Application Confinement with User namespaces

Serge Hallyn, Scott Moser

Canonical, Inc

serge.hallyn@ubuntu.com, scott.moser@canonical.com

October 30, 2014

Overview

1. Quick Introduction to Containers
2. State of Containers Prior to User namespaces
3. User namespaces
4. Graphical Demo

Linux Containers?

- operating system-level virtualization method for running multiple isolated Linux systems (containers) on a single control host.
- "chroot on steroids"
- "it's like bsd jails" (or solaris zones)
- from the inside looks like a vm
- from the outside looks like processes

Containers prior to user namespaces

Namespaces

- *id* → *resource* mapping
  - Prevent resource access by not providing a handle
  - i.e. pid 1 is not global init
  - `/etc/shadow` not accessible
- Many leaks (`/proc/pid/fd/N`

Control groups

1. Resource limits and accounting
2. Limit device access
3. If root, re-mount cgroups and change/escape limits.

Capabilities bounding set

1. Limit privs of root in container
2. Root still owns most host files
3. http://www.sevagas.com/IMG/pdf/exploiting_capabilities_the_dark_side.pdf
4. Prevents useful things like tmpfs mounts

LSMs

1. Paper of the (huge) remaining holes
2. i.e. prevent `/proc/sys/*` writing, etc
3. "Safe from accidental damage by container root"
4. People always want unsafe exceptions
5. Lack of policy nesting limits use *in* containers

Seccomp

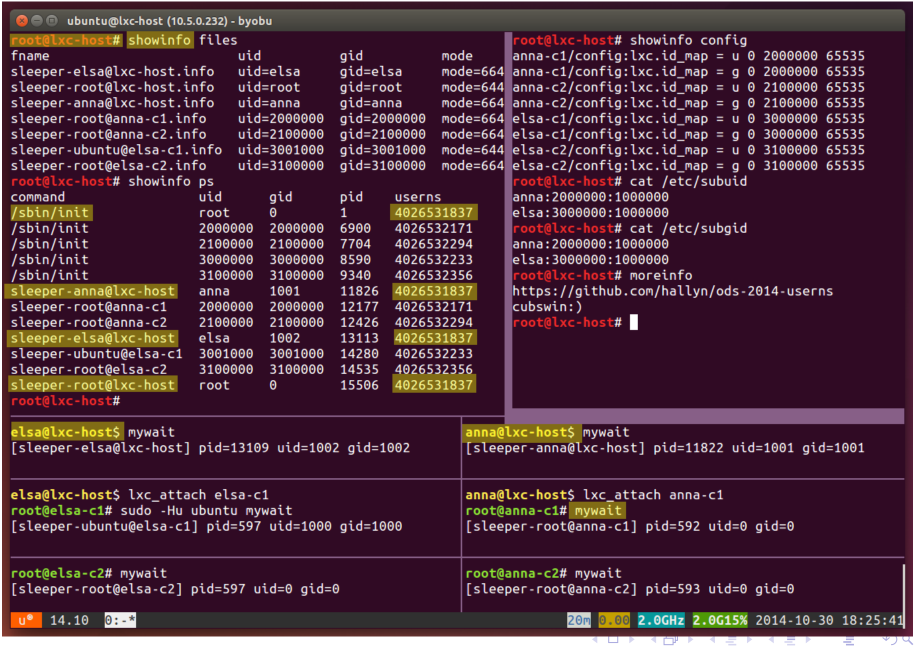
1. Prevent use of some syscalls
2. Reduce exposed kernel surface
3. Hard to do generally

1. Nevertheless
    1. Root in container is still root on host
    2. Any leak = game over
    3. Answer: "Wait for user namespaces"

Demo Time [sort of].

1. Ubuntu 14.10 instance with hostname 'lxc-host'.
2. 2 users (elsa, anna) are each configured to run lxc unprivileged.
3. 'showinfo': simple shell filter to 'find' or 'ps' or 'grep'.
4. 'mywait': Very Exciting. Run it, it prints its pid, uid, gid. Then creates a file named 'sleeper-user@hostname' and sleeps forever. copied into each container's /usr/local/bin.

