リスト1（名前空間一覧の確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo lsns
        NS TYPE   NPROCS   PID USER            COMMAND
4026531834 time      203     1 root            /sbin/init splash
4026531835 cgroup    203     1 root            /sbin/init splash
4026531836 pid       203     1 root            /sbin/init splash
4026531837 user      203     1 root            /sbin/init splash
4026531838 uts       199     1 root            /sbin/init splash
4026531839 ipc       203     1 root            /sbin/init splash
4026531840 net       201     1 root            /sbin/init splash
4026531841 mnt       194     1 root            /sbin/init splash
4026532393 mnt         2   294 root             ├─/lib/systemd/systemd-udevd
4026532394 uts         2   294 root             ├─/lib/systemd/systemd-udevd
4026532456 mnt         1   485 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532478 uts         1   485 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532479 net         1   548 root             ├─/usr/libexec/accounts-daemon
4026532537 mnt         1   548 root             ├─/usr/libexec/accounts-daemon
4026532538 mnt         1   551 root             ├─/usr/libexec/bluetooth/bluetoothd
4026532557 net         1   956 rtkit            ├─/usr/libexec/rtkit-daemon
4026532598 mnt         1   572 root             ├─/lib/systemd/systemd-logind
4026532599 uts         1   572 root             ├─/lib/systemd/systemd-logind
4026532600 mnt         1   670 root             ├─/usr/sbin/NetworkManager --no-daemon
4026532661 mnt         1   699 root             └─/usr/sbin/ModemManager
4026531862 mnt         1    39 root            kdevtmpfs
cq@rp4-mycont:~/CQ/CONT $
```

リスト2（PID名前空間を分離してbashを起動）

```
cq@rp4-mycont:~/CQ/CONT $ sudo unshare --pid --mount-proc --fork bash
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト3（PID名前空間を分離したbashでプロセス一覧を確認）

```
root@rp4-mycont:/home/cq/CQ/CONT# ps -aef
UID          PID    PPID  C STIME TTY          TIME CMD
root           1       0  0 19:36 pts/2    00:00:00 bash
root           2       1  0 19:36 pts/2    00:00:00 ps -aef
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト4（bashを起動して再度プロセス一覧を確認）

```
root@rp4-mycont:/home/cq/CQ/CONT# bash
root@rp4-mycont:/home/cq/CQ/CONT# ps -aef
UID          PID    PPID  C STIME TTY          TIME CMD
root           1       0  0 19:36 pts/2    00:00:00 bash
root           3       1  0 19:36 pts/2    00:00:00 bash
root           4       3 99 19:36 pts/2    00:00:00 ps -aef
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト5（再度名前空間一覧を確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo lsns
        NS TYPE   NPROCS    PID USER            COMMAND
4026531834 time      206      1 root            /sbin/init splash
4026531835 cgroup    206      1 root            /sbin/init splash
4026531836 pid       204      1 root            /sbin/init splash
4026531837 user      206      1 root            /sbin/init splash
4026531838 uts       203      1 root            /sbin/init splash
4026531839 ipc       206      1 root            /sbin/init splash
4026531840 net       204      1 root            /sbin/init splash
4026531841 mnt       195      1 root            /sbin/init splash
4026532393 mnt         1    294 root             ├─/lib/systemd/systemd-udevd
4026532394 uts         1    294 root             ├─/lib/systemd/systemd-udevd
4026532456 mnt         1    485 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532478 uts         1    485 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532479 net         1    548 root             ├─/usr/libexec/accounts-daemon
4026532537 mnt         1    548 root             ├─/usr/libexec/accounts-daemon
4026532538 mnt         1    551 root             ├─/usr/libexec/bluetooth/bluetoothd
4026532557 net         1    956 rtkit            ├─/usr/libexec/rtkit-daemon
4026532598 mnt         1    572 root             ├─/lib/systemd/systemd-logind
4026532599 uts         1    572 root             ├─/lib/systemd/systemd-logind
4026532600 mnt         1    670 root             ├─/usr/sbin/NetworkManager - -no-daemon
4026532661 mnt         1    699 root             └─/usr/sbin/ModemManager
4026531862 mnt         1     39 root            kdevtmpfs
4026532602 mnt         3 365757 root            unshare --pid --mount-proc --fork bash
4026532603 pid         2 365758 root             └─bash
cq@rp4-mycont:~/CQ/CONT $ ps -aef
```

リスト6（プロセス一覧を確認）

```
cq@rp4-mycont:~/CQ/CONT $ ps -aef
```

```
UID          PID    PPID  C STIME TTY          TIME CMD
root           1       0  0 14:22 ?        00:00:14 /sbin/init splash
root           2       0  0 14:22 ?        00:00:00 [kthreadd]
root           3       2  0 14:22 ?        00:00:00 [pool_workqueue_release]
root           4       2  0 14:22 ?        00:00:00 [kworker/R-rcu_g]
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root      365755  355328  0 19:36 pts/0    00:00:00 sudo unshare --pid --mount-proc --fork bash
root      365756  365755  0 19:36 pts/2    00:00:00 sudo unshare --pid --mount-proc --fork bash
root      365757  365756  0 19:36 pts/2    00:00:00 unshare --pid --mount-proc --fork bash
root      365758  365757  0 19:36 pts/2    00:00:00 bash
root      365793       2  0 19:36 ?        00:00:00 [kworker/1:0]
root      365831  365758  0 19:36 pts/2    00:00:00 bash
root      366456       2  0 19:37 ?        00:00:00 [kworker/3:2H]
root      366574     294  0 19:37 ?        00:00:00 (udev-worker)
vnc       366628       1  0 19:37 ?        00:00:00 /bin/sh /usr/sbin/wayvnc-run.sh
vnc       366688  366628  0 19:37 ?        00:00:00 sleep 0.1
cq        366689  338768 99 19:37 pts/1    00:00:00 ps -aef
cq@rp4-mycont:~/CQ/CONT $
```

リスト7（名前空間一覧を確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo lsns
        NS TYPE   NPROCS   PID USER            COMMAND
4026531834 time      198     1 root            /sbin/init splash
4026531835 cgroup    198     1 root            /sbin/init splash
4026531836 pid       198     1 root            /sbin/init splash
4026531837 user      198     1 root            /sbin/init splash
4026531838 uts       195     1 root            /sbin/init splash
4026531839 ipc       198     1 root            /sbin/init splash
4026531840 net       196     1 root            /sbin/init splash
4026531841 mnt       190     1 root            /sbin/init splash
4026532393 mnt         1   294 root             ├─/lib/systemd/systemd-udevd
4026532394 uts         1   294 root             ├─/lib/systemd/systemd-udevd
4026532456 mnt         1   485 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532478 uts         1   485 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532479 net         1   548 root             ├─/usr/libexec/accounts-daemon
4026532537 mnt         1   548 root             ├─/usr/libexec/accounts-daemon
4026532538 mnt         1   551 root             ├─/usr/libexec/bluetooth/bluetoothd
4026532557 net         1   956 rtkit            ├─/usr/libexec/rtkit-daemon
4026532598 mnt         1   572 root             ├─/lib/systemd/systemd-logind
4026532599 uts         1   572 root             ├─/lib/systemd/systemd-logind
4026532600 mnt         1   670 root             ├─/usr/sbin/NetworkManager --no-daemon
4026532661 mnt         1   699 root             └─/usr/sbin/ModemManager
4026531862 mnt         1    39 root            kdevtmpfs
cq@rp4-mycont:~/CQ/CONT $
```

リスト8（MOUNT名前空間を分離してbashを起動）

```
cq@rp4-mycont:~/CQ/CONT $ sudo unshare --mount  bash
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト9（再度名前空間一覧を確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo lsns
        NS TYPE   NPROCS    PID USER            COMMAND
4026531834 time      203      1 root            /sbin/init splash
4026531835 cgroup    203      1 root            /sbin/init splash
4026531836 pid       203      1 root            /sbin/init splash
4026531837 user      203      1 root            /sbin/init splash
4026531838 uts       200      1 root            /sbin/init splash
4026531839 ipc       203      1 root            /sbin/init splash
4026531840 net       201      1 root            /sbin/init splash
4026531841 mnt       194      1 root            /sbin/init splash
4026532393 mnt         1    294 root             ├─/lib/systemd/systemd-udevd
4026532394 uts         1    294 root             ├─/lib/systemd/systemd-udevd
4026532456 mnt         1    485 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532478 uts         1    485 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532479 net         1    548 root             ├─/usr/libexec/accounts-daemon
4026532537 mnt         1    548 root             ├─/usr/libexec/accounts-daemon
4026532538 mnt         1    551 root             ├─/usr/libexec/bluetooth/bluetoothd
4026532557 net         1    956 rtkit            ├─/usr/libexec/rtkit-daemon
4026532598 mnt         1    572 root             ├─/lib/systemd/systemd-logind
4026532599 uts         1    572 root             ├─/lib/systemd/systemd-logind
4026532600 mnt         1    670 root             ├─/usr/sbin/NetworkManager --no-daemon
4026532661 mnt         1    699 root             └─/usr/sbin/ModemManager
4026531862 mnt         1     39 root            kdevtmpfs
4026532602 mnt         1 418671 root            bash
cq@rp4-mycont:~/CQ/CONT $
```

