Rootless Containers in Gitpod

CNCF Webinar

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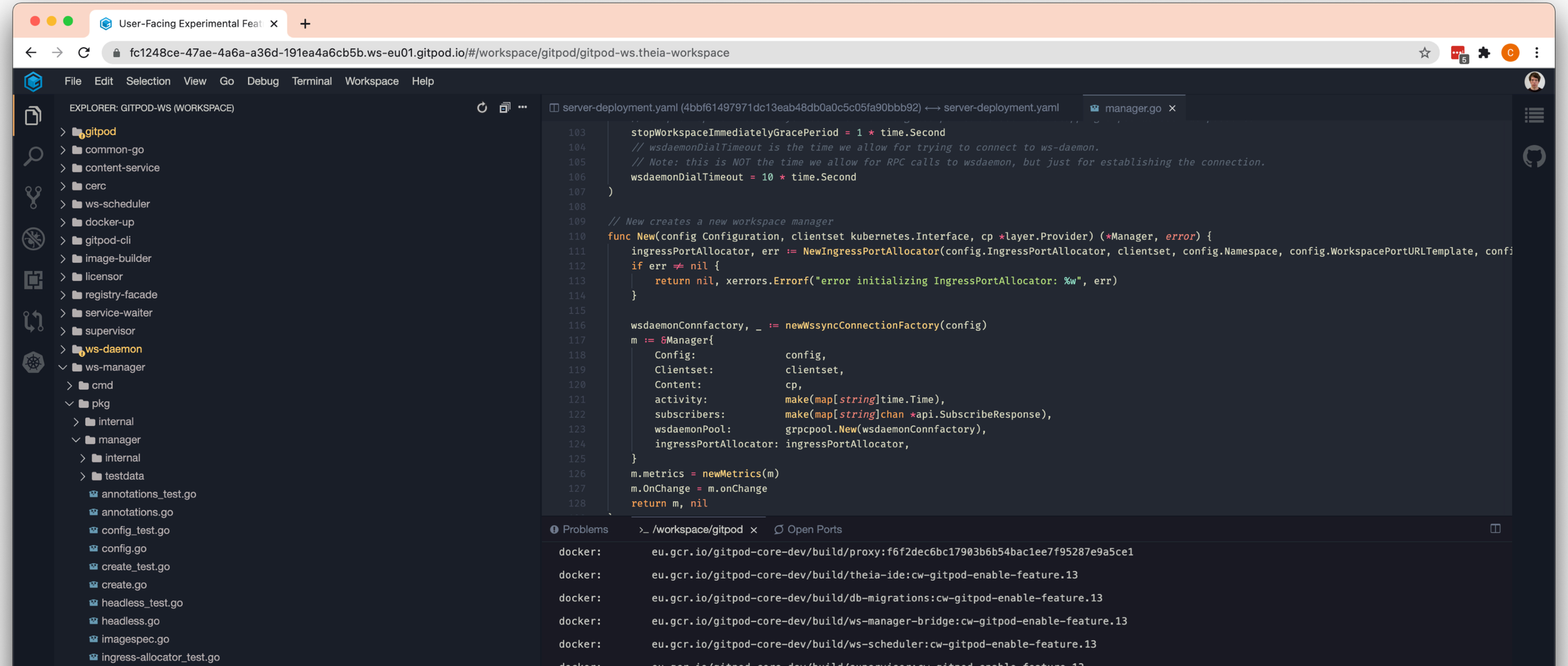
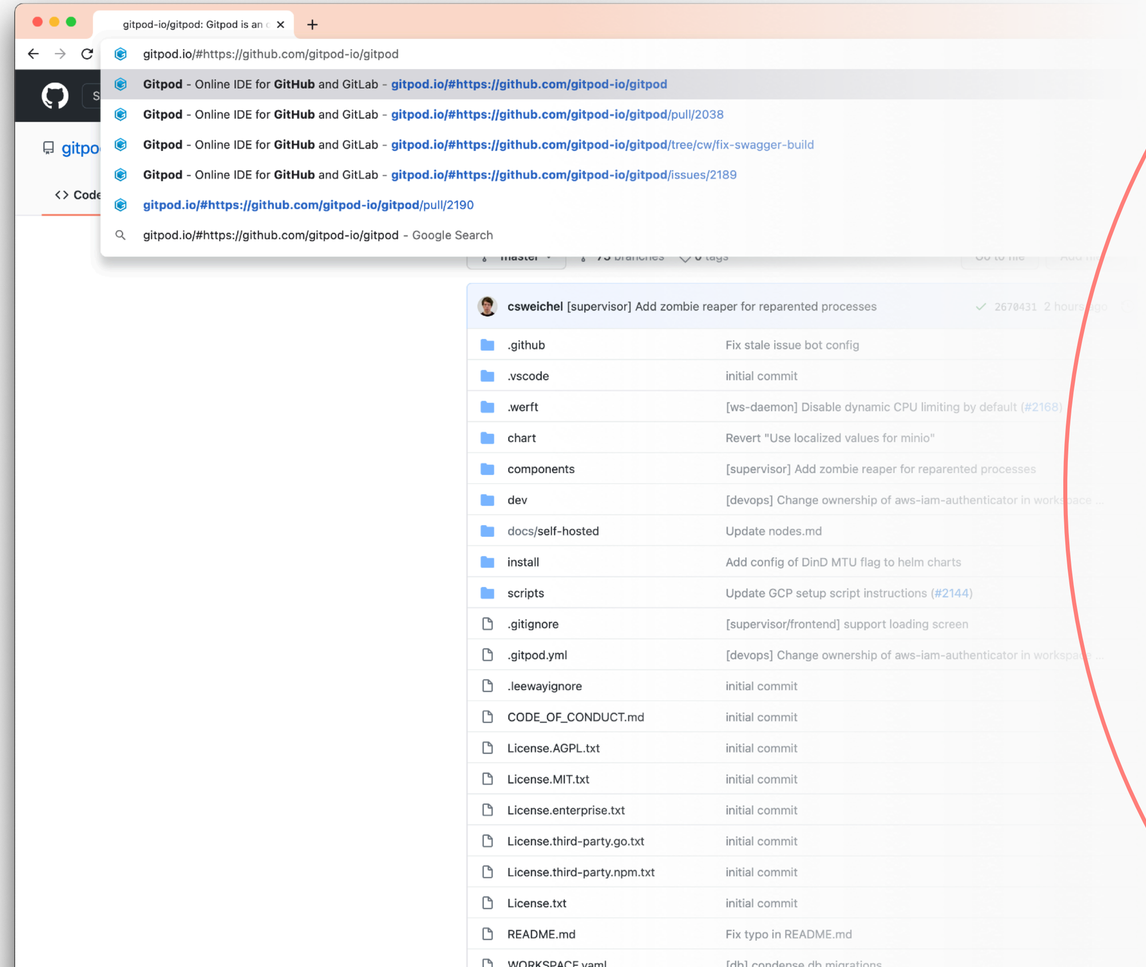
Gitpod provides

