864
```

```
ubuntu@ip-172-26-8-43:~$ ps -ef | grep '/bin/bash'
ubuntu   18864 18616  0 06:23 pts/0    00:00:00 /bin/bash
ubuntu   19132 19115  0 06:41 pts/1    00:00:00 grep --color=auto /bin/bash
```

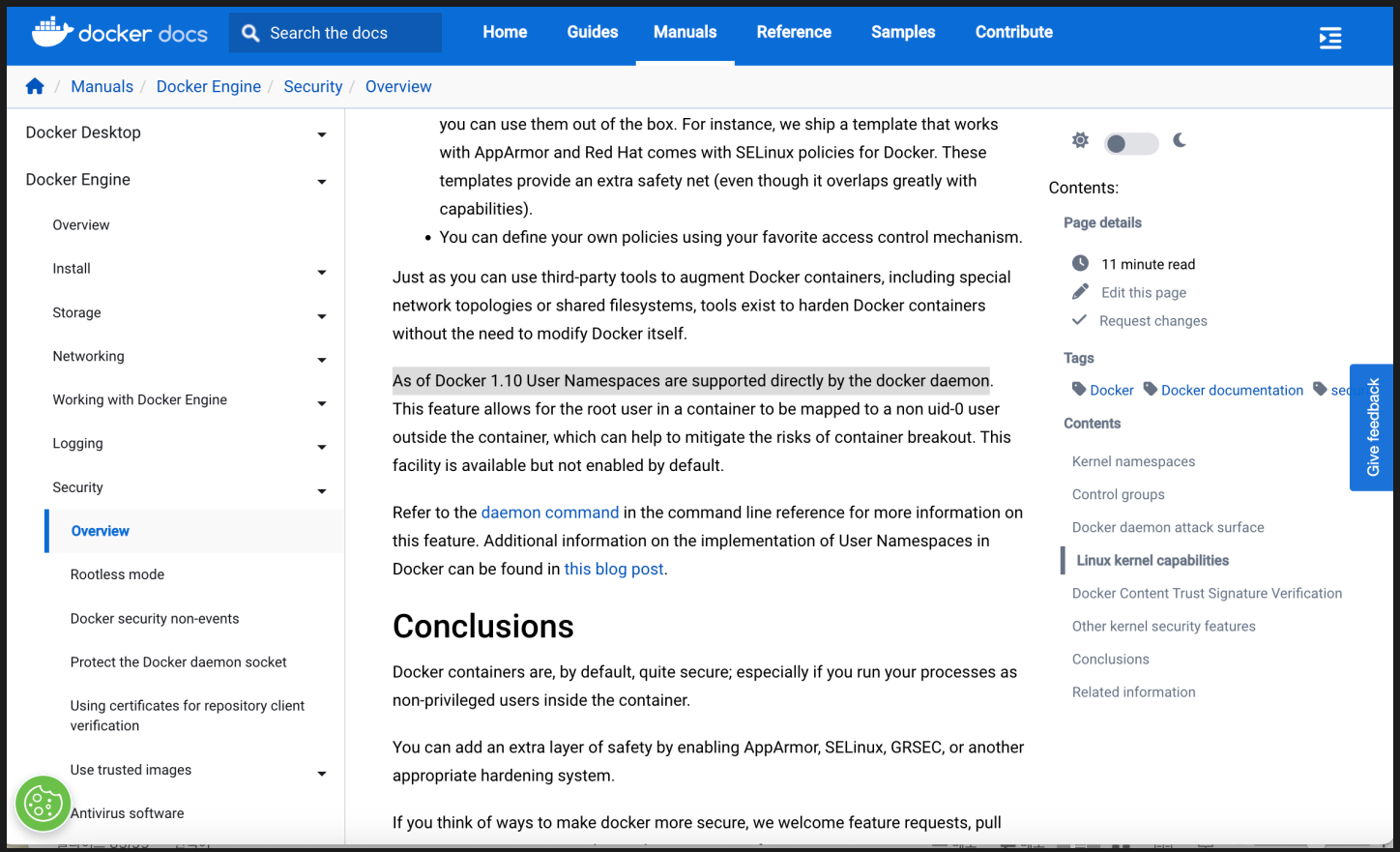
USER namespace

```
sudo echo '0 1000 1' > /proc/18864/uid_map
```

```
nobody@ip-172-26-8-43:~$ id
uid=0(root) gid=65534(nogroup) groups=65534(nogroup)
nobody@ip-172-26-8-43:~$
nobody@ip-172-26-8-43:~$ capsh --print | grep Current
Current: = cap_chown,cap_dac_override,cap_dac_read_search,cap_fowner,cap_fsetid,cap_kill,cap_setgid,ca
p_setuid,cap_setpcap,cap_linux_immutable,cap_net_bind_service,cap_net_broadcast,cap_net_admin,cap_net_
raw,cap_ipc_lock,cap_ipc_owner,cap_sys_module,cap_sys_rawio,cap_sys_chroot,cap_sys_ptrace,cap_sys_pacc