リスト10（ディレクトリを2つ作成しbindマウント）

```
cq@rp4-mycont:~/CQ/CONT $ mkdir dir1 dir2
cq@rp4-mycont:~/CQ/CONT $ sudo mount --bind ./dir1 ./dir2
mount: (hint) your fstab has been modified, but systemd still uses
```

```
                                                          S2_list.txt
       the old version; use 'systemctl daemon-reload' to reload.
cq@rp4-mycont:~/CQ/CONT $
```

リスト11（マウント情報を確認）

```
cq@rp4-mycont:~/CQ/CONT $ mount
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)
proc on /proc type proc (rw,relatime)

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/dev/mmcblk0p2 on /home/cq/CQ/CONT/dir2 type ext4 (rw,noatime)
cq@rp4-mycont:~/CQ/CONT $
```

リスト12（MOUNT名前空間を分離したbashでマウント情報を確認）

```
root@rp4-mycont:/home/cq/CQ/CONT# mount
/dev/mmcblk0p2 on / type ext4 (rw,noatime)

～～　中略　～～

/dev/mmcblk0p1 on /boot/firmware type vfat
(rw,relatime,fmask=0022,dmask=0022,codepage=437,iocharset=ascii,shortname=mixed,errors=remount-ro)
root@rp4-mycont:/home/cq/CQ/CONT# mkdir dir3 dir4
```

リスト13（ディレクトリを2つ作成しbindマウント）

```
root@rp4-mycont:/home/cq/CQ/CONT# mkdir dir3 dir4
root@rp4-mycont:/home/cq/CQ/CONT# sudo mount --bind ./dir3 ./dir4
mount: (hint) your fstab has been modified, but systemd still uses
       the old version; use 'systemctl daemon-reload' to reload.
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト14（マウント状態を確認）

```
root@rp4-mycont:/home/cq/CQ/CONT# mount
/dev/mmcblk0p2 on / type ext4 (rw,noatime)

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/dev/mmcblk0p1 on /boot/firmware type vfat
(rw,relatime,fmask=0022,dmask=0022,codepage=437,iocharset=ascii,shortname=mixed,errors=remount-ro)
/dev/mmcblk0p2 on /home/cq/CQ/CONT/dir4 type ext4 (rw,noatime)
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト15（ターミナル1でマウント情報を確認）

```
cq@rp4-mycont:~/CQ/CONT $ mount
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)

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/dev/mmcblk0p2 on /home/cq/CQ/CONT/dir2 type ext4 (rw,noatime)
cq@rp4-mycont:~/CQ/CONT $
```

リスト16（名前空間一覧を確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo lsns
        NS TYPE   NPROCS   PID USER            COMMAND
4026531834 time      195     1 root            /sbin/init splash
4026531835 cgroup    195     1 root            /sbin/init splash
4026531836 pid       195     1 root            /sbin/init splash
4026531837 user      195     1 root            /sbin/init splash
4026531838 uts       192     1 root            /sbin/init splash
4026531839 ipc       195     1 root            /sbin/init splash
4026531840 net       193     1 root            /sbin/init splash
4026531841 mnt       187     1 root            /sbin/init splash
4026532393 mnt         1   293 root             ├─/lib/systemd/systemd-udevd
4026532394 uts         1   293 root             ├─/lib/systemd/systemd-udevd
4026532468 mnt         1   470 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532478 uts         1   470 systemd-timesync ├─/lib/systemd/systemd-timesyncd
4026532479 net         1   545 root             ├─/usr/libexec/accounts-daemon
4026532537 mnt         1   545 root             ├─/usr/libexec/accounts-daemon
4026532538 mnt         1   548 root             ├─/usr/libexec/bluetooth/bluetoothd
4026532539 net         1   953 rtkit            ├─/usr/libexec/rtkit-daemon
4026532598 mnt         1   568 root             ├─/lib/systemd/systemd-logind
4026532599 uts         1   568 root             ├─/lib/systemd/systemd-logind
4026532600 mnt         1   670 root             ├─/usr/sbin/NetworkManager --no-daemon
4026532661 mnt         1   694 root             └─/usr/sbin/ModemManager
4026531862 mnt         1    39 root            kdevtmpfs
cq@rp4-mycont:~/CQ/CONT $
```

リスト17（インターフェース一覧を確認）

```
cq@rp4-mycont:~/CQ/CONT $ ip addr
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
2: eth0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN group default qlen 1000
    link/ether dc:a6:32:6d:46:cc brd ff:ff:ff:ff:ff:ff
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether dc:a6:32:6d:46:cd brd ff:ff:ff:ff:ff:ff
    inet 192.168.3.11/24 brd 192.168.3.255 scope global dynamic noprefixroute wlan0
       valid_lft 78670sec preferred_lft 78670sec
cq@rp4-mycont:~/CQ/CONT $
```

リスト18（NET名前空間を分離してbashを起動）

```
cq@rp4-mycont:~/CQ/CONT $ sudo unshare --net  bash
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト19（NET名前空間を分離したbashでインターフェース一覧を確認）

```
root@rp4-mycont:/home/cq/CQ/CONT# ip addr
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@rp4-mycont:/home/cq/CQ/CONT#
```

リスト20（再度名前空間一覧を確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo lsns
        NS TYPE   NPROCS    PID USER             COMMAND
4026531834 time      199      1 root             /sbin/init splash
4026531835 cgroup    199      1 root             /sbin/init splash
4026531836 pid       199      1 root             /sbin/init splash
4026531837 user      199      1 root             /sbin/init splash
4026531838 uts       196      1 root             /sbin/init splash
4026531839 ipc       199      1 root             /sbin/init splash
4026531840 net       196      1 root             /sbin/init splash
4026531841 mnt       191      1 root             /sbin/init splash
4026532393 mnt         1    293 root              ├─/lib/systemd/systemd-udevd
4026532394 uts         1    293 root              ├─/lib/systemd/systemd-udevd
4026532468 mnt         1    470 systemd-timesync  ├─/lib/systemd/systemd-timesyncd
4026532478 uts         1    470 systemd-timesync  ├─/lib/systemd/systemd-timesyncd
4026532479 net         1    545 root              ├─/usr/libexec/accounts-daemon
4026532537 mnt         1    545 root              ├─/usr/libexec/accounts-daemon
4026532538 mnt         1    548 root              ├─/usr/libexec/bluetooth/bluetoothd
4026532539 net         1    953 rtkit             ├─/usr/libexec/rtkit-daemon
4026532598 mnt         1    568 root              ├─/lib/systemd/systemd-logind
4026532599 uts         1    568 root              ├─/lib/systemd/systemd-logind
4026532600 mnt         1    670 root              ├─/usr/sbin/NetworkManager --no-daemon
4026532661 mnt         1    694 root              └─/usr/sbin/ModemManager
4026531862 mnt         1     39 root             kdevtmpfs
4026532602 net         1 151272 root             bash
cq@rp4-mycont:~/CQ/CONT $
```

リスト21（ローカル・ホストにping）

```
cq@rp4-mycont:~/CQ/CONT $ ping localhost
PING localhost (127.0.0.1) 56(84) bytes of data.
64 bytes from localhost (127.0.0.1): icmp_seq=1 ttl=64 time=0.095 ms
64 bytes from localhost (127.0.0.1): icmp_seq=2 ttl=64 time=0.101 ms
64 bytes from localhost (127.0.0.1): icmp_seq=3 ttl=64 time=0.103 ms
^C
--- localhost ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2057ms
rtt min/avg/max/mdev = 0.095/0.099/0.103/0.003 ms
cq@rp4-mycont:~/CQ/CONT $
```

リスト22（別のNET名前空間としたbashでローカル・ホストにping）

```
root@rp4-mycont:/home/cq/CQ/CONT# ping localhost
ping: connect: Network is unreachable
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト23（NET名前空間を分離したbashでloインターフェースをUP）

```
root@rp4-mycont:/home/cq/CQ/CONT# ip link set lo up
root@rp4-mycont:/home/cq/CQ/CONT# ip addr
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
```

```
                                                                S2_list.txt
       valid_lft forever preferred_lft forever
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト24（再度ローカル・ホストにping）

```
root@rp4-mycont:/home/cq/CQ/CONT# ping localhost
PING localhost (127.0.0.1) 56(84) bytes of data.
64 bytes from localhost (127.0.0.1): icmp_seq=1 ttl=64 time=0.146 ms
64 bytes from localhost (127.0.0.1): icmp_seq=2 ttl=64 time=0.105 ms
64 bytes from localhost (127.0.0.1): icmp_seq=3 ttl=64 time=0.108 ms
64 bytes from localhost (127.0.0.1): icmp_seq=4 ttl=64 time=0.108 ms
^C
--- localhost ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3054ms
rtt min/avg/max/mdev = 0.105/0.116/0.146/0.016 ms
root@rp4-mycont:/home/cq/CQ/CONT#
```

リスト25（bashのプロセスIDを確認後にCPUを消費するコマンドを実行）

```
cq@rp4-mycont:~/CQ/CONT $ echo $$
3239
cq@rp4-mycont:~/CQ/CONT $ while :; do date; done
```

リスト26（ラズベリー・パイ4BのCPU情報）