automated dev environments



Gitpod provides

automated dev environments in Kubernetes



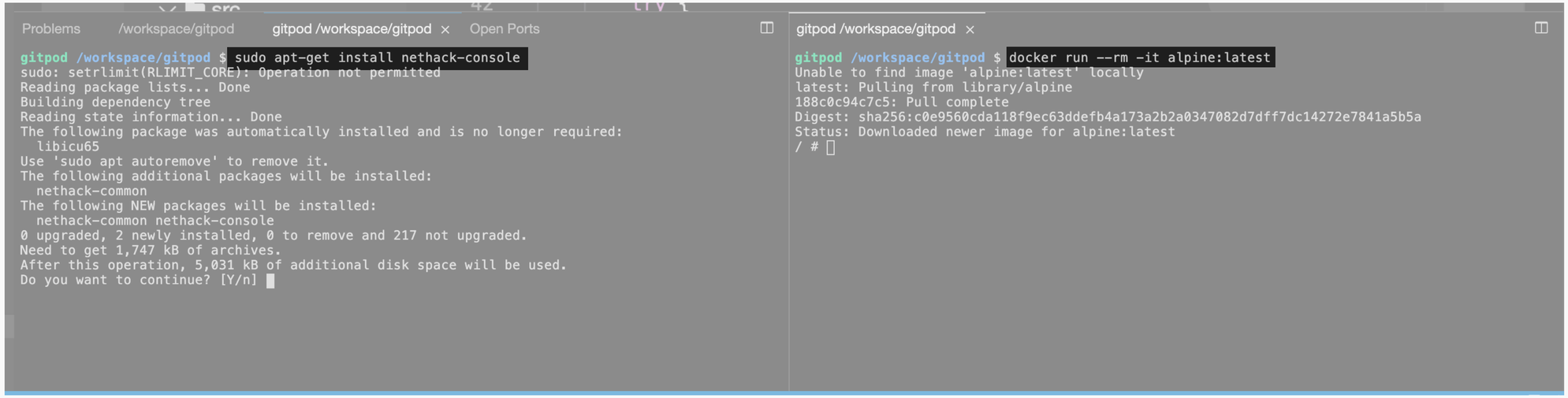
How it started

no sudo, no apt-get install, no Docker

```
gitpod /workspace/gitpod $ sudo apt-get install docker.io
sudo: effective uid is not 0, is /usr/bin/sudo on a file system with the 'nosuid' option set or an NFS file system without root privileges?
gitpod /workspace/gitpod $ docker run --rm -it alpine:latest
docker: Cannot connect to the Docker daemon at unix:///var/run/docker.sock. Is the docker daemon running?.
See 'docker run --help'.
gitpod /workspace/gitpod $
```