t,cap_sys_admin,cap_sys_boot,cap_sys_nice,cap_sys_resource,cap_sys_time,cap_sys_tty_config,cap_mknod,c
ap_lease,cap_audit_write,cap_audit_control,cap_setfcap,cap_mac_override,cap_mac_admin,cap_syslog,cap_w
ake_alarm,cap_block_suspend,cap_audit_read+ep
nobody@ip-172-26-8-43:~$
nobody@ip-172-26-8-43:~$ unshare --uts /bin/bash
root@ip-172-26-8-43:~#
root@ip-172-26-8-43:~# hostname jaehong21
root@ip-172-26-8-43:~# hostname
jaehong21
```



USER namespace



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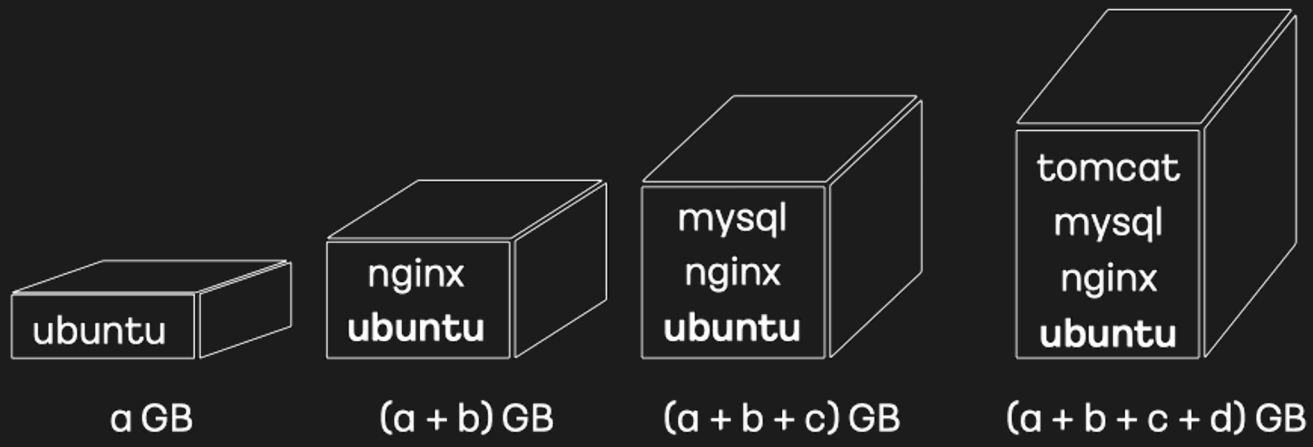
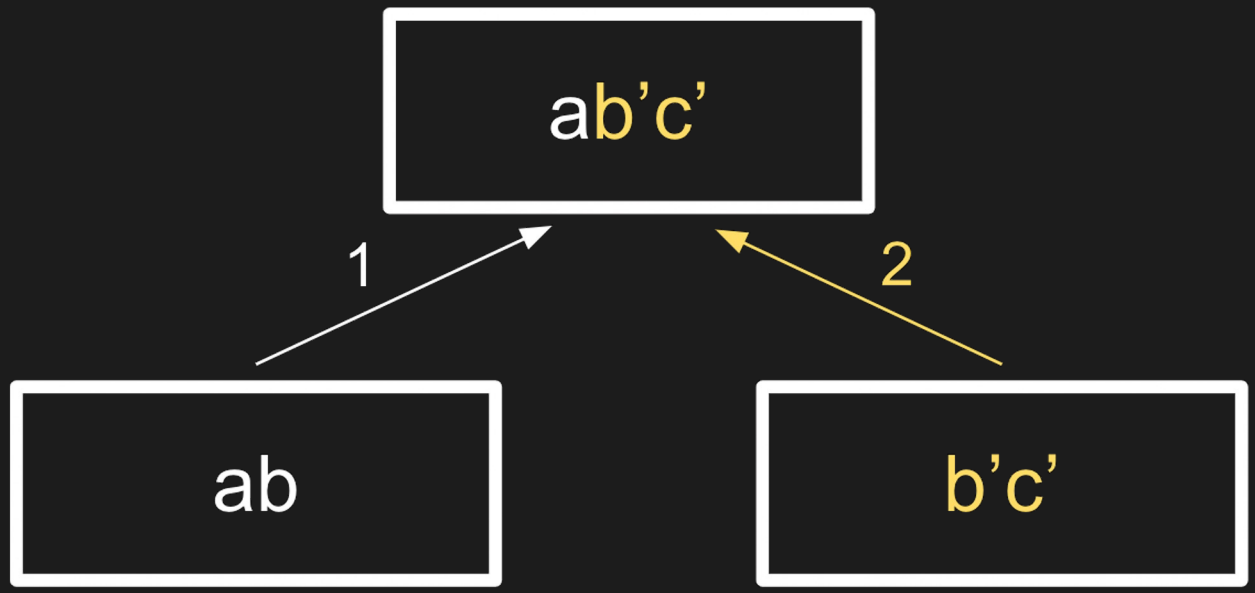
Overlay Filesystem

Duplicated File Problem

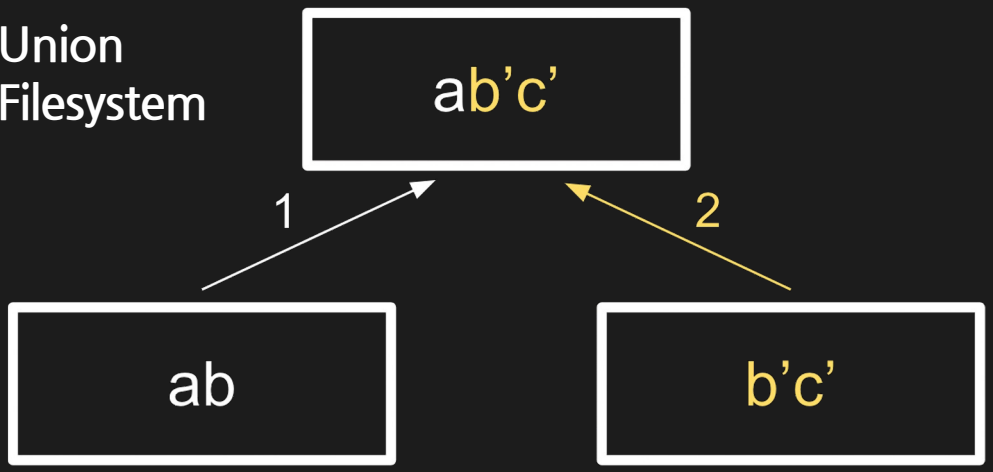


Overlay Filesystem