```
cq@rp4-mycont:~/CQ/CONT $ cat /proc/cpuinfo
processor       : 0
BogoMIPS        : 108.00
Features        : fp asimd evtstrm crc32 cpuid
CPU implementer : 0x41
CPU architecture: 8
CPU variant     : 0x0
CPU part        : 0xd08
CPU revision    : 3

processor       : 1
BogoMIPS        : 108.00
Features        : fp asimd evtstrm crc32 cpuid
CPU implementer : 0x41
CPU architecture: 8
CPU variant     : 0x0
CPU part        : 0xd08
CPU revision    : 3

processor       : 2
BogoMIPS        : 108.00
Features        : fp asimd evtstrm crc32 cpuid
CPU implementer : 0x41
CPU architecture: 8
CPU variant     : 0x0
CPU part        : 0xd08
CPU revision    : 3

processor       : 3
BogoMIPS        : 108.00
Features        : fp asimd evtstrm crc32 cpuid
CPU implementer : 0x41
CPU architecture: 8
CPU variant     : 0x0
CPU part        : 0xd08
CPU revision    : 3

Revision        : c03112
Serial          : 1000000039f840b6
Model           : Raspberry Pi 4 Model B Rev 1.2
cq@rp4-mycont:~/CQ/CONT $
```

リスト27（編集前の/boot/firmware/cmdline.txt）

```
console=serial0,115200 console=tty1 root=PARTUUID=b60f051e-02 rootfstype=ext4 fsck.repair=yes rootwait quiet splash
plymouth.ignore-serial-consoles cfg80211.ieee80211_regdom=JP ipv6.disable=1
```

リスト28（編集後の/boot/firmware/cmdline.txt）

```
console=serial0,115200 console=tty1 root=PARTUUID=b60f051e-02 rootfstype=ext4 fsck.repair=yes rootwait quiet splash
plymouth.ignore-serial-consoles cfg80211.ieee80211_regdom=JP ipv6.disable=1 cgroup_enable=memory
```

リスト29（メモリ・コントローラ有効化前の様子）

```
cq@rp4-mycont:~/CQ/CONT $ cat /sys/fs/cgroup/cgroup.controllers
cpuset cpu io pids
```

```
cq@rp4-mycont:~/CQ/CONT $
```

リスト30（メモリ・コントローラ有効化後の様子）

```
cq@rp4-mycont:~/CQ/CONT $ cat /sys/fs/cgroup/cgroup.controllers
cpuset cpu io memory pids
cq@rp4-mycont:~/CQ/CONT $ sudo mkdir -p /sys/fs/cgroup/mycgroup
```

リスト31（メモリ・コントローラ有効化前のパラメータ）

```
cq@rp4-mycont:~/CQ/CONT $ sudo mkdir /sys/fs/cgroup/mycgroup
cq@rp4-mycont:~/CQ/CONT $ ls -l /sys/fs/cgroup/mycgroup
total 0
-r--r--r-- 1 root root 0 Sep 26 10:20 cgroup.controllers
-r--r--r-- 1 root root 0 Sep 26 10:20 cgroup.events
-rw-r--r-- 1 root root 0 Sep 26 10:20 cgroup.freeze
--w------- 1 root root 0 Sep 26 10:20 cgroup.kill
-rw-r--r-- 1 root root 0 Sep 26 10:20 cgroup.max.depth
-rw-r--r-- 1 root root 0 Sep 26 10:20 cgroup.max.descendants
-rw-r--r-- 1 root root 0 Sep 26 09:26 cgroup.procs
-r--r--r-- 1 root root 0 Sep 26 10:20 cgroup.stat
-rw-r--r-- 1 root root 0 Sep 26 10:20 cgroup.subtree_control
-rw-r--r-- 1 root root 0 Sep 26 10:20 cgroup.threads
-rw-r--r-- 1 root root 0 Sep 26 10:20 cgroup.type
-rw-r--r-- 1 root root 0 Sep 26 10:20 cpu.idle
-rw-r--r-- 1 root root 0 Sep 26 10:20 cpu.max
-rw-r--r-- 1 root root 0 Sep 26 10:20 cpu.max.burst
-r--r--r-- 1 root root 0 Sep 26 10:20 cpu.stat
-r--r--r-- 1 root root 0 Sep 26 10:20 cpu.stat.local
-rw-r--r-- 1 root root 0 Sep 26 10:20 cpu.weight
-rw-r--r-- 1 root root 0 Sep 26 10:20 cpu.weight.nice
-r--r--r-- 1 root root 0 Sep 26 10:20 pids.current
-r--r--r-- 1 root root 0 Sep 26 10:20 pids.events
-rw-r--r-- 1 root root 0 Sep 26 10:20 pids.max
-r--r--r-- 1 root root 0 Sep 26 10:20 pids.peak
cq@rp4-mycont:~/CQ/CONT $
```

リスト32（メモリ・コントローラ有効化後のパラメータ）

```
cq@rp4-mycont:~/CQ/CONT $ sudo mkdir -p /sys/fs/cgroup/mycgroup
cq@rp4-mycont:~/CQ/CONT $ ls -l /sys/fs/cgroup/mycgroup
total 0
-r--r--r-- 1 root root 0 Sep 26 10:30 cgroup.controllers
-r--r--r-- 1 root root 0 Sep 26 10:30 cgroup.events
-rw-r--r-- 1 root root 0 Sep 26 10:30 cgroup.freeze
--w------- 1 root root 0 Sep 26 10:30 cgroup.kill
-rw-r--r-- 1 root root 0 Sep 26 10:30 cgroup.max.depth
-rw-r--r-- 1 root root 0 Sep 26 10:30 cgroup.max.descendants
-rw-r--r-- 1 root root 0 Sep 26 10:30 cgroup.procs
-r--r--r-- 1 root root 0 Sep 26 10:30 cgroup.stat
-rw-r--r-- 1 root root 0 Sep 26 10:30 cgroup.subtree_control
-rw-r--r-- 1 root root 0 Sep 26 10:30 cgroup.threads
-rw-r--r-- 1 root root 0 Sep 26 10:30 cgroup.type
-rw-r--r-- 1 root root 0 Sep 26 10:30 cpu.idle
-rw-r--r-- 1 root root 0 Sep 26 10:30 cpu.max
-rw-r--r-- 1 root root 0 Sep 26 10:30 cpu.max.burst
-r--r--r-- 1 root root 0 Sep 26 10:30 cpu.stat
-r--r--r-- 1 root root 0 Sep 26 10:30 cpu.stat.local
-rw-r--r-- 1 root root 0 Sep 26 10:30 cpu.weight
-rw-r--r-- 1 root root 0 Sep 26 10:30 cpu.weight.nice
-r--r--r-- 1 root root 0 Sep 26 10:30 memory.current     ★増えたパラメータ
-r--r--r-- 1 root root 0 Sep 26 10:30 memory.events      ★増えたパラメータ
-r--r--r-- 1 root root 0 Sep 26 10:30 memory.events.local  ★増えたパラメータ
-rw-r--r-- 1 root root 0 Sep 26 10:30 memory.high     ★増えたパラメータ
-rw-r--r-- 1 root root 0 Sep 26 10:30 memory.low      ★増えたパラメータ
-rw-r--r-- 1 root root 0 Sep 26 10:30 memory.max      ★増えたパラメータ
-rw-r--r-- 1 root root 0 Sep 26 10:30 memory.min      ★増えたパラメータ
-rw-r--r-- 1 root root 0 Sep 26 10:30 memory.oom.group  ★増えたパラメータ
-r--r--r-- 1 root root 0 Sep 26 10:30 memory.peak     ★増えたパラメータ
--w------- 1 root root 0 Sep 26 10:30 memory.reclaim    ★増えたパラメータ
-r--r--r-- 1 root root 0 Sep 26 10:30 memory.stat       ★増えたパラメータ
-r--r--r-- 1 root root 0 Sep 26 10:30 memory.swap.current  ★増えたパラメータ
-r--r--r-- 1 root root 0 Sep 26 10:30 memory.swap.events  ★増えたパラメータ
-rw-r--r-- 1 root root 0 Sep 26 10:30 memory.swap.high  ★増えたパラメータ
-rw-r--r-- 1 root root 0 Sep 26 10:30 memory.swap.max   ★増えたパラメータ
-r--r--r-- 1 root root 0 Sep 26 10:30 memory.swap.peak   ★増えたパラメータ
-r--r--r-- 1 root root 0 Sep 26 10:30 memory.zswap.current   ★増えたパラメータ
-rw-r--r-- 1 root root 0 Sep 26 10:30 memory.zswap.max   ★増えたパラメータ
-r--r--r-- 1 root root 0 Sep 26 10:30 pids.current
-r--r--r-- 1 root root 0 Sep 26 10:30 pids.events
-rw-r--r-- 1 root root 0 Sep 26 10:30 pids.max
-r--r--r-- 1 root root 0 Sep 26 10:30 pids.peak
cq@rp4-mycont:~/CQ/CONT $
```

リスト33（swapの無効化前）

```
cq@rp4-mycont:~/CQ/CONT $ sudo swapon --show
NAME      TYPE SIZE USED PRIO
/var/swap file 200M   0B   -2
cq@rp4-mycont:~/CQ/CONT $
```

リスト34（swapの無効化後）