How it’s going

sudo, apt-get install, Docker

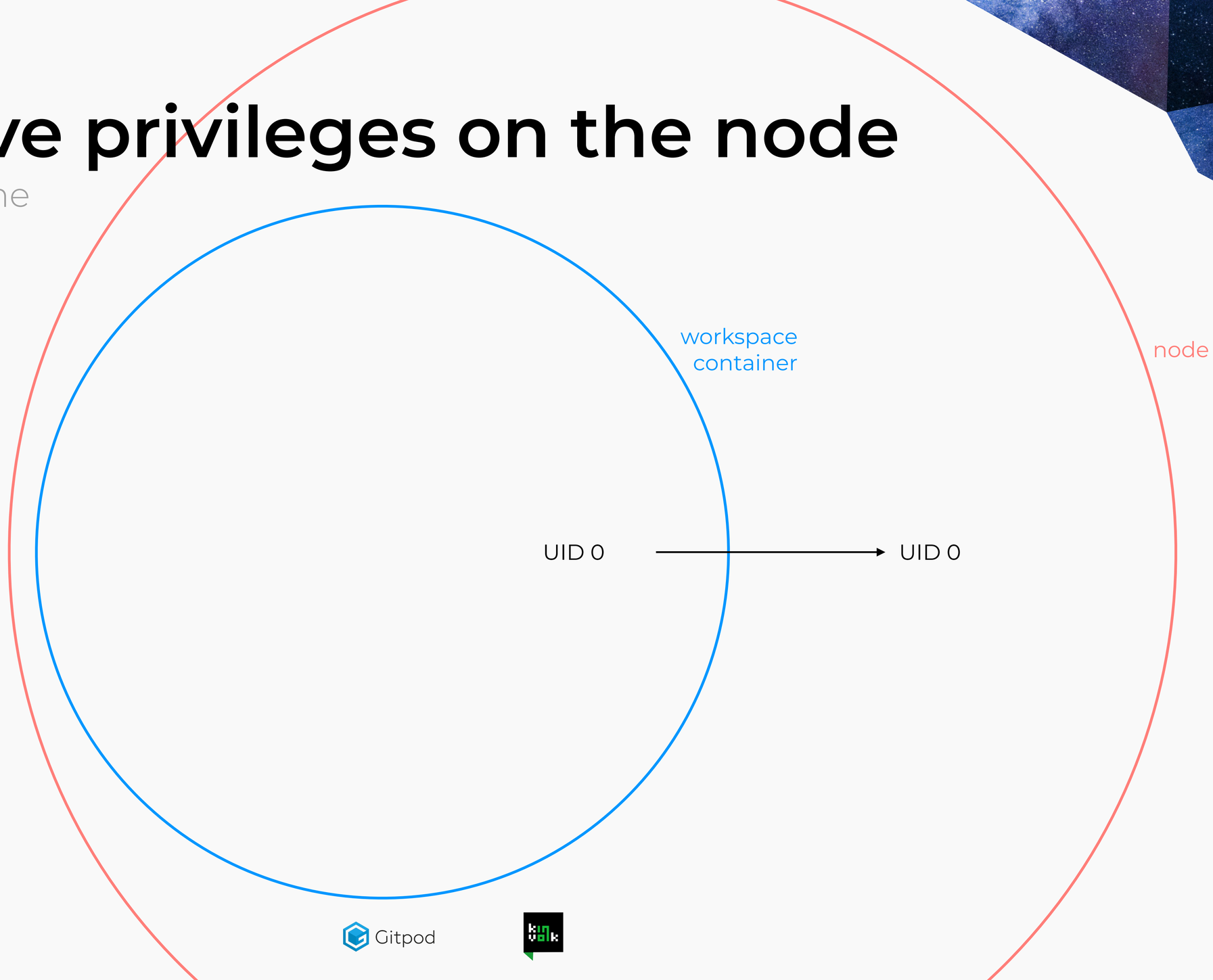


Gitpod

Naïve: give privileges on the node

Don’t to this at home

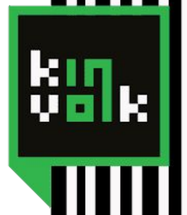
```
spec:
  allowPrivilegeEscalation: true
  allowedCapabilities:
  - '*'
  fsGroup:
    rule: RunAsAny
  hostIPC: true
  hostNetwork: true
  hostPID: true
  hostPorts:
  - max: 65535
    min: 0
  privileged: true
  runAsUser:
    rule: RunAsAny
  seLinux:
    rule: RunAsAny
  supplementalGroups:
    rule: RunAsAny
  volumes:
  - '*'
```



Gitpod

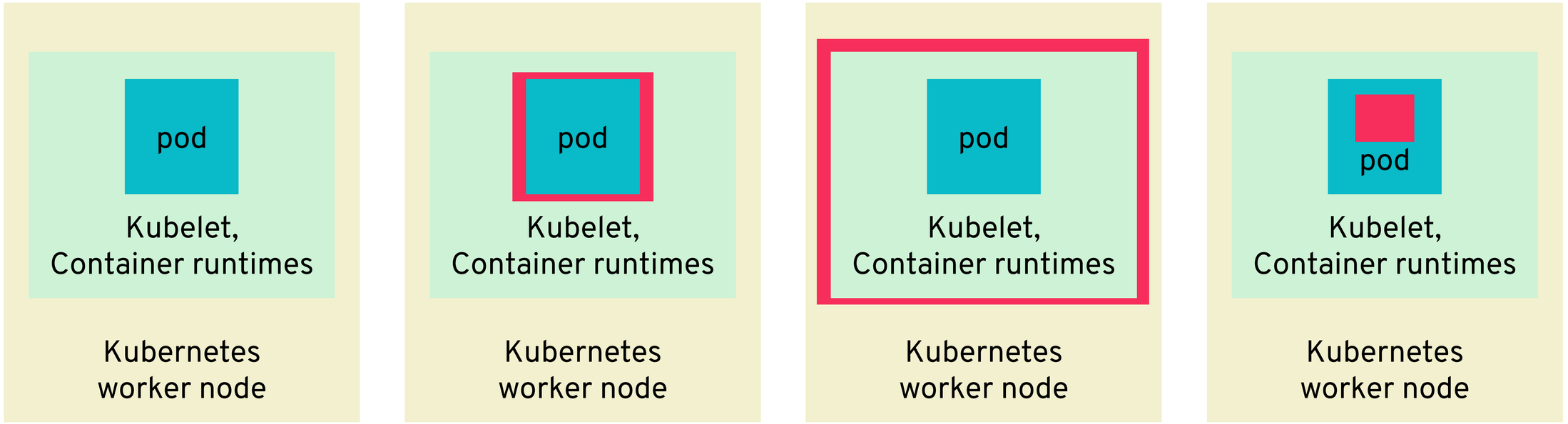
Overview of isolation tech (1)

- VM-like Container Runtimes
  - Nabla containers: unikernel built specifically for the workload
  - gVisor: application kernel, written in Go, that implements a substantial portion of the Linux system surface
  - Kata Containers: container runtime, building lightweight virtual machines
  - Firecracker: Virtual Machine Manager like QEMU
- Limitations
  - Compatibility
  - Network or filesystem performance
  - Density



User namespaces in Kubernetes

Three different ways to use user namespaces in Kubernetes



Without user namespaces

KEP-127:
New field in PodSpec
hostUserNamespace=

KEP-2033:
rootless mode

Workload in the pod creating user namespaces (Gitpod)