Union File system allows files and directories from multiple sources to be **combined** into a single, virtual file system



Union Filesystem



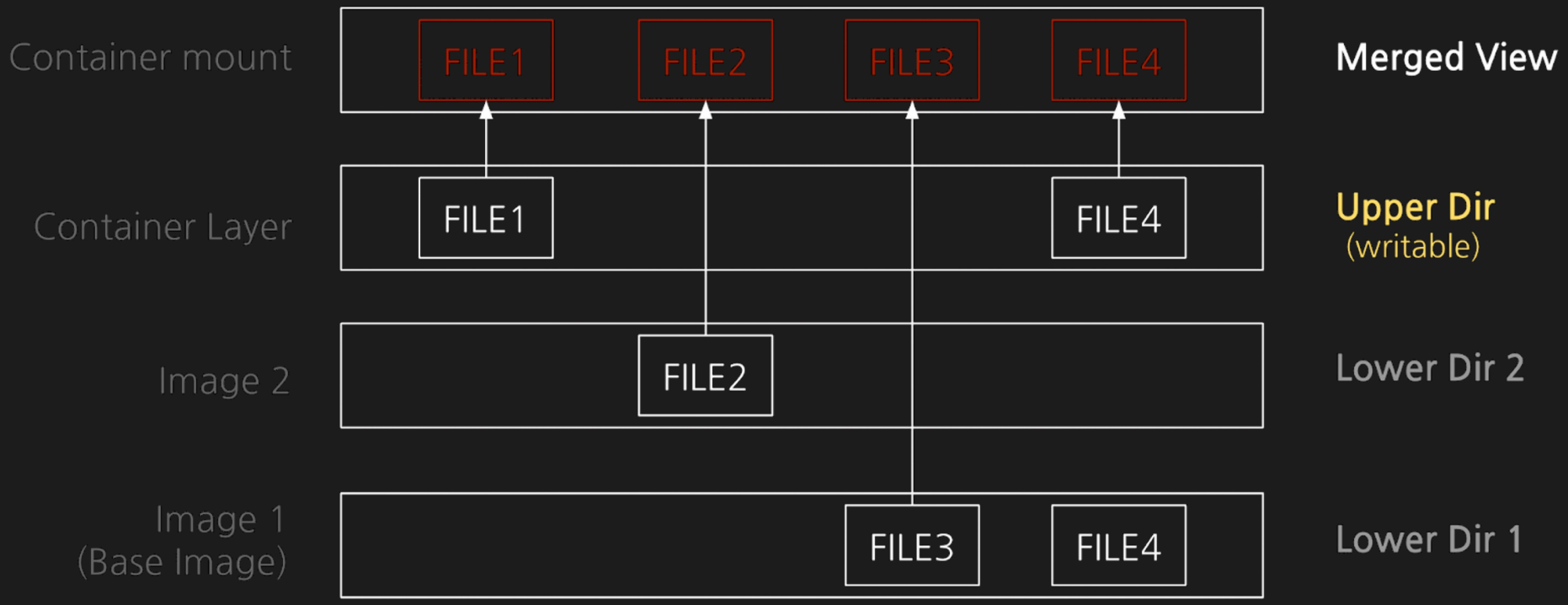
1. Combines multiple file systems into one by using a union mount

2. When two layers contain files with the same name, the file from the higher (more recently mounted) layer is overlaid on top of the file from the lower layer

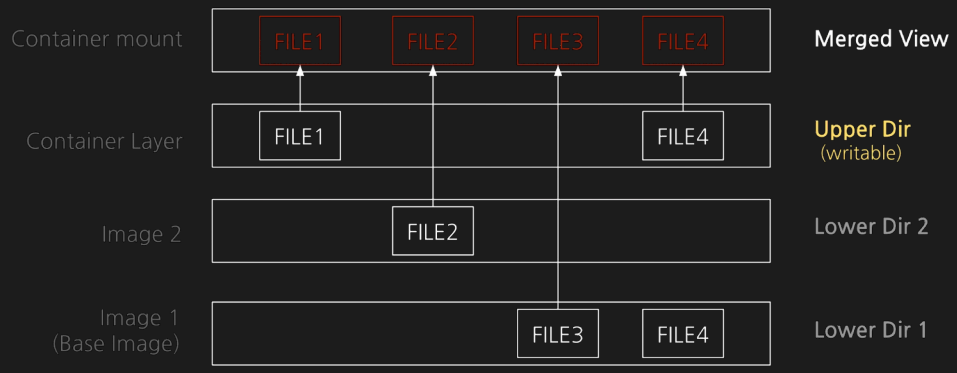
3. When a write operation is performed on a file in a lower (read-only) layer, a copy is made before the write operation
   uses CoW(Copy-on-Write)

OverlayFS2

(AUFS → OverlayFS → OverlayFS2)



OverlayFS2
(AUFS → OverlayFS → OverlayFS2)




```
root@ubuntu1804:~# docker pull nginx@sha256:75a55d33ecc73c2a242450a9f1cc858499d468f077ea942867e662c247b5e412

docker.io/library/nginx@sha256:75a55d33ecc73c2a242450a9f1cc858499d468f077ea942867e662c247b5e412: Pulling from library/nginx
f7ec5a41d630: Pull complete
aa1efa14b3bf: Pull complete
b78b95af9b17: Pull complete
c7d6bca2b8dc: Pull complete
cf16cd8e71e0: Pull complete
0241c68333ef: Pull complete
Digest: sha256:75a55d33ecc73c2a242450a9f1cc858499d468f077ea942867e662c247b5e412
Status: Downloaded newer image for nginx@sha256:75a55d33ecc73c2a242450a9f1cc858499d468f077ea942867e662c247b5e412
docker.io/library/nginx@sha256:75a55d33ecc73c2a242450a9f1cc858499d468f077ea942867e662c247b5e412
```

Overlay Filesystem

```
mkdir rootfs
cd rootfs

mkdir image1 image2 container work merge
touch image1/a image1/b image2/c

tree .
---
```

```
root@ip-172-26-8-43:/tmp/rootfs# tree .
.