Host Processes / Users.



```
root@lxc-host# showinfo files
fname                        uid          gid          mode
sleeper-elsa@lxc-host.info   uid=elsa     gid=elsa     mode=664
sleeper-root@lxc-host.info   uid=root     gid=root     mode=644
sleeper-anna@lxc-host.info   uid=anna     gid=anna     mode=664
sleeper-root@anna-c1.info    uid=2000000  gid=2000000  mode=664
sleeper-root@anna-c2.info    uid=2100000  gid=2100000  mode=664
sleeper-ubuntu@elsa-c1.info  uid=3001000  gid=3001000  mode=644
sleeper-root@elsa-c2.info    uid=3100000  gid=3100000  mode=664
root@lxc-host# showinfo ps
command                 uid      gid      pid      userns
/sbin/init              root     0        1        4026531837
/sbin/init              2000000  2000000  6900     4026532171
/sbin/init              2100000  2100000  7704     4026532294
/sbin/init              3000000  3000000  8590     4026532233
/sbin/init              3100000  3100000  9340     4026532356
sleeper-anna@lxc-host   anna     1001     11826    4026531837
sleeper-root@anna-c1    2000000  2000000  12177    4026532171
sleeper-root@anna-c2    2100000  2100000  12426    4026532294
sleeper-elsa@lxc-host   elsa     1002     13113    4026531837
sleeper-ubuntu@elsa-c1  3001000  3001000  14280    4026532233
sleeper-root@elsa-c2    3100000  3100000  14535    4026532356
sleeper-root@lxc-host   root     0        15506    4026531837
root@lxc-host#
```

```
root@lxc-host# showinfo config
anna-c1/config:lxc.id_map = u 0 2000000 65535
anna-c1/config:lxc.id_map = g 0 2000000 65535
anna-c2/config:lxc.id_map = u 0 2100000 65535
anna-c2/config:lxc.id_map = g 0 2100000 65535
elsa-c1/config:lxc.id_map = u 0 3000000 65535
elsa-c1/config:lxc.id_map = g 0 3000000 65535
elsa-c2/config:lxc.id_map = u 0 3100000 65535
elsa-c2/config:lxc.id_map = g 0 3100000 65535
root@lxc-host# cat /etc/subuid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# cat /etc/subgid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# moreinfo
https://github.com/hallyn/ods-2014-userns
cubswin:)
root@lxc-host# 
```

```
elsa@lxc-host$ mywait
[sleeper-elsa@lxc-host] pid=13109 uid=1002 gid=1002
```

```
anna@lxc-host$ mywait
[sleeper-anna@lxc-host] pid=11822 uid=1001 gid=1001
```

```
elsa@lxc-host$ lxc_attach elsa-c1
root@elsa-c1# sudo -Hu ubuntu mywait
[sleeper-ubuntu@elsa-c1] pid=597 uid=1000 gid=1000
```

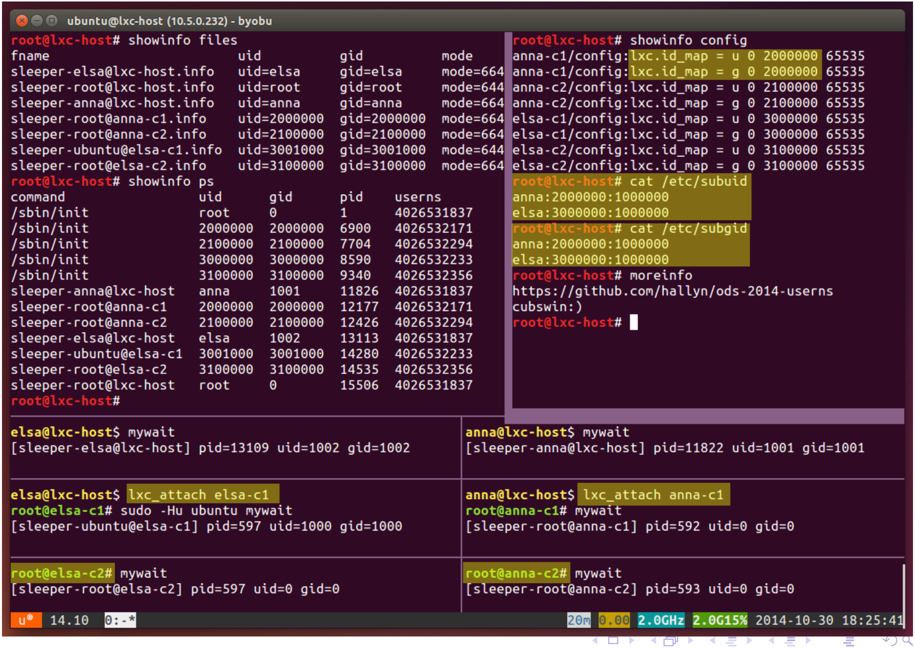
```
anna@lxc-host$ lxc_attach anna-c1
root@anna-c1# mywait
[sleeper-root@anna-c1] pid=592 uid=0 gid=0
```

```
root@elsa-c2# mywait
[sleeper-root@elsa-c2] pid=597 uid=0 gid=0
```

```
root@anna-c2# mywait
[sleeper-root@anna-c2] pid=593 uid=0 gid=0
```

```
u°  14.10  0:-*                    20m 0.00 2.0GHz 2.0G15% 2014-10-30 18:25:41
```