User Namespaces

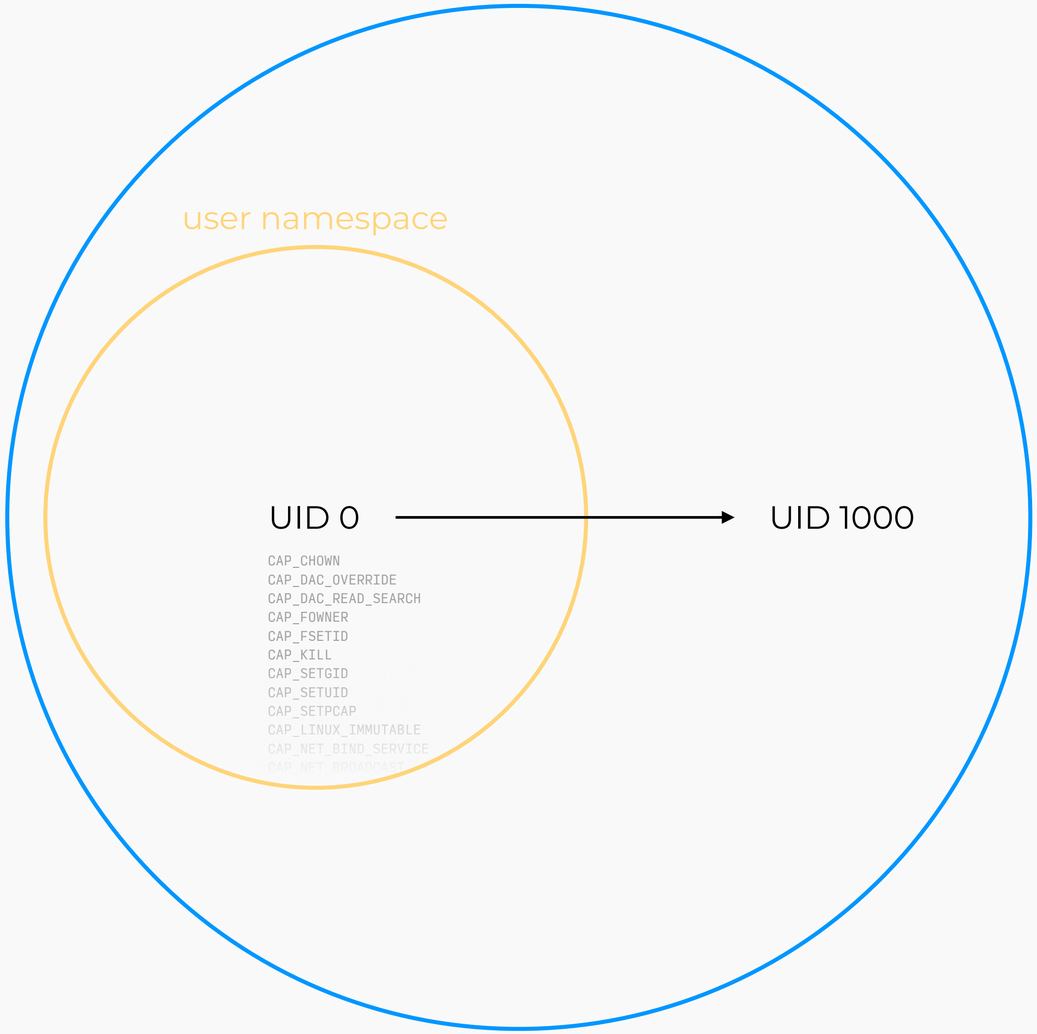
a rough sketch

unshare()

⚡ write(/proc/<pid>/uid_map)
⚡ write(/proc/<pid>/gid_map)

execve()