```
cq@rp4-mycont:~/CQ/CONT $ sudo swapoff -a
cq@rp4-mycont:~/CQ/CONT $ sudo swapon --show
cq@rp4-mycont:~/CQ/CONT $
```

リスト35（メモリ獲得テスト・プログラム）

```
1  #include <stdio.h>
2  #include <stdlib.h>
3  #include <unistd.h>
4  #include <string.h>
5
6  int main(int argc, char **argv)
7  {
8    int size = 1024*1024*200;  // 299MB
9    if (argc > 1) {
10     // 引数でサイズで指定
11     size = atoi(argv[1]);
12   }
13   printf("size = %d bytes¥n", size);
14   char *p = malloc(size);
15   memset(p, 'A', size);
16   printf("p = %p¥n", p);
17   sleep(100);
18   return(0);
19 }
```

リスト36（プログラム実行の様子）

```
cq@rp4-mycont:~/CQ/CONT $ cc -o mem mem.c
cq@rp4-mycont:~/CQ/CONT $ ls -l mem
-rwxr-xr-x 1 cq cq 70536 Sep 26 10:55 mem
cq@rp4-mycont:~/CQ/CONT $
```

リスト37（メモリ獲得プログラムの実行結果）

```
cq@rp4-mycont:~/CQ/CONT $ sudo swapoff -a
cq@rp4-mycont:~/CQ/CONT $ sudo swapon --show
cq@rp4-mycont:~/CQ/CONT $
cq@rp4-mycont:~/CQ/CONT $ ./mem
size = 209715200 bytes
p = 0x7fa8cdf010
cq@rp4-mycont:~/CQ/CONT $
```

リスト38（プロセスに制限をかけるためにbashのPIDを調べる）

```
cq@rp4-mycont:~/CQ/CONT $ echo $$
84715
cq@rp4-mycont:~/CQ/CONT $
```

リスト39（メモリ獲得プログラムを実行）

```
cq@rp4-mycont:~/CQ/CONT $ ./mem
size = 209715200 bytes
Killed
cq@rp4-mycont:~/CQ/CONT $
```

リスト40（dmesgコマンドでメッセージを確認）

```
$ dmesg
[10551.305525] mem invoked oom-killer: gfp_mask=0xcc0(GFP_KERNEL), order=0, oom_score_adj=0
[10551.305567] CPU: 2 PID: 204901 Comm: mem Tainted: G         C         6.6.47+rpt-rpi-v8 #1  Debian 1:6.6.47-1+rpt1
[10551.305585] Hardware name: Raspberry Pi 4 Model B Rev 1.2 (DT)
[10551.305594] Call trace:
[10551.305602]  dump_backtrace+0xa0/0x100
[10551.305625]  show_stack+0x20/0x38
[10551.305637]  dump_stack_lvl+0x48/0x60
[10551.305658]  dump_stack+0x18/0x28
[10551.305674]  dump_header+0x48/0x230
[10551.305692]  oom_kill_process+0x140/0x2e8
```

```
[10551.305709]  out_of_memory+0xe4/0x358
[10551.305725]  mem_cgroup_out_of_memory+0x134/0x150
[10551.305747]  try_charge_memcg+0x5e0/0x6c8
[10551.305760]  charge_memcg+0x54/0xc0
[10551.305772]  __mem_cgroup_charge+0x40/0x90
[10551.305785]  __handle_mm_fault+0x3dc/0xb18
[10551.305802]  handle_mm_fault+0x204/0x330
[10551.305818]  do_page_fault+0x198/0x4b8
[10551.305830]  do_translation_fault+0xa4/0xc0
[10551.305841]  do_mem_abort+0x4c/0xa8
[10551.305857]  el0_da+0x30/0x88
[10551.305876]  el0t_64_sync_handler+0xb8/0x130
[10551.305886]  el0t_64_sync+0x190/0x198
[10551.305899] memory: usage 102400kB, limit 102400kB, failcnt 7219
[10551.305909] swap: usage 0kB, limit 9007199254740988kB, failcnt 0
[10551.305918] Memory cgroup stats for /mycgroup:
[10551.306105] anon 104247296
[10551.306114] file 28672
[10551.306120] kernel 581632
[10551.306126] kernel_stack 16384
[10551.306132] pagetables 241664
[10551.306138] sec_pagetables 0
[10551.306143] percpu 96
[10551.306149] sock 0
[10551.306154] vmalloc 0
[10551.306160] shmem 0
[10551.306165] zswap 0
[10551.306171] zswapped 0
[10551.306177] file_mapped 0
[10551.306182] file_dirty 0
[10551.306188] file_writeback 0
[10551.306194] swapcached 0
[10551.306199] inactive_anon 28393472
[10551.306205] active_anon 75853824
[10551.306210] inactive_file 0
[10551.306216] active_file 28672
[10551.306221] unevictable 0
[10551.306227] slab_reclaimable 295328
[10551.306232] slab_unreclaimable 22056
[10551.306238] slab 317384
[10551.306243] workingset_refault_anon 0
[10551.306249] workingset_refault_file 0
[10551.306255] workingset_activate_anon 0
[10551.306261] workingset_activate_file 0
[10551.306266] workingset_restore_anon 0
[10551.306272] workingset_restore_file 0
[10551.306277] workingset_nodereclaim 0
[10551.306283] pgscan 7278
[10551.306288] pgsteal 7137
[10551.306294] pgscan_kswapd 0
[10551.306300] pgscan_direct 7278
[10551.306305] pgscan_khugepaged 0
[10551.306311] pgsteal_kswapd 0
[10551.306316] pgsteal_direct 7137
[10551.306322] pgsteal_khugepaged 0
[10551.306328] pgfault 41648
[10551.306333] pgmajfault 220
[10551.306339] pgrefill 38
[10551.306344] pgactivate 141
[10551.306350] pgdeactivate 0
[10551.306355] pglazyfree 0
[10551.306361] pglazyfreed 0
[10551.306366] zswpin 0
[10551.306372] zswpout 0
[10551.306378] Tasks state (memory values in pages):
[10551.306384] [  pid  ]   uid  tgid total_vm      rss pgtables_bytes swapents oom_score_adj name
[10551.306394] [  84715]  1000 84715     2059     1248    53248        0             0 bash
[10551.306412] [ 204901]  1000 204901    51749    25664   241664        0             0 mem
[10551.306429]
oom-kill:constraint=CONSTRAINT_MEMCG,nodemask=(null),cpuset=/,mems_allowed=0,oom_memcg=/mycgroup,task_memcg=/mycgroup,task=
mem,pid=204901,uid=1000
[10551.306501] Memory cgroup out of memory: Killed process 204901 (mem) total-vm:206996kB, anon-rss:101504kB,
file-rss:1152kB, shmem-rss:0kB, UID:1000 pgtables:236kB oom_score_adj:0
[10557.332650]
```

リスト41（メモリ獲得プログラムを実行）

```
cq@rp4-mycont:~/CQ/CONT $ ./mem
size = 209715200 bytes
p = 0x7f892ff010
cq@rp4-mycont:~/CQ/CONT $
```

リスト42（cgroup制限値を設定）

```
cq@rp4-mycont:~/CQ/CONT $ cat  /sys/fs/cgroup/mycgroup/memory.max
```

```
104857600
cq@rp4-mycont:~/CQ/CONT $ sudo sh -c "echo $((1024*1024*300)) > /sys/fs/cgroup/mycgroup/memory.max"
cq@rp4-mycont:~/CQ/CONT $ sudo sh -c "echo $((1024*1024*100)) > /sys/fs/cgroup/mycgroup/memory.high"
cq@rp4-mycont:~/CQ/CONT $ cat  /sys/fs/cgroup/mycgroup/memory.max
314572800
cq@rp4-mycont:~/CQ/CONT $ cat /sys/fs/cgroup/mycgroup/memory.high
104857600
cq@rp4-mycont:~/CQ/CONT $
```

リスト43（cgroup制限値を引き上げる）

```
cq@rp4-mycont:~/CQ/CONT $ sudo sh -c "echo $((1024*1024*210)) > /sys/fs/cgroup/mycgroup/memory.high"
cq@rp4-mycont:~/CQ/CONT $ cat /sys/fs/cgroup/mycgroup/memory.high
220200960
cq@rp4-mycont:~/CQ/CONT $
```

リスト44（プロセスのメモリ獲得が完了）

```
cq@rp4-mycont:~/CQ/CONT $ ./mem
size = 209715200 bytes
p = 0x7fa359f010
cq@rp4-mycont:~/CQ/CONT $
```

リスト45（使用するBPFプログラム）

```
1  #include <linux/bpf.h>
2  #include <bpf/bpf_helpers.h>
3
4  SEC("cgroup/dev")
5  int my_dev_cntl(struct bpf_cgroup_dev_ctx *ctx)
6  {
7    /*
8     bpf_cgroup_dev_ctx にアクセスタイプと対象デバイスが入っている
9     タイプやデバイスを見て制御する処理を実装する
10    ここでは,
11      /dev/random はアクセ不可
12      /dev/zero はアクセ可能
13      その他はアクセス可能
14      という制御を実装する
15    */
16    if (ctx->major == 1 && ctx->minor == 8) {
17      bpf_printk("my_dev_cntl:NOT allowed");
18      return 0;       // アクセス不可能
19    }
20    else if (ctx->major == 1 && ctx->minor == 5) {
21      bpf_printk("my_dev_cntl:allowed");
22      return 1;       // アクセス可能
23    }
24    else {
25      return 1;       // アクセス可能
26    }
27 }
28 char _license[] SEC("license") = "GPL";
```

リスト46（デバイス番号の確認）