LXC Containers and Configuration



```
root@lxc-host# showinfo files
fname                        uid          gid          mode
sleeper-elsa@lxc-host.info   uid=elsa     gid=elsa     mode=664
sleeper-root@lxc-host.info   uid=root     gid=root     mode=644
sleeper-anna@lxc-host.info   uid=anna     gid=anna     mode=664
sleeper-root@anna-c1.info    uid=2000000  gid=2000000  mode=664
sleeper-root@anna-c2.info    uid=2100000  gid=2100000  mode=664
sleeper-ubuntu@elsa-c1.info  uid=3001000  gid=3001000  mode=644
sleeper-root@elsa-c2.info    uid=3100000  gid=3100000  mode=664
root@lxc-host# showinfo ps
command                  uid      gid      pid     userns
/sbin/init               root     0        1       4026531837
/sbin/init               2000000  2000000  6900    4026532171
/sbin/init               2100000  2100000  7704    4026532294
/sbin/init               3000000  3000000  8590    4026532233
/sbin/init               3100000  3100000  9340    4026532356
sleeper-anna@lxc-host    anna     1001     11826   4026531837
sleeper-root@anna-c1     2000000  2000000  12177   4026532171
sleeper-root@anna-c2     2100000  2100000  12426   4026532294
sleeper-elsa@lxc-host    elsa     1002     13113   4026531837
sleeper-ubuntu@elsa-c1   3001000  3001000  14280   4026532233
sleeper-root@elsa-c2     3100000  3100000  14535   4026532356
sleeper-root@lxc-host    root     0        15506   4026531837
root@lxc-host#
```

```
root@lxc-host# showinfo config
anna-c1/config:lxc.id_map = u 0 2000000 65535
anna-c1/config:lxc.id_map = g 0 2000000 65535
anna-c2/config:lxc.id_map = u 0 2100000 65535
anna-c2/config:lxc.id_map = g 0 2100000 65535
elsa-c1/config:lxc.id_map = u 0 3000000 65535
elsa-c1/config:lxc.id_map = g 0 3000000 65535
elsa-c2/config:lxc.id_map = u 0 3100000 65535
elsa-c2/config:lxc.id_map = g 0 3100000 65535
root@lxc-host# cat /etc/subuid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# cat /etc/subgid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# moreinfo
https://github.com/hallyn/ods-2014-userns
cubswin:)
root@lxc-host#
```

```
elsa@lxc-host$ mywait
[sleeper-elsa@lxc-host] pid=13109 uid=1002 gid=1002
```

```
anna@lxc-host$ mywait
[sleeper-anna@lxc-host] pid=11822 uid=1001 gid=1001
```

```
elsa@lxc-host$ lxc_attach elsa-c1
root@elsa-c1# sudo -Hu ubuntu mywait
[sleeper-ubuntu@elsa-c1] pid=597 uid=1000 gid=1000
```