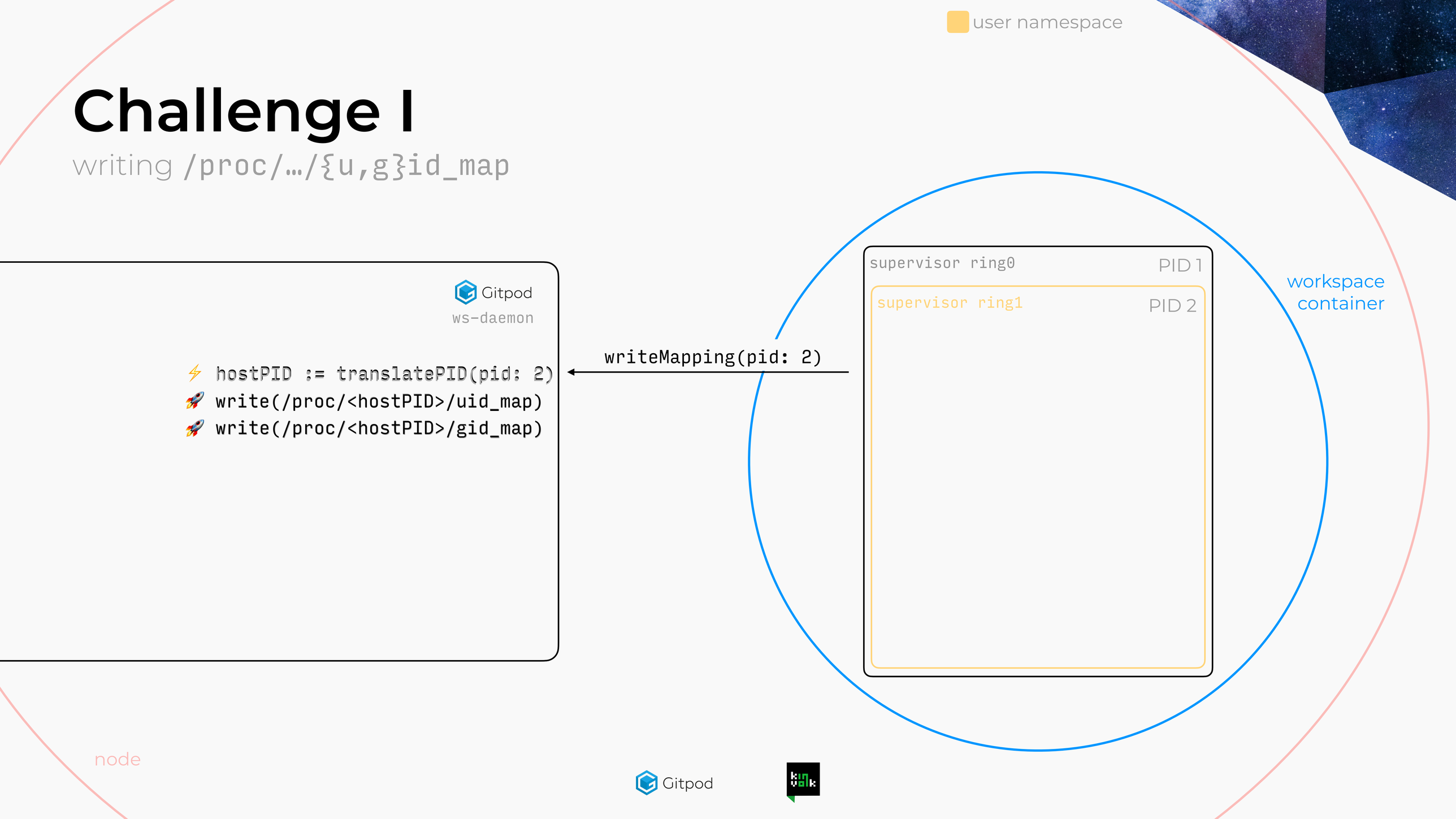
```
$ strace -f -e openat,write,unshare unshare -U -r echo
```