```
cq@rp4-mycont:~/CQ/CONT $ ls -l /dev/random
crw-rw-rw- 1 root root 1, 8 Sep 25 20:36 /dev/random
cq@rp4-mycont:~/CQ/CONT $ ls -l /dev/zero
crw-rw-rw- 1 root root 1, 5 Sep 25 20:36 /dev/zero
cq@rp4-mycont:~/CQ/CONT $
```

リスト47（BPFプログラムのビルド）

```
cq@rp4-mycont:~/CQ/CONT $ clang -O1 -g -c -target bpf my_devctl.c -o my_devctl.o
cq@rp4-mycont:~/CQ/CONT $
```

リスト48（ビルド後のファイル）

```
cq@rp4-mycont:~/CQ/CONT $ ls -ltr
total 32
-rw-r--r-- 1 cq cq   772 Sep 26 01:47 my_devctl.c
-rw-r--r-- 1 cq cq  5888 Sep 26 09:22 my_devctl.o
cq@rp4-mycont:~/CQ/CONT $
```

リスト49（BPFプログラムのロード）

```
cq@rp4-mycont:~/CQ/CONT $ sudo bpftool prog load ./my_devctl.o /sys/fs/bpf/my_devctl
cq@rp4-mycont:~/CQ/CONT $
```

リスト50（登録されたプログラムの一覧表示と対象となるプログラムのidを取得）

```
1  cq@rp4-mycont:~/CQ/CONT $ sudo bpftool prog
2  3: cgroup_device  name sd_devices  tag 47dd357395126b0c  gpl
3       loaded_at 2024-09-26T09:03:02+0900  uid 0
4       xlated 504B  jited 488B  memlock 4096B
5
6
7  ～～  中略  ～～
8
9  22: cgroup_device  name my_dev_cntl  tag 3ac5306bce6dc5ef  gpl
10      loaded_at 2024-09-26T09:23:24+0900  uid 0
11      xlated 160B  jited 232B  memlock 4096B  map_ids 3
12      btf_id 9
13  cq@rp4-mycont:~/CQ/CONT $
```

リスト51（cgroupの作成）

```
cq@rp4-mycont:~/CQ/CONT $ sudo mkdir -p /sys/fs/cgroup/mycgroup
cq@rp4-mycont:~/CQ/CONT $
```

リスト52（cgroupにBPFプログラムを対応させる）

```
cq@rp4-mycont:~/CQ/CONT $ sudo bpftool cgroup attach /sys/fs/cgroup/mycgroup/ device id 22
cq@rp4-mycont:~/CQ/CONT $
```

リスト53（BPFプログラムの登録状況を確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo bpftool cgroup list  /sys/fs/cgroup/mycgroup
ID       AttachType      AttachFlags     Name
libbpf: failed to find valid kernel BTF
22       cgroup_device                   my_dev_cntl
cq@rp4-mycont:~/CQ/CONT $
```

リスト54（PIDの確認）

```
cq@rp4-mycont:~/CQ/CONT $ echo $$
4202
cq@rp4-mycont:~/CQ/CONT $
```

リスト55（cgroupにプロセスを入れる）

```
cq@rp4-mycont:~/CQ/CONT $ sudo sh -c "echo
4202 > /sys/fs/cgroup/mycgroup/cgroup.procs"
cq@rp4-mycont:~/CQ/CONT $
```

リスト56（登録状況の確認）

```
cq@rp4-mycont:~/CQ/CONT $ cat  /sys/fs/cgroup/mycgroup/cgroup.procs
4202
28758
cq@rp4-mycont:~/CQ/CONT $
```

リスト57（ddコマンドでデバイスにアクセス）

```
cq@rp4-mycont:~/CQ/CONT $ dd  bs=512 count=1 if=/dev/random of=./a
dd: failed to open '/dev/random': Operation not permitted
cq@rp4-mycont:~/CQ/CONT $
```

リスト58（BPFプログラムの出力メッセージを確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo cat  /sys/kernel/debug/tracing/trace_pipe
              dd-33816   [000] ...11  1653.376767: bpf_trace_printk: my_dev_cntl:NOT allowed
```

リスト59（/dev/zeroデバイスにアクセス）

```
cq@rp4-mycont:~/CQ/CONT $ dd  bs=512 count=1 if=/dev/zero of=./a
1+0 records in
1+0 records out
512 bytes copied, 0.000589235 s, 869 kB/s
cq@rp4-mycont:~/CQ/CONT $
```

リスト60（BPFプログラムの出力メッセージを確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo cat  /sys/kernel/debug/tracing/trace_pipe
              dd-35527   [001] ...11  1741.651062: bpf_trace_printk: my_dev_cntl:allowed
```

```
^C
cq@rp4-mycont:~/CQ/CONT $
```

リスト61（アクセス制限の解除）

```
cq@rp4-mycont:~/CQ/CONT $ sudo sh -c "echo 4202 > /sys/fs/cgroup/cgroup.procs"
cq@rp4-mycont:~/CQ/CONT $ cat  /sys/fs/cgroup/mycgroup/cgroup.procs
cq@rp4-mycont:~/CQ/CONT $
```

リスト62（再度/dev/randomデバイスにアクセス）

```
cq@rp4-mycont:~/CQ/CONT $ dd  bs=512 count=1 if=/dev/random of=./a
1+0 records in
1+0 records out
512 bytes copied, 0.000844567 s, 606 kB/s
cq@rp4-mycont:~/CQ/CONT $
```

リスト63（BPFプログラムの出力メッセージを確認）

```
cq@rp4-mycont:~/CQ/CONT $ sudo cat  /sys/kernel/debug/tracing/trace_pipe
^C
cq@rp4-mycont:~/CQ/CONT $
```

リスト64（OverlayFSの準備の様子）

```
cq@rp4-mycont:~/CQ/STORAGE $ mkdir lower diff view work  ★ディレクトリ作成
cq@rp4-mycont:~/CQ/STORAGE $ ls -l
total 16
drwxr-xr-x 2 cq cq 4096 Sep 26 20:07 diff
drwxr-xr-x 2 cq cq 4096 Sep 26 20:07 lower
drwxr-xr-x 2 cq cq 4096 Sep 26 20:07 view
drwxr-xr-x 2 cq cq 4096 Sep 26 20:07 work
cq@rp4-mycont:~/CQ/STORAGE $ cp -pr /etc/* lower/    ★元データのコピー
cp: cannot access '/etc/chatscripts': Permission denied

        ～～  中略  ～～

cp: cannot open '/etc/wpa_supplicant/wpa_supplicant.conf' for reading: Permission denied
cq@rp4-mycont:~/CQ/STORAGE $ ls -l lower/
total 1116
-rw-r--r--  1 cq cq  3040 May 26  2023 adduser.conf

        ～～  中略  ～～

drwxr-xr-x 14 cq cq  4096 Jul  4 09:09 xdg
drwxr-xr-x  2 cq cq  4096 Jul  4 09:09 xml
drwxr-xr-x  2 cq cq  4096 Jul  4 09:09 xsettingsd
cq@rp4-mycont:~/CQ/STORAGE $
cq@rp4-mycont:~/CQ/STORAGE $ sudo  mount -t overlay myoverlay -o lowerdir=lower,upperdir=diff,workdir=work view  ★OverlayFSマウント
mount: (hint) your fstab has been modified, but systemd still uses
       the old version; use 'systemctl daemon-reload' to reload.
cq@rp4-mycont:~/CQ/STORAGE $ mount     ★マウント結果の確認
sysfs on /sys type sysfs (rw,nosuid,nodev,noexec,relatime)
proc on /proc type proc (rw,relatime)
udev on /dev type devtmpfs (rw,nosuid,relatime,size=1668236k,nr_inodes=417059,mode=755)

        ～～  中略  ～～

myoverlay on /home/cq/CQ/STORAGE/view type overlay (rw,relatime,lowerdir=lower,upperdir=diff,workdir=work,uuid=on)
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト65（lowerの内容）

```
cq@rp4-mycont:~/CQ/STORAGE $ ls -l lower
total 1116
-rw-r--r--  1 cq cq  3040 May 26  2023 adduser.conf
        ～～  中略  ～～
drwxr-xr-x 14 cq cq  4096 Jul  4 09:09 xdg
drwxr-xr-x  2 cq cq  4096 Jul  4 09:09 xml
drwxr-xr-x  2 cq cq  4096 Jul  4 09:09 xsettingsd
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト66（diffの内容）

```
cq@rp4-mycont:~/CQ/STORAGE $ ls -l diff/
total 0
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト67（viewの内容）