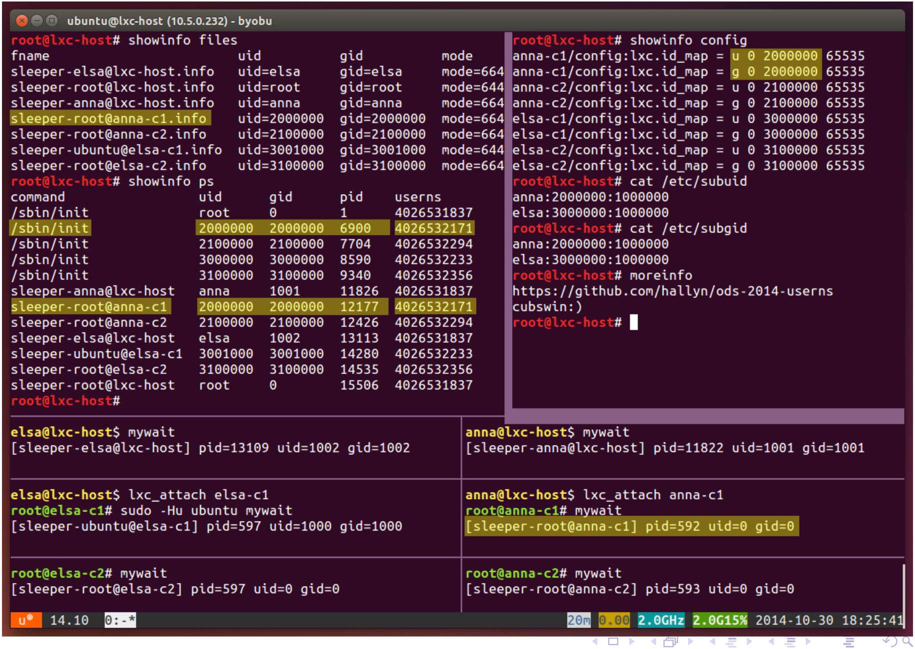
```
anna@lxc-host$ lxc_attach anna-c1
root@anna-c1# mywait
[sleeper-root@anna-c1] pid=592 uid=0 gid=0
```

```
root@elsa-c2# mywait
[sleeper-root@elsa-c2] pid=597 uid=0 gid=0
```

```
root@anna-c2# mywait
[sleeper-root@anna-c2] pid=593 uid=0 gid=0
```

```
u°  14.10  0:-*                 20m 0.00 2.0GHz 2.0G15% 2014-10-30 18:25:41
```

Anna's containers: **anna-c1**, anna-c2



```
root@lxc-host# showinfo files
fname                        uid          gid          mode
sleeper-elsa@lxc-host.info   uid=elsa     gid=elsa     mode=664
sleeper-root@lxc-host.info   uid=root     gid=root     mode=644
sleeper-anna@lxc-host.info   uid=anna     gid=anna     mode=664
sleeper-root@anna-c1.info    uid=2000000  gid=2000000  mode=664
sleeper-root@anna-c2.info    uid=2100000  gid=2100000  mode=664
sleeper-ubuntu@elsa-c1.info  uid=3001000  gid=3001000  mode=644
sleeper-root@elsa-c2.info    uid=3100000  gid=3100000  mode=664
root@lxc-host# showinfo ps
command                 uid      gid      pid    userns
/sbin/init              root     0        1      4026531837
/sbin/init              2000000  2000000  6900   4026532171
/sbin/init              2100000  2100000  7704   4026532294
/sbin/init              3000000  3000000  8590   4026532233
/sbin/init              3100000  3100000  9340   4026532356
sleeper-anna@lxc-host   anna     1001     11826  4026531837
sleeper-root@anna-c1    2000000  2000000  12177  4026532171
sleeper-root@anna-c2    2100000  2100000  12426  4026532294
sleeper-elsa@lxc-host   elsa     1002     13113  4026531837
sleeper-ubuntu@elsa-c1  3001000  3001000  14280  4026532233
sleeper-root@elsa-c2    3100000  3100000  14535  4026532356
sleeper-root@lxc-host   root     0        15506  4026531837
root@lxc-host#
```

```
root@lxc-host# showinfo config
anna-c1/config:lxc.id_map = u 0 2000000 65535
anna-c1/config:lxc.id_map = g 0 2000000 65535
anna-c2/config:lxc.id_map = u 0 2100000 65535
anna-c2/config:lxc.id_map = g 0 2100000 65535
elsa-c1/config:lxc.id_map = u 0 3000000 65535
elsa-c1/config:lxc.id_map = g 0 3000000 65535
elsa-c2/config:lxc.id_map = u 0 3100000 65535
elsa-c2/config:lxc.id_map = g 0 3100000 65535
root@lxc-host# cat /etc/subuid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# cat /etc/subgid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# moreinfo
https://github.com/hallyn/ods-2014-userns
cubswin:)
root@lxc-host#
```

```
elsa@lxc-host$ mywait
[sleeper-elsa@lxc-host] pid=13109 uid=1002 gid=1002
```

```
anna@lxc-host$ mywait
[sleeper-anna@lxc-host] pid=11822 uid=1001 gid=1001
```

```
elsa@lxc-host$ lxc_attach elsa-c1
root@elsa-c1# sudo -Hu ubuntu mywait
[sleeper-ubuntu@elsa-c1] pid=597 uid=1000 gid=1000
```