Gitpod

Challenge I

writing /proc/…/{u,g}id_map

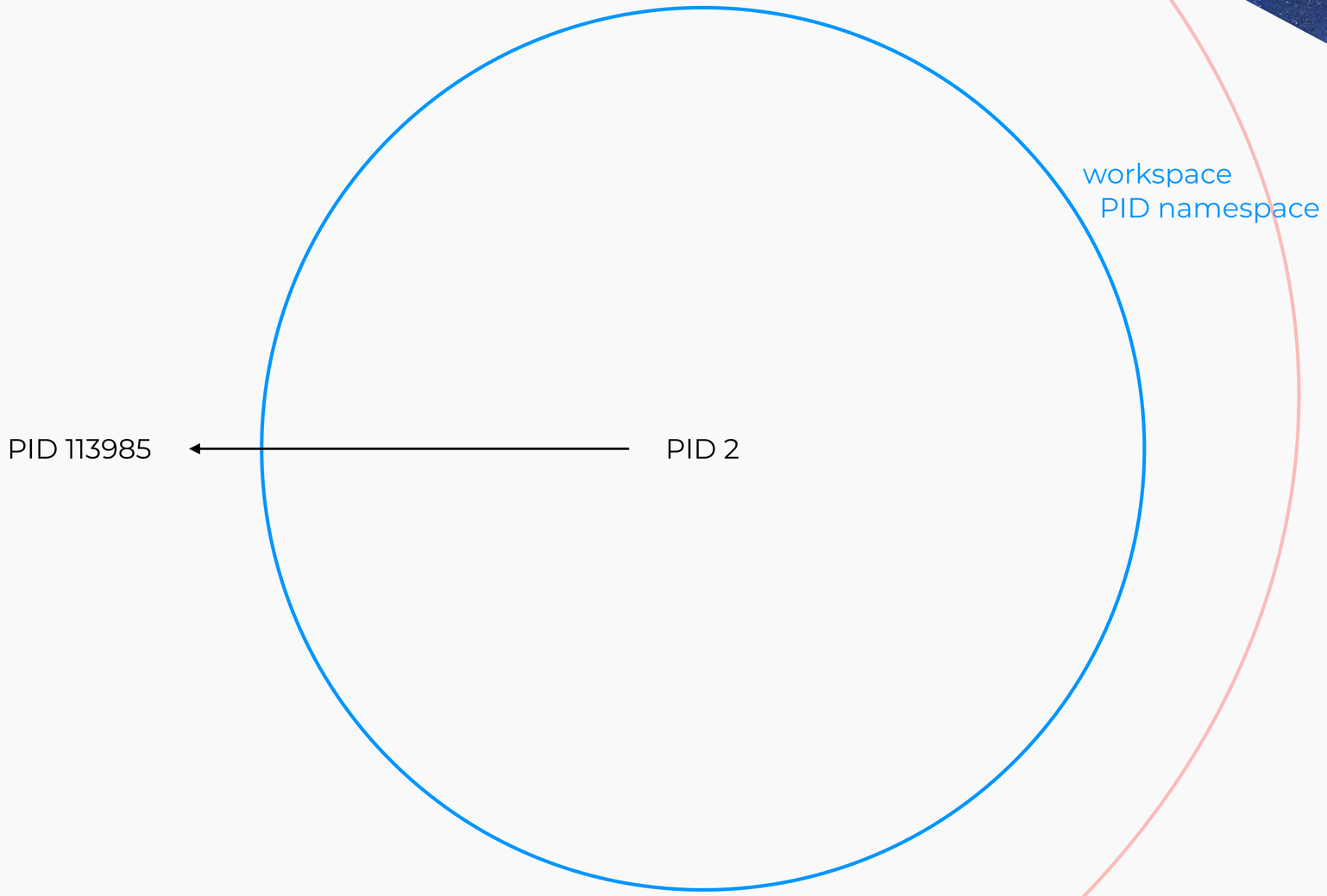


Challenge II

PID mapping

Gitpod

ws-daemon



node

Challenge II

PID mapping

```
root@ws-daemon-8nh7g:/# cat /proc/2548604/status
Name:   sleep
Umask:  0022
State:  S (sleeping)
Tgid:   2548604
Ngid:   0
Pid:    2548604
PPid:   27259
TracerPid:      0
Uid:    0       0       0       0
Gid:    0       0       0       0
FDSize: 256
Groups: 1 2 3 4 6 10 11 20 26 27
NStgid: 2548604 1349
NSpid:  2548604 1349
NSpgid: 27259   1
NSsid:  27259   1
VmPeak:     3520 kB
VmSize:     1492 kB
VmLck:         0 kB
VmPin:         0 kB
VmHWM:         4 kB
VmRSS:         4 kB
RssAnon:               4 kB
RssFile:               0 kB
RssShmem:              0 kB
VmData:       20 kB
VmStk:       132 kB
VmExe:       756 kB
VmLib:       552 kB
VmPTE:        48 kB
VmSwap:        0 kB
HugetlbPages:          0 kB
CoreDumping:    0
THP_enabled:    1
Threads:        1
SigQ:   3/120489
SigPnd: 0000000000000000
ShdPnd: 0000000000000000
SigBlk: 0000000000000000
SigIgn: 0000000000000000
SigCgt: 0000000000000000
CapInh: 0000003fffffffff
CapPrm: 0000003fffffffff
CapEff: 0000003fffffffff
CapBnd: 0000003fffffffff
CapAmb: 0000000000000000
NoNewPrivs:     0
Seccomp:        0
```

“container process”