```
cq@rp4-mycont:~/CQ/STORAGE $ ls -l view/
total 1116
-rw-r--r--  1 cq cq  3040 May 26  2023 adduser.conf
        ～～  中略  ～～
drwxr-xr-x 14 cq cq  4096 Jul  4 09:09 xdg
drwxr-xr-x  2 cq cq  4096 Jul  4 09:09 xml
drwxr-xr-x  2 cq cq  4096 Jul  4 09:09 xsettingsd
cq@rp4-mycont:~/CQ/STORAGE $

cq@rp4-mycont:~/CQ/STORAGE $ diff -rc view lower
diff: view/mtab: No such file or directory
diff: lower/mtab: No such file or directory
diff: view/os-release: No such file or directory
diff: lower/os-release: No such file or directory
diff: view/pulse/client.conf.d/01-enable-autospawn.conf: No such file or directory
diff: lower/pulse/client.conf.d/01-enable-autospawn.conf: No such file or directory
diff: view/xdg/menus/debian-menu.menu: No such file or directory
diff: lower/xdg/menus/debian-menu.menu: No such file or directory
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト68（OverlayFSにファイルを新規作成）

```
cq@rp4-mycont:~/CQ/STORAGE $ echo "My DATA" > /home/cq/CQ/STORAGE/view/ADDED
cq@rp4-mycont:~/CQ/STORAGE $ cat  /home/cq/CQ/STORAGE/view/ADDED
My DATA
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト69（diffディレクトリにはファイルが作成される）

```
cq@rp4-mycont:~/CQ/STORAGE $ cat  /home/cq/CQ/STORAGE/diff/ADDED
cq@rp4-mycont:~/CQ/STORAGE $ cat  /home/cq/CQ/STORAGE/diff/ADDED
My DATA
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト70（lowerディレクトリにはファイルは存在しない）

```
cq@rp4-mycont:~/CQ/STORAGE $ cat  /home/cq/CQ/STORAGE/lower/ADDED
cat: /home/cq/CQ/STORAGE/lower/ADDED: No such file or directory
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト71（既存ファイルの更新）

```
cq@rp4-mycont:~/CQ/STORAGE $ echo "MODIFIED" >> /home/cq/CQ/STORAGE/view/fstab
cq@rp4-mycont:~/CQ/STORAGE $ ls -l /home/cq/CQ/STORAGE/view/fstab
-rw-r--r-- 1 cq cq 323 Sep 26 21:12 /home/cq/CQ/STORAGE/view/fstab
cq@rp4-mycont:~/CQ/STORAGE $ cat  /home/cq/CQ/STORAGE/view/fstab
proc            /proc           proc    defaults          0       0
PARTUUID=b60f051e-01  /boot/firmware  vfat    defaults          0       2
PARTUUID=b60f051e-02  /               ext4    defaults,noatime  0       1
# a swapfile is not a swap partition, no line here
#   use  dphys-swapfile swap[on|off]  for that
MODIFIED
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト72（diffディレクトリの内容を確認）

```
cq@rp4-mycont:~/CQ/STORAGE $ cat  /home/cq/CQ/STORAGE/diff/fstab
proc            /proc           proc    defaults          0       0
PARTUUID=b60f051e-01  /boot/firmware  vfat    defaults          0       2
PARTUUID=b60f051e-02  /               ext4    defaults,noatime  0       1
# a swapfile is not a swap partition, no line here
#   use  dphys-swapfile swap[on|off]  for that
MODIFIED
cq@rp4-mycont:~/CQ/STORAGE $ ls -l  /home/cq/CQ/STORAGE/diff/fstab
-rw-r--r-- 1 cq cq 323 Sep 26 21:12 /home/cq/CQ/STORAGE/diff/fstab
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト73（lowerディレクトリのファイルを確認）

```
cq@rp4-mycont:~/CQ/STORAGE $ ls -l  /home/cq/CQ/STORAGE/lower/fstab
-rw-r--r-- 1 cq cq 314 Jul  4 09:17 /home/cq/CQ/STORAGE/lower/fstab
cq@rp4-mycont:~/CQ/STORAGE $ cat  /home/cq/CQ/STORAGE/lower/fstab
proc            /proc           proc    defaults          0       0
PARTUUID=b60f051e-01  /boot/firmware  vfat    defaults          0       2
PARTUUID=b60f051e-02  /               ext4    defaults,noatime  0       1
# a swapfile is not a swap partition, no line here
#   use  dphys-swapfile swap[on|off]  for that
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト74（ファイルの削除）

```
cq@rp4-mycont:~/CQ/STORAGE $ rm   /home/cq/CQ/STORAGE/view/adduser.conf
cq@rp4-mycont:~/CQ/STORAGE $ ls -l   /home/cq/CQ/STORAGE/view/adduser.conf
ls: cannot access '/home/cq/CQ/STORAGE/view/adduser.conf': No such file or directory
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト75（diffディレクトリの内容を確認）

```
cq@rp4-mycont:~/CQ/STORAGE $ ls -l   /home/cq/CQ/STORAGE/diff/adduser.conf
c--------- 2 root root 0, 0 Sep 26 21:26 /home/cq/CQ/STORAGE/diff/adduser.conf
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト76（lowerディレクトリの内容を確認）

```
cq@rp4-mycont:~/CQ/STORAGE $ ls -l   /home/cq/CQ/STORAGE/lower/adduser.conf
-rw-r--r-- 1 cq cq 3040 May 26  2023 /home/cq/CQ/STORAGE/lower/adduser.conf
cq@rp4-mycont:~/CQ/STORAGE $
```

リスト77（フォワーディングの設定）

```
cq@rp4:~ $ sudo sed -i 's/#net.ipv4.ip_forward=1/net.ipv4.ip_forward=1/g' /etc/sysctl.conf
cq@rp4:~ $ sudo sysctl -p
net.ipv4.ip_forward = 1
cq@rp4:~ $ sudo sysctl net.ipv4.ip_forward
net.ipv4.ip_forward = 1
cq@rp4:~ $
```

リスト78（名前空間一覧の確認）

```
cq@rp4-mycont:~/CQ/NET $ sudo lsns
        NS TYPE   NPROCS   PID USER             COMMAND
4026531834 time      203     1 root             /sbin/init splash
4026531835 cgroup    203     1 root             /sbin/init splash
4026531836 pid       203     1 root             /sbin/init splash
4026531837 user      203     1 root             /sbin/init splash
4026531838 uts       200     1 root             /sbin/init splash
4026531839 ipc       203     1 root             /sbin/init splash
4026531840 net       201     1 root             /sbin/init splash
4026531841 mnt       195     1 root             /sbin/init splash
4026532393 mnt         1   292 root              ├─/lib/systemd/systemd-udevd
4026532394 uts         1   292 root              ├─/lib/systemd/systemd-udevd
4026532468 mnt         1   479 systemd-timesync  ├─/lib/systemd/systemd-timesyncd
4026532478 uts         1   479 systemd-timesync  ├─/lib/systemd/systemd-timesyncd
4026532479 net         1   537 root              ├─/usr/libexec/accounts-daemon
4026532537 mnt         1   537 root              ├─/usr/libexec/accounts-daemon
4026532538 mnt         1   540 root              ├─/usr/libexec/bluetooth/bluetoothd
4026532557 net         1   962 rtkit             ├─/usr/libexec/rtkit-daemon
4026532598 mnt         1   594 root              ├─/lib/systemd/systemd-logind
4026532599 uts         1   594 root              ├─/lib/systemd/systemd-logind
4026532600 mnt         1   639 root              ├─/usr/sbin/NetworkManager --no-daemon
4026532661 mnt         1   696 root              └─/usr/sbin/ModemManager
4026531862 mnt         1    39 root             kdevtmpfs
cq@rp4-mycont:~/CQ/NET $
```

リスト79（インターフェース一覧の確認）

```
cq@rp4-mycont:~/CQ/NET $ ip addr
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
2: eth0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN group default qlen 1000
    link/ether dc:a6:32:6d:46:cc brd ff:ff:ff:ff:ff:ff
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether dc:a6:32:6d:46:cd brd ff:ff:ff:ff:ff:ff
    inet 192.168.3.11/24 brd 192.168.3.255 scope global dynamic noprefixroute wlan0
       valid_lft 61449sec preferred_lft 61449sec
cq@rp4-mycont:~/CQ/NET $
```

リスト80（NET名前空間を分離してbashを起動しネットワーク・アドレスの状態を確認）

```
cq@rp4-mycont:~/CQ/NET $ sudo unshare --net bash
root@rp4-mycont:/home/cq/CQ/NET# echo $$
13316
root@rp4-mycont:/home/cq/CQ/NET# ip link set lo up
root@rp4-mycont:/home/cq/CQ/NET# ip addr
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
root@rp4-mycont:/home/cq/CQ/NET#
```