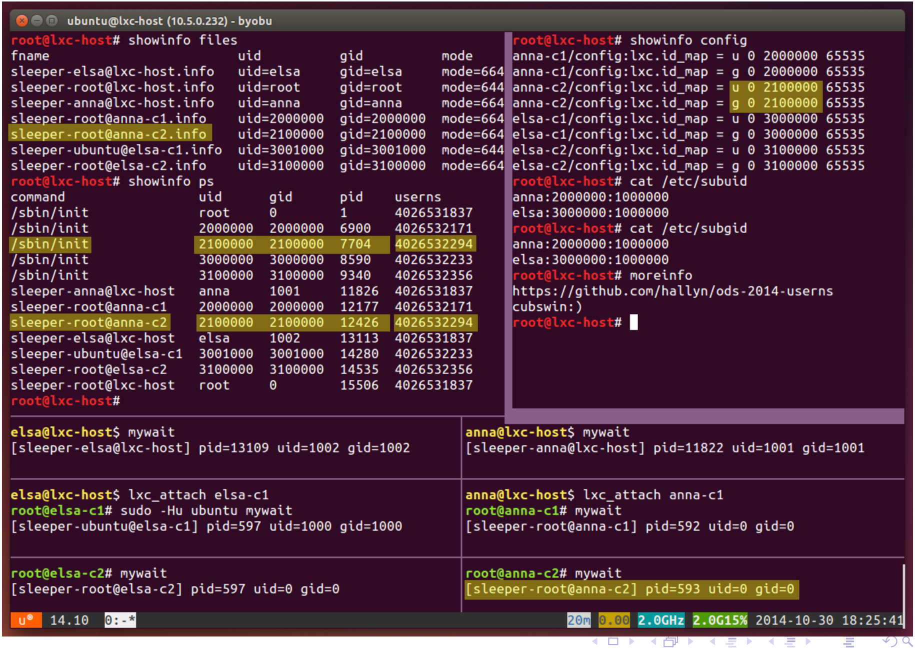
```
anna@lxc-host$ lxc_attach anna-c1
root@anna-c1# mywait
[sleeper-root@anna-c1] pid=592 uid=0 gid=0
```

```
root@elsa-c2# mywait
[sleeper-root@elsa-c2] pid=597 uid=0 gid=0
```

```
root@anna-c2# mywait
[sleeper-root@anna-c2] pid=593 uid=0 gid=0
```

```
u  14.10  0:-*                    20m 0.00 2.0GHz 2.0G15% 2014-10-30 18:25:41
```

Anna's containers: anna-c1, **anna-c2**



```
root@lxc-host# showinfo files
fname                        uid          gid          mode
sleeper-elsa@lxc-host.info   uid=elsa     gid=elsa     mode=664
sleeper-root@lxc-host.info   uid=root     gid=root     mode=644
sleeper-anna@lxc-host.info   uid=anna     gid=anna     mode=664
sleeper-root@anna-c1.info    uid=2000000  gid=2000000  mode=664
sleeper-root@anna-c2.info    uid=2100000  gid=2100000  mode=664
sleeper-ubuntu@elsa-c1.info  uid=3001000  gid=3001000  mode=644
sleeper-root@elsa-c2.info    uid=3100000  gid=3100000  mode=664
root@lxc-host# showinfo ps
command                 uid      gid      pid    userns
/sbin/init              root     0        1      4026531837
/sbin/init              2000000  2000000  6900   4026532171
/sbin/init              2100000  2100000  7704   4026532294
/sbin/init              3000000  3000000  8590   4026532233
/sbin/init              3100000  3100000  9340   4026532356
sleeper-anna@lxc-host   anna     1001     11826  4026531837
sleeper-root@anna-c1    2000000  2000000  12177  4026532171
sleeper-root@anna-c2    2100000  2100000  12426  4026532294
sleeper-elsa@lxc-host   elsa     1002     13113  4026531837
sleeper-ubuntu@elsa-c1  3001000  3001000  14280  4026532233
sleeper-root@elsa-c2    3100000  3100000  14535  4026532356
sleeper-root@lxc-host   root     0        15506  4026531837
root@lxc-host#
```

```
root@lxc-host# showinfo config
anna-c1/config:lxc.id_map = u 0 2000000 65535
anna-c1/config:lxc.id_map = g 0 2000000 65535
anna-c2/config:lxc.id_map = u 0 2100000 65535
anna-c2/config:lxc.id_map = g 0 2100000 65535
elsa-c1/config:lxc.id_map = u 0 3000000 65535
elsa-c1/config:lxc.id_map = g 0 3000000 65535
elsa-c2/config:lxc.id_map = u 0 3100000 65535
elsa-c2/config:lxc.id_map = g 0 3100000 65535
root@lxc-host# cat /etc/subuid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# cat /etc/subgid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# moreinfo
https://github.com/hallyn/ods-2014-userns
cubswin:)
root@lxc-host#
```

```
elsa@lxc-host$ mywait
[sleeper-elsa@lxc-host] pid=13109 uid=1002 gid=1002
```

```
anna@lxc-host$ mywait
[sleeper-anna@lxc-host] pid=11822 uid=1001 gid=1001
```

```
elsa@lxc-host$ lxc_attach elsa-c1
root@elsa-c1# sudo -Hu ubuntu mywait
[sleeper-ubuntu@elsa-c1] pid=597 uid=1000 gid=1000
```