├── container
├── image1
│   ├── a
│   └── b
├── image2
│   └── c
├── merge
└── work

5 directories, 3 files
```

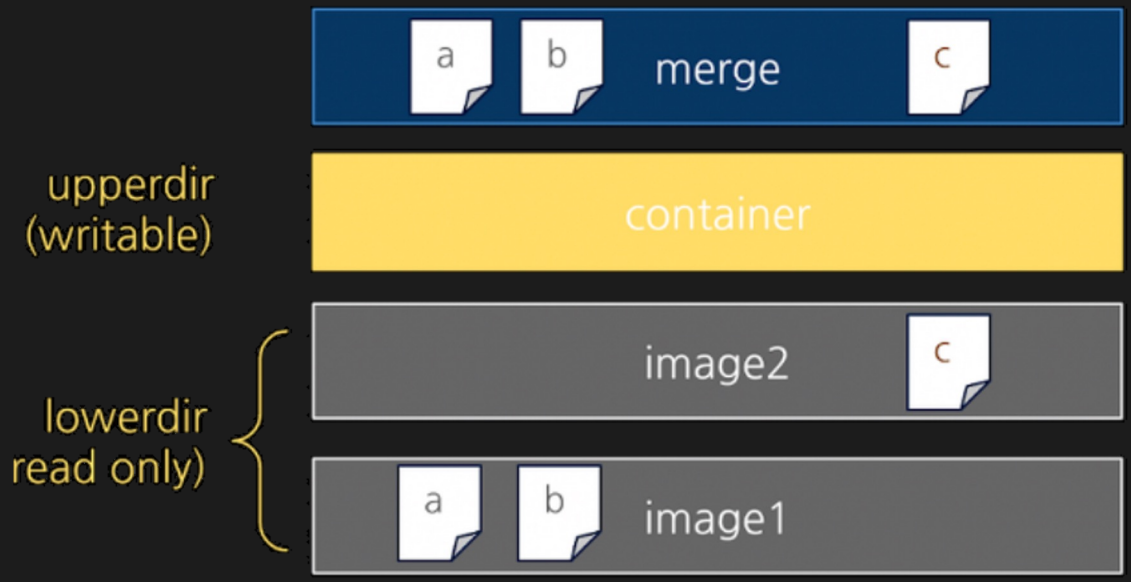
Overlay Filesystem

```
mount -t overlay overlay -o lowerdir=image2:image1,upperdir=container,workdir=work merge
```

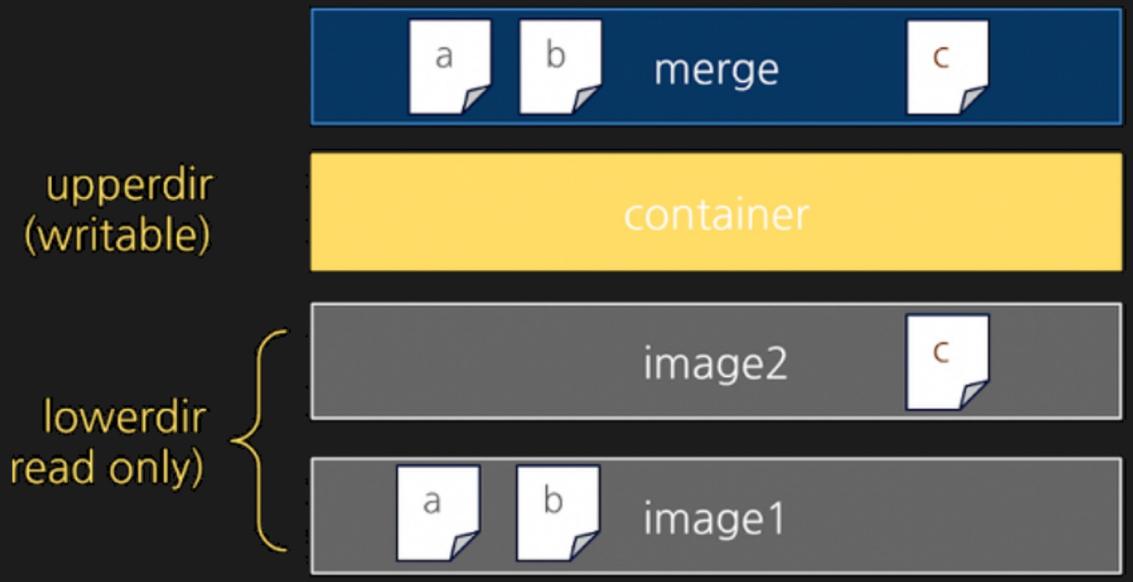
```
root@ip-172-26-8-43:/tmp/rootfs# tree .
.
├── container
├── image1
│   ├── a
│   └── b
├── image2
│   └── c
├── merge
│   ├── a
│   ├── b
│   └── c
└── work
    └── work

6 directories, 6 files
```

Overlay Filesystem

```
.
├── container
├── image1
│   ├── a
│   └── b
├── image2
│   └── c
├── merge
│   ├── a
│   ├── b
│   └── c
└── work
    └── work
```



Overlay Filesystem