リスト81（再度名前空間一覧を確認）

```
cq@rp4-mycont:~/CQ/NET $ sudo lsns
        NS TYPE   NPROCS   PID USER             COMMAND
4026531834 time      204     1 root             /sbin/init splash
4026531835 cgroup    204     1 root             /sbin/init splash
4026531836 pid       204     1 root             /sbin/init splash
4026531837 user      204     1 root             /sbin/init splash
4026531838 uts       201     1 root             /sbin/init splash
4026531839 ipc       204     1 root             /sbin/init splash
4026531840 net       201     1 root             /sbin/init splash
4026531841 mnt       196     1 root             /sbin/init splash
4026532393 mnt         1   298 root              ├─/lib/systemd/systemd-udevd
4026532394 uts         1   298 root              ├─/lib/systemd/systemd-udevd
4026532468 mnt         1   487 systemd-timesync  ├─/lib/systemd/systemd-timesyncd
4026532478 uts         1   487 systemd-timesync  ├─/lib/systemd/systemd-timesyncd
4026532479 net         1   551 root              ├─/usr/libexec/accounts-daemon
4026532537 mnt         1   551 root              ├─/usr/libexec/accounts-daemon
4026532538 mnt         1   554 root              ├─/usr/libexec/bluetooth/bluetoothd
4026532539 net         1   965 rtkit             ├─/usr/libexec/rtkit-daemon
4026532598 mnt         1   573 root              ├─/lib/systemd/systemd-logind
4026532599 uts         1   573 root              ├─/lib/systemd/systemd-logind
4026532600 mnt         1   684 root              ├─/usr/sbin/NetworkManager --no-daemon
4026532661 mnt         1   704 root              └─/usr/sbin/ModemManager
4026531862 mnt         1    39 root             kdevtmpfs
4026532602 net         1 13316 root             bash
cq@rp4-mycont:~/CQ/NET $
```

リスト82（仮想Ethernetデバイスを作成しネットワーク・インターフェースの状態を確認）

```
cq@rp4-mycont:~/CQ/NET $ ip addr
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
2: eth0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN group default qlen 1000
    link/ether dc:a6:32:6d:46:cc brd ff:ff:ff:ff:ff:ff
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether dc:a6:32:6d:46:cd brd ff:ff:ff:ff:ff:ff
    inet 192.168.3.11/24 brd 192.168.3.255 scope global dynamic noprefixroute wlan0
       valid_lft 85699sec preferred_lft 85699sec
4: my-host-veth@my-ns-veth: <BROADCAST,MULTICAST,M-DOWN> mtu 1500 qdisc noop state DOWN group default qlen 1000
    link/ether 66:aa:1a:39:79:cd brd ff:ff:ff:ff:ff:ff
5: my-ns-veth@my-host-veth: <BROADCAST,MULTICAST,M-DOWN> mtu 1500 qdisc noop state DOWN group default qlen 1000
    link/ether 82:ec:34:25:4f:70 brd ff:ff:ff:ff:ff:ff
cq@rp4-mycont:~/CQ/NET $
```

リスト83（作成したNET名前空間にアクセスできるようにする）

```
cq@rp4-mycont:~/CQ/NET $ ip netns ls
cq@rp4-mycont:~/CQ/NET $ sudo mkdir -p /var/run/netns
cq@rp4-mycont:~/CQ/NET $ sudo ln -s /proc/13316/ns/net /var/run/netns/my-netns
cq@rp4-mycont:~/CQ/NET $ ip netns ls
my-netns
cq@rp4-mycont:~/CQ/NET $
```

リスト84（分離したNET名前空間に一端をつなげる操作）

```
sudo ip link set my-ns-veth netns my-netns
sudo ip netns exec my-netns ip link set my-ns-veth up
sudo ip link set my-host-veth up
sudo ip netns exec my-netns ip addr add 10.1.1.100/24 dev my-ns-veth
sudo ip addr add 10.1.1.10/24 dev my-host-veth
ip addr
```

リスト85（リスト84の実行結果）

```
cq@rp4-mycont:~/CQ/NET $ sudo ip link set my-ns-veth netns my-netns
cq@rp4-mycont:~/CQ/NET $ sudo ip netns exec my-netns ip link set my-ns-veth up
cq@rp4-mycont:~/CQ/NET $ sudo ip link set my-host-veth up
cq@rp4-mycont:~/CQ/NET $ sudo ip netns exec my-netns ip addr add 10.1.1.100/24 dev my-ns-veth
cq@rp4-mycont:~/CQ/NET $ sudo ip addr add 10.1.1.10/24 dev my-host-veth
cq@rp4-mycont:~/CQ/NET $ ip addr
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
2: eth0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN group default qlen 1000
    link/ether dc:a6:32:6d:46:cc brd ff:ff:ff:ff:ff:ff
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
```

```
    link/ether dc:a6:32:6d:46:cd brd ff:ff:ff:ff:ff:ff
    inet 192.168.3.11/24 brd 192.168.3.255 scope global dynamic noprefixroute wlan0
       valid_lft 85147sec preferred_lft 85147sec
4: my-host-veth@if5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 66:aa:1a:39:79:cd brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.1.1.10/24 scope global my-host-veth
       valid_lft forever preferred_lft forever
cq@rp4-mycont:~/CQ/NET $
```

リスト86（NET名前空間を分離したbashでインターフェースを確認）

```
root@rp4-mycont:/home/cq/CQ/NET# ip addr
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
5: my-ns-veth@if4: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 82:ec:34:25:4f:70 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.1.1.100/24 scope global my-ns-veth
       valid_lft forever preferred_lft forever
root@rp4-mycont:/home/cq/CQ/NET#
```

リスト87（分離したNET名前空間にアクセスできることを確認）

```
cq@rp4-mycont:~/CQ/NET $ ping 10.1.1.100
PING 10.1.1.100 (10.1.1.100) 56(84) bytes of data.
64 bytes from 10.1.1.100: icmp_seq=1 ttl=64 time=0.235 ms
64 bytes from 10.1.1.100: icmp_seq=2 ttl=64 time=0.133 ms
64 bytes from 10.1.1.100: icmp_seq=3 ttl=64 time=0.119 ms
64 bytes from 10.1.1.100: icmp_seq=4 ttl=64 time=0.121 ms
^C
--- 10.1.1.100 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3053ms
rtt min/avg/max/mdev = 0.119/0.152/0.235/0.048 ms
cq@rp4-mycont:~/CQ/NET $
```

リスト88（NET名前空間を分離したbashでWebサーバを起動）

```
mkdir -p web
echo "<html>Hello My Container</html>" > web/index.html
python3 -m http.server -d ./web 8000
```

リスト89（リスト88の実行結果）

```
root@rp4-mycont:/home/cq/CQ/NET# mkdir -p web
root@rp4-mycont:/home/cq/CQ/NET# echo "<html>Hello My Container</html>" > web/index.html
root@rp4-mycont:/home/cq/CQ/NET# python3 -m http.server -d ./web 8000
Serving HTTP on 0.0.0.0 port 8000 (http://0.0.0.0:8000/) ...
```

リスト90（分離したNET名前空間のWebサーバにアクセスする）

```
cq@rp4-mycont:~/CQ/NET $ curl -v http://10.1.1.100:8000
*   Trying 10.1.1.100:8000...
* Connected to 10.1.1.100 (10.1.1.100) port 8000 (#0)
> GET / HTTP/1.1
> Host: 10.1.1.100:8000
> User-Agent: curl/7.88.1
> Accept: */*
>
* HTTP 1.0, assume close after body
< HTTP/1.0 200 OK
< Server: SimpleHTTP/0.6 Python/3.11.2
< Date: Fri, 27 Sep 2024 00:40:30 GMT
< Content-type: text/html
< Content-Length: 32
< Last-Modified: Fri, 27 Sep 2024 00:39:26 GMT
<
<html>Hello My Container</html>
* Closing connection 0
cq@rp4-mycont:~/CQ/NET $
cq@rp4-mycont:~/CQ/NET $
```

リスト91（NET名前空間を分離したbashからホストへアクセスできることを確認）

```
root@rp4-mycont:/home/cq/CQ/NET# ping 10.1.1.10
PING 10.1.1.10 (10.1.1.10) 56(84) bytes of data.
64 bytes from 10.1.1.10: icmp_seq=1 ttl=64 time=0.152 ms
64 bytes from 10.1.1.10: icmp_seq=2 ttl=64 time=0.125 ms
64 bytes from 10.1.1.10: icmp_seq=3 ttl=64 time=0.128 ms
^C
--- 10.1.1.10 ping statistics ---
```

```
3 packets transmitted, 3 received, 0% packet loss, time 2051ms
rtt min/avg/max/mdev = 0.125/0.135/0.152/0.012 ms
root@rp4-mycont:/home/cq/CQ/NET#
```

リスト92（NET名前空間を分離したbashからホストの無線LANネットワーク側のIPアドレスへアクセスを確認）

```
root@rp4-mycont:/home/cq/CQ/NET# ping 192.168.3.11
ping: connect: Network is unreachable
```

リスト93（仮想ブリッジの作成）

```
cq@rp4-mycont:~/CQ/NET $ sudo ip link add name mybr type bridge
cq@rp4-mycont:~/CQ/NET $ sudo ip link set dev mybr up
cq@rp4-mycont:~/CQ/NET $ 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: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN mode DEFAULT group default qlen 1000
    link/ether dc:a6:32:6d:46:cc brd ff:ff:ff:ff:ff:ff
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP mode DORMANT group default qlen 1000
    link/ether dc:a6:32:6d:46:cd brd ff:ff:ff:ff:ff:ff
4: my-host-veth@if5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP mode DEFAULT group default qlen 1000
    link/ether 66:aa:1a:39:79:cd brd ff:ff:ff:ff:ff:ff link-netnsid 0
6: mybr: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UNKNOWN mode DEFAULT group default qlen 1000
    link/ether 96:8d:b3:37:14:84 brd ff:ff:ff:ff:ff:ff
cq@rp4-mycont:~/CQ/NET $
```