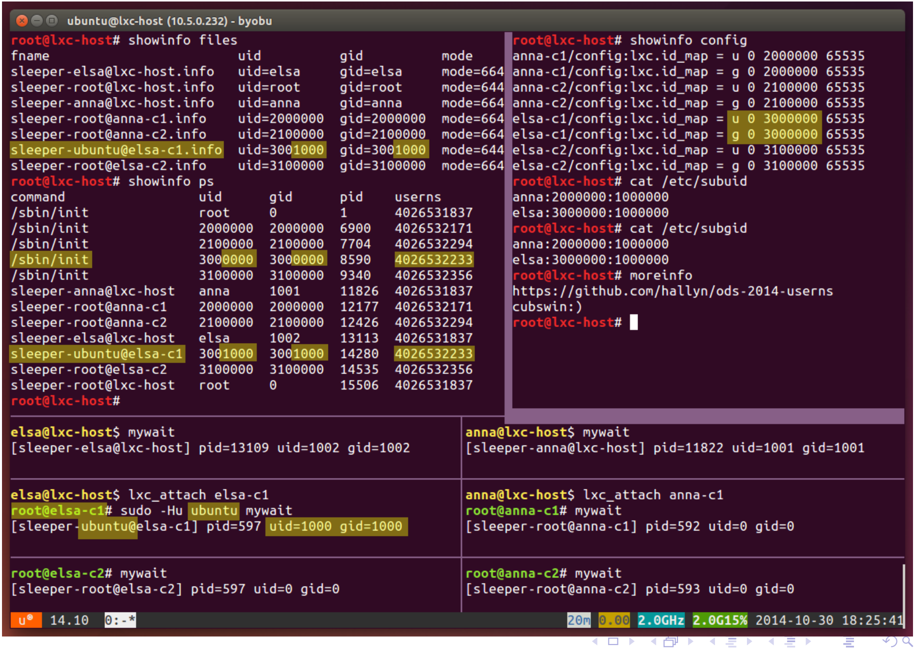
```
anna@lxc-host$ lxc_attach anna-c1
root@anna-c1# mywait
[sleeper-root@anna-c1] pid=592 uid=0 gid=0
```

```
root@elsa-c2# mywait
[sleeper-root@elsa-c2] pid=597 uid=0 gid=0
```

```
root@anna-c2# mywait
[sleeper-root@anna-c2] pid=593 uid=0 gid=0
```

```
u® 14.10 0:-*                20m 0.00 2.0GHz 2.0G15% 2014-10-30 18:25:41
```