1. What if **delete merge/a** ?
2. What if we **edit merge/b**?
3. What if we **edit image1/b**?

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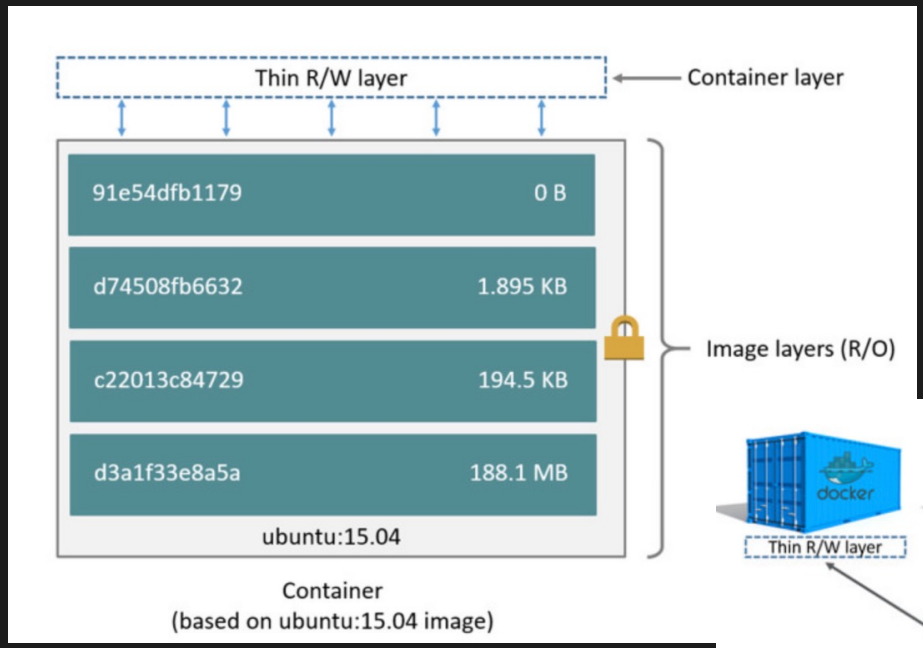
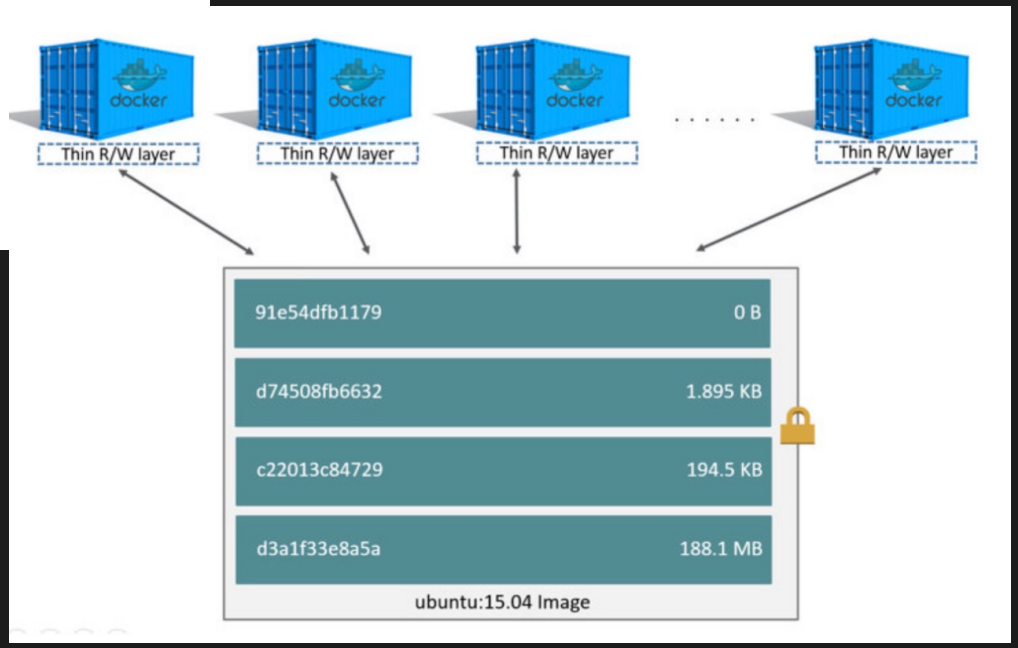