リスト94（仮想Ethrnetデバイスのホスト側の端点を仮想ブリッジに繋ぐ）

```
sudo ip addr delete 10.1.1.10/24 dev my-host-veth
sudo ip link set dev my-host-veth master mybr
sudo ip addr add 10.1.1.10/24 broadcast 10.1.1.255 label mybr dev mybr
sudo ip netns exec my-netns ip route add default via 10.1.1.10
```

リスト95（リスト94の実行結果）

```
cq@rp4-mycont:~/CQ/NET $ sudo ip addr delete 10.1.1.10/24 dev my-host-veth
cq@rp4-mycont:~/CQ/NET $ sudo ip link set dev my-host-veth master mybr
cq@rp4-mycont:~/CQ/NET $ sudo ip addr add 10.1.1.10/24 broadcast 10.1.1.255 label mybr dev mybr
cq@rp4-mycont:~/CQ/NET $ sudo ip netns exec my-netns ip route add default via 10.1.1.10
cq@rp4-mycont:~/CQ/NET $ ip addr
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
2: eth0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc mq state DOWN group default qlen 1000
    link/ether dc:a6:32:6d:46:cc brd ff:ff:ff:ff:ff:ff
3: wlan0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether dc:a6:32:6d:46:cd brd ff:ff:ff:ff:ff:ff
    inet 192.168.3.11/24 brd 192.168.3.255 scope global dynamic noprefixroute wlan0
       valid_lft 83963sec preferred_lft 83963sec
4: my-host-veth@if5: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master mybr state UP group default qlen 1000
    link/ether 66:aa:1a:39:79:cd brd ff:ff:ff:ff:ff:ff link-netnsid 0
6: mybr: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 66:aa:1a:39:79:cd brd ff:ff:ff:ff:ff:ff
    inet 10.1.1.10/24 brd 10.1.1.255 scope global mybr
       valid_lft forever preferred_lft forever
cq@rp4-mycont:~/CQ/NET $
```

リスト96（NET名前空間を分離したbashからホストへアクセスできるか確認）

```
root@rp4-mycont:/home/cq/CQ/NET# ip addr
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
5: my-ns-veth@if4: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP group default qlen 1000
    link/ether 82:ec:34:25:4f:70 brd ff:ff:ff:ff:ff:ff link-netnsid 0
    inet 10.1.1.100/24 scope global my-ns-veth
       valid_lft forever preferred_lft forever
root@rp4-mycont:/home/cq/CQ/NET# ip route                                    ★今度はルーティング設定があります.
default via 10.1.1.10 dev my-ns-veth
10.1.1.0/24 dev my-ns-veth proto kernel scope link src 10.1.1.100
root@rp4-mycont:/home/cq/CQ/NET#
root@rp4-mycont:/home/cq/CQ/NET# ping 10.1.1.10
PING 10.1.1.10 (10.1.1.10) 56(84) bytes of data.
64 bytes from 10.1.1.10: icmp_seq=1 ttl=64 time=0.269 ms
64 bytes from 10.1.1.10: icmp_seq=2 ttl=64 time=0.148 ms
64 bytes from 10.1.1.10: icmp_seq=3 ttl=64 time=0.144 ms
^C
--- 10.1.1.10 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2050ms
rtt min/avg/max/mdev = 0.144/0.187/0.269/0.058 ms
root@rp4-mycont:/home/cq/CQ/NET#
```

リスト97（NET名前空間を分離したbashからホスト・ネットワークへのアクセスを確認）

```
root@rp4-mycont:/home/cq/CQ/NET# ping 10.1.1.10
PING 10.1.1.10 (10.1.1.10) 56(84) bytes of data.
64 bytes from 10.1.1.10: icmp_seq=1 ttl=64 time=0.269 ms
64 bytes from 10.1.1.10: icmp_seq=2 ttl=64 time=0.148 ms
64 bytes from 10.1.1.10: icmp_seq=3 ttl=64 time=0.144 ms
^C
--- 10.1.1.10 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2050ms
rtt min/avg/max/mdev = 0.144/0.187/0.269/0.058 ms
root@rp4-mycont:/home/cq/CQ/NET#
root@rp4-mycont:/home/cq/CQ/NET# ping 192.168.3.11
PING 192.168.3.11 (192.168.3.11) 56(84) bytes of data.
64 bytes from 192.168.3.11: icmp_seq=1 ttl=64 time=0.140 ms
64 bytes from 192.168.3.11: icmp_seq=2 ttl=64 time=0.146 ms
64 bytes from 192.168.3.11: icmp_seq=3 ttl=64 time=0.156 ms
64 bytes from 192.168.3.11: icmp_seq=4 ttl=64 time=0.147 ms
^C
--- 192.168.3.11 ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3071ms
rtt min/avg/max/mdev = 0.140/0.147/0.156/0.005 ms
root@rp4-mycont:/home/cq/CQ/NET#
```

リスト98（natという名前でテーブルを作成する）

```
sudo nft flush ruleset
sudo nft add table nat
sudo nft -a list ruleset
```

リスト99（リスト98の実行結果）

```
cq@rp4-mycont:~/CQ/NET $ sudo nft flush ruleset
cq@rp4-mycont:~/CQ/NET $
cq@rp4-mycont:~/CQ/NET $ sudo nft add table nat
cq@rp4-mycont:~/CQ/NET $ sudo nft -a list ruleset
table ip nat { # handle 1
}
```

リスト100（テーブルにチェーンを作成する）

```
sudo nft 'add chain nat postrouting { type nat hook postrouting priority 100 ; }'
sudo nft 'add chain nat prerouting { type nat hook prerouting priority -100; }'
sudo nft -a list ruleset
```

リスト101（リスト100の実行結果）

```
cq@rp4-mycont:~/CQ/NET $ sudo nft 'add chain nat postrouting { type nat hook postrouting priority 100 ; }'
cq@rp4-mycont:~/CQ/NET $ sudo nft 'add chain nat prerouting { type nat hook prerouting priority -100; }'
cq@rp4-mycont:~/CQ/NET $ sudo nft -a list ruleset
table ip nat { # handle 1
        chain postrouting { # handle 1
                type nat hook postrouting priority srcnat; policy accept;
        }

        chain prerouting { # handle 2
                type nat hook prerouting priority dstnat; policy accept;
        }
}
```

リスト102（ポートフォワードのルールを登録する）

```
sudo nft add rule nat prerouting tcp dport { 8888 } dnat 10.1.1.100:8000
sudo nft add rule nat postrouting masquerade
sudo nft -a list ruleset
```

リスト103（リスト102の実行結果）

```
cq@rp4-mycont:~/CQ/NET $ sudo nft add rule nat prerouting tcp dport { 8888 } dnat 10.1.1.100:8000
cq@rp4-mycont:~/CQ/NET $ sudo nft add rule nat postrouting masquerade
cq@rp4-mycont:~/CQ/NET $ sudo nft -a list ruleset
table ip nat { # handle 1
        chain postrouting { # handle 1
                type nat hook postrouting priority srcnat; policy accept;
                masquerade # handle 8
        }

        chain prerouting { # handle 2
                type nat hook prerouting priority dstnat; policy accept;
```

```
                                                          S2_list.txt
                tcp dport 8888 dnat to 10.1.1.100:8000 # handle 5
        }
}
```

リスト104（分離したNET名前空間のWebサーバにアクセスする）

```
(base) tsuchiya@macbook CQ ゼロから作るコンテナ % curl -v http://192.168.3.11:8888
*   Trying 192.168.3.11:8888...
* Connected to 192.168.3.11 (192.168.3.11) port 8888 (#0)
> GET / HTTP/1.1
> Host: 192.168.3.11:8888
> User-Agent: curl/7.78.0
> Accept: */*
>
* Mark bundle as not supporting multiuse
* HTTP 1.0, assume close after body
< HTTP/1.0 200 OK
< Server: SimpleHTTP/0.6 Python/3.11.2
< Date: Fri, 27 Sep 2024 00:57:57 GMT
< Content-type: text/html
< Content-Length: 32
< Last-Modified: Fri, 27 Sep 2024 00:39:26 GMT
<
<html>Hello My Container</html>
* Closing connection 0
(base) tsuchiya@macbook CQ ゼロから作るコンテナ %
```

リスト105（NET名前空間を分離したbashからインターネットにアクセスする）

```
root@rp4-mycont:/home/cq/CQ/NET# ping www.yahoo.co.jp
PING edge12.g.yimg.jp (182.22.25.124) 56(84) bytes of data.
64 bytes from 182.22.25.124 (182.22.25.124): icmp_seq=1 ttl=58 time=5.89 ms
64 bytes from 182.22.25.124 (182.22.25.124): icmp_seq=2 ttl=58 time=9.72 ms
64 bytes from 182.22.25.124 (182.22.25.124): icmp_seq=3 ttl=58 time=9.02 ms
64 bytes from 182.22.25.124 (182.22.25.124): icmp_seq=4 ttl=58 time=9.80 ms
^C
--- edge12.g.yimg.jp ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 5.887/8.607/9.802/1.599 ms
root@rp4-mycont:/home/cq/CQ/NET#
```