Elsa's Containers: **elsa-c1**, elsa-c2



```
root@lxc-host# showinfo files
fname                        uid          gid          mode
sleeper-elsa@lxc-host.info   uid=elsa     gid=elsa     mode=664
sleeper-root@lxc-host.info   uid=root     gid=root     mode=644
sleeper-anna@lxc-host.info   uid=anna     gid=anna     mode=664
sleeper-root@anna-c1.info    uid=2000000  gid=2000000  mode=664
sleeper-root@anna-c2.info    uid=2100000  gid=2100000  mode=664
sleeper-ubuntu@elsa-c1.info  uid=3001000  gid=3001000  mode=644
sleeper-root@elsa-c2.info    uid=3100000  gid=3100000  mode=664
root@lxc-host# showinfo ps
command                 uid      gid      pid    userns
/sbin/init              root     0        1      4026531837
/sbin/init              2000000  2000000  6900   4026532171
/sbin/init              2100000  2100000  7704   4026532294
/sbin/init              3000000  3000000  8590   4026532233
/sbin/init              3100000  3100000  9340   4026532356
sleeper-anna@lxc-host   anna     1001     11826  4026531837
sleeper-root@anna-c1    2000000  2000000  12177  4026532171
sleeper-root@anna-c2    2100000  2100000  12426  4026532294
sleeper-elsa@lxc-host   elsa     1002     13113  4026531837
sleeper-ubuntu@elsa-c1  3001000  3001000  14280  4026532233
sleeper-root@elsa-c2    3100000  3100000  14535  4026532356
sleeper-root@lxc-host   root     0        15506  4026531837
root@lxc-host#
```

```
root@lxc-host# showinfo config
anna-c1/config:lxc.id_map = u 0 2000000 65535
anna-c1/config:lxc.id_map = g 0 2000000 65535
anna-c2/config:lxc.id_map = u 0 2100000 65535
anna-c2/config:lxc.id_map = g 0 2100000 65535
elsa-c1/config:lxc.id_map = u 0 3000000 65535
elsa-c1/config:lxc.id_map = g 0 3000000 65535
elsa-c2/config:lxc.id_map = u 0 3100000 65535
elsa-c2/config:lxc.id_map = g 0 3100000 65535
root@lxc-host# cat /etc/subuid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# cat /etc/subgid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# moreinfo
https://github.com/hallyn/ods-2014-userns
cubswin:)
root@lxc-host# █
```

```
elsa@lxc-host$ mywait
[sleeper-elsa@lxc-host] pid=13109 uid=1002 gid=1002
```

```
anna@lxc-host$ mywait
[sleeper-anna@lxc-host] pid=11822 uid=1001 gid=1001
```

```
elsa@lxc-host$ lxc_attach elsa-c1
root@elsa-c1# sudo -Hu ubuntu mywait
[sleeper-ubuntu@elsa-c1] pid=597 uid=1000 gid=1000
```

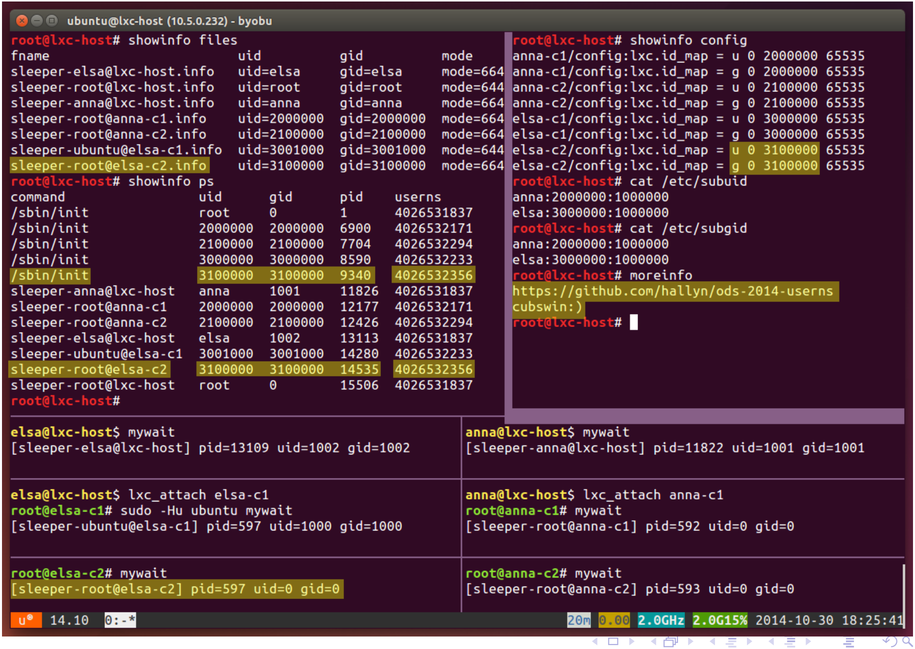
```
anna@lxc-host$ lxc_attach anna-c1
root@anna-c1# mywait
[sleeper-root@anna-c1] pid=592 uid=0 gid=0
```

```
root@elsa-c2# mywait
[sleeper-root@elsa-c2] pid=597 uid=0 gid=0
```

```
root@anna-c2# mywait
[sleeper-root@anna-c2] pid=593 uid=0 gid=0
```

```
u  14.10  0:-*                          20m 0.00 2.0GHz 2.0G15% 2014-10-30 18:25:41
```