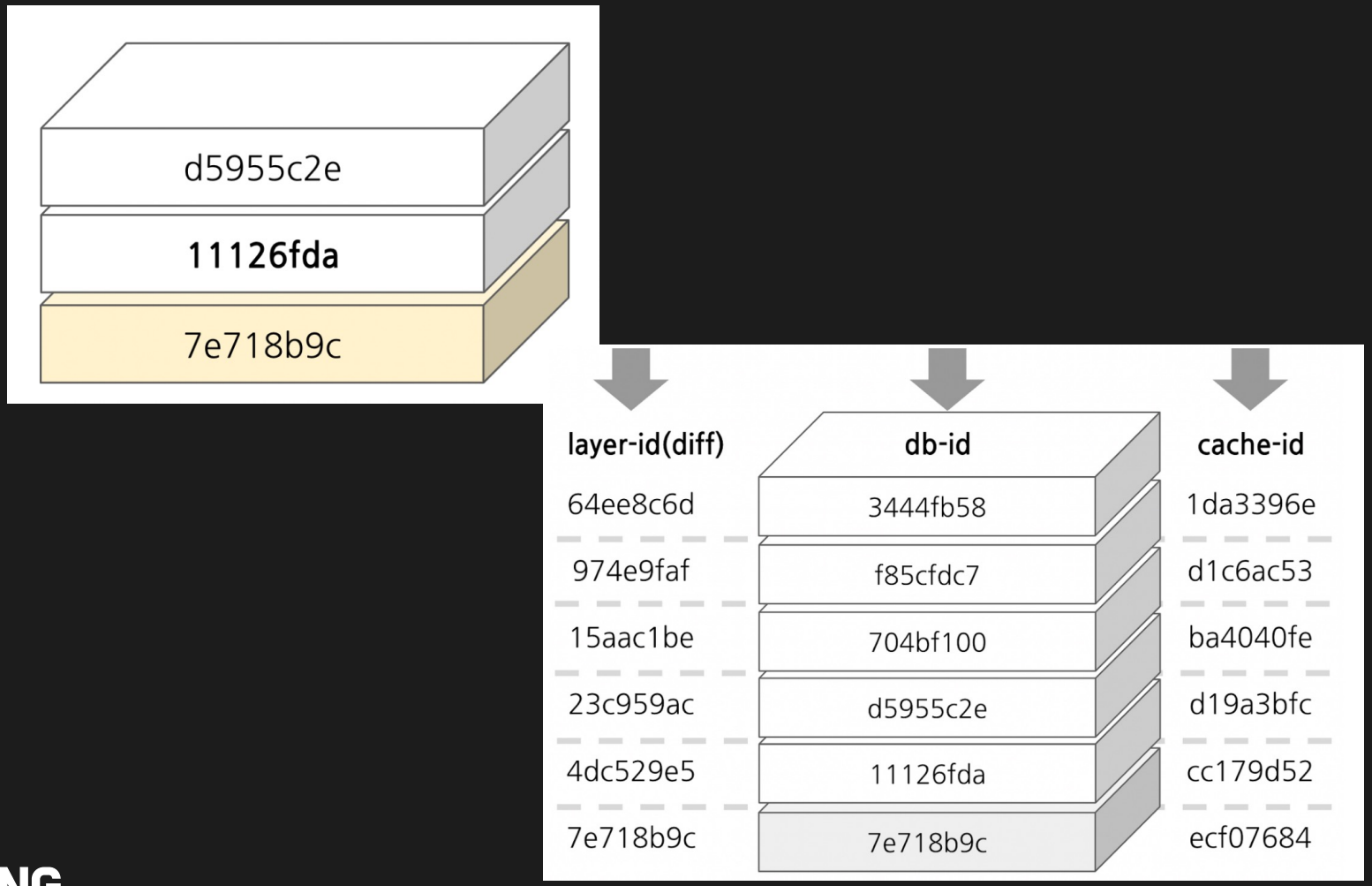
Docker
Layer





Docker Layer



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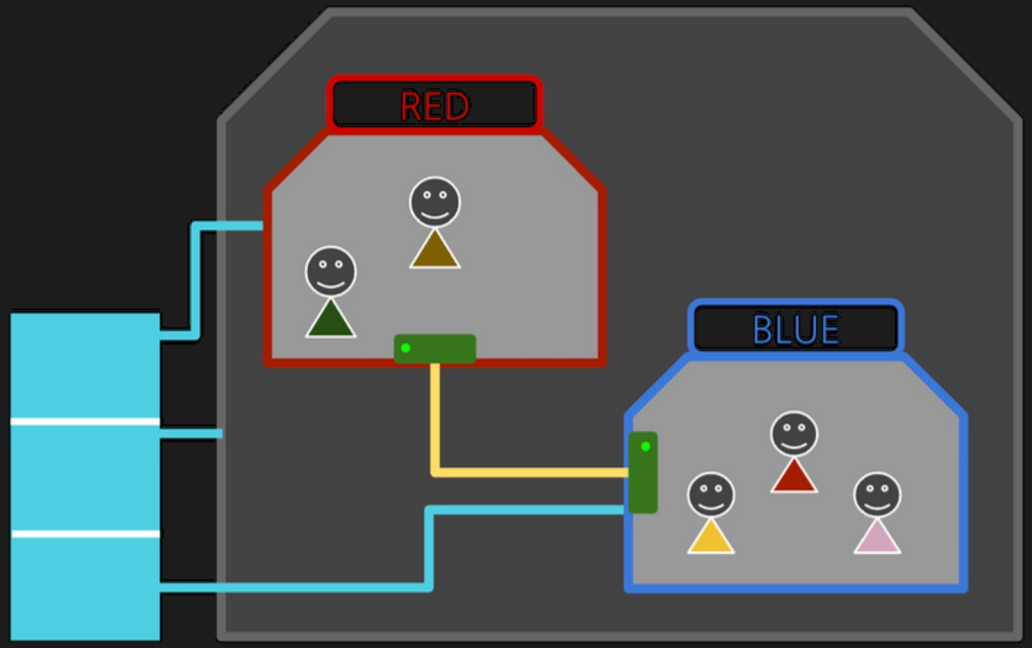
WING

Let's do it



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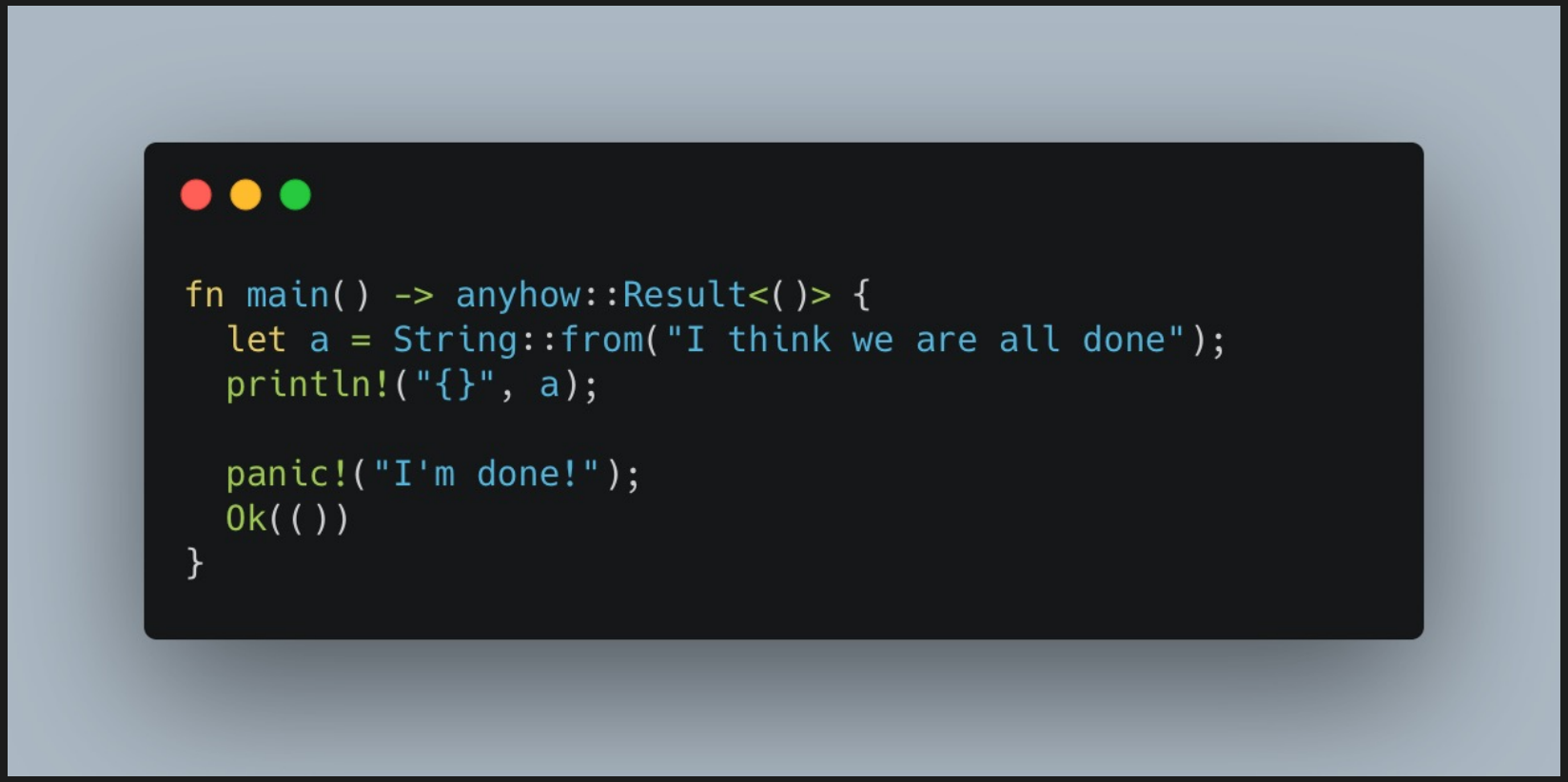
WING


fn main() -> anyhow::Result<()> {
let a = String::from("I think we are all done");
println!("{}", a);
panic!("I'm done!");
Ok(())
}

WING