Elsa's Containers: elsa-c1, **elsa-c2**



```
root@lxc-host# showinfo files
fname                        uid           gid           mode
sleeper-elsa@lxc-host.info   uid=elsa      gid=elsa      mode=664
sleeper-root@lxc-host.info   uid=root      gid=root      mode=644
sleeper-anna@lxc-host.info   uid=anna      gid=anna      mode=664
sleeper-root@anna-c1.info    uid=2000000   gid=2000000   mode=664
sleeper-root@anna-c2.info    uid=2100000   gid=2100000   mode=664
sleeper-ubuntu@elsa-c1.info  uid=3001000   gid=3001000   mode=644
sleeper-root@elsa-c2.info    uid=3100000   gid=3100000   mode=664
root@lxc-host# showinfo ps
command                 uid      gid      pid     userns
/sbin/init              root     0        1       4026531837
/sbin/init              2000000  2000000  6900    4026532171
/sbin/init              2100000  2100000  7704    4026532294
/sbin/init              3000000  3000000  8590    4026532233
/sbin/init              3100000  3100000  9340    4026532356
sleeper-anna@lxc-host   anna     1001     11826   4026531837
sleeper-root@anna-c1    2000000  2000000  12177   4026532171
sleeper-root@anna-c2    2100000  2100000  12426   4026532294
sleeper-elsa@lxc-host   elsa     1002     13113   4026531837
sleeper-ubuntu@elsa-c1  3001000  3001000  14280   4026532233
sleeper-root@elsa-c2    3100000  3100000  14535   4026532356
sleeper-root@lxc-host   root     0        15506   4026531837
root@lxc-host#
```

```
root@lxc-host# showinfo config
anna-c1/config:lxc.id_map = u 0 2000000 65535
anna-c1/config:lxc.id_map = g 0 2000000 65535
anna-c2/config:lxc.id_map = u 0 2100000 65535
anna-c2/config:lxc.id_map = g 0 2100000 65535
elsa-c1/config:lxc.id_map = u 0 3000000 65535
elsa-c1/config:lxc.id_map = g 0 3000000 65535
elsa-c2/config:lxc.id_map = u 0 3100000 65535
elsa-c2/config:lxc.id_map = g 0 3100000 65535
root@lxc-host# cat /etc/subuid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# cat /etc/subgid
anna:2000000:1000000
elsa:3000000:1000000
root@lxc-host# moreinfo
https://github.com/hallyn/ods-2014-userns
cubswin:)
root@lxc-host# 
```

```
elsa@lxc-host$ mywait
[sleeper-elsa@lxc-host] pid=13109 uid=1002 gid=1002
```

```
anna@lxc-host$ mywait
[sleeper-anna@lxc-host] pid=11822 uid=1001 gid=1001
```

```
elsa@lxc-host$ lxc_attach elsa-c1
root@elsa-c1# sudo -Hu ubuntu mywait
[sleeper-ubuntu@elsa-c1] pid=597 uid=1000 gid=1000
```

```
anna@lxc-host$ lxc_attach anna-c1
root@anna-c1# mywait
[sleeper-root@anna-c1] pid=592 uid=0 gid=0
```

```
root@elsa-c2# mywait
[sleeper-root@elsa-c2] pid=597 uid=0 gid=0
```

```
root@anna-c2# mywait
[sleeper-root@anna-c2] pid=593 uid=0 gid=0
```

```
u°  14.10  0:-*                          20m 0.00 2.0GHz 2.0G15% 2014-10-30 18:25:41
```

User namespaces

Goals

1. Uid separation
    1. c1.500 != c2.500
    2. Separate access controls (kill, open, etc)
    3. Separate accounting, limits
2. Container root privileged over container
    1. uids
    2. network
    3. etc
3. Container root has no privilege outside of container
    1. Root in container as safe as unpriv user on host
    2. Safe for use by untrusted users
4. Able to be nested

User namespace design

1. By Eric Biederman
2. Uids map 1-1 to kuids
    1. Translated at kernel-user boundary
    2. Default mapping 0-4294967295:0-4294967295
    3. Unmapped userids show up as -1, has ‘o’ perms
    4. Unpriv user can only map own host uid
3. Other namespaces owned by a user ns
    1. Root in ns has full privilege over what it owns

Uid delegation

1. Root delegates *subuids* to users
   1. /etc/subuid and /etc/subgid: serge:100000:65536
   2. Set using usermod: usermod -v 100000-200000 -w 100000-200000 serge
2. Setuid-root programs write to /proc/self/{ug}id_map
3. Each user may be delegated a set of subuids and subgids