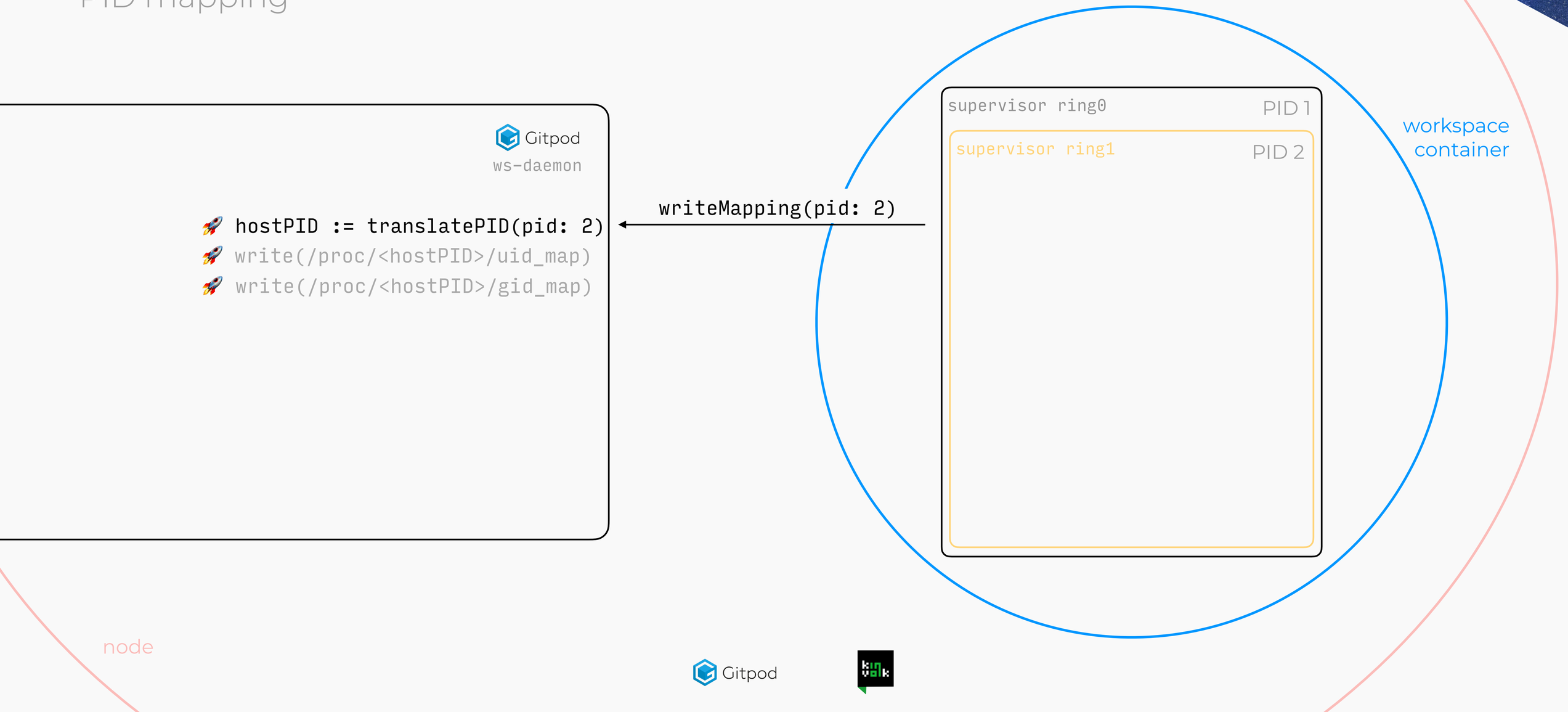
“target process”

```
    PID USER      PR  NI    VIRT    RES    SHR S  %CPU %MEM     TIME+ COMMAND
2970734 root      20   0    1020      4      0 S   0.0  0.0   0:00.43         `- /pause
2972768 root      20   0   10796   4912   4340 S   0.0  0.0   0:00.07      `- containerd-shim -namespace k8s.io -workdir
2972788 33333     20   0  716576  15752  11228 S   0.0  0.1   0:00.45         - /.supervisor/supervisor ring0
2972959 33333     30  10  717984  15312  10716 S   0.0  0.0   0:00.07           `- /proc/self/exe ring1 --mapping-esta
2973008 33333     30  10  718240  14860  10332 S   0.0  0.0   0:00.05              `- /proc/self/exe ring2
2973027 133332    30  10  720096  22856  12888 S   0.3  0.1   0:00.63                 `- /proc/self/exe run --inns
2973115 133332    25   5 1400816 118844  31028 S   0.0  0.4   0:05.82                    `- /theia/node/bin/gitpod-
2975354 133332    25   5  284184  43480  28728 S   0.3  0.1   0:00.78                       `- /theia/node/bin/git
2975533 133332    26   6   12924   9848   3544 S   0.0  0.0   0:00.15                       `- /bin/bash -i
2976781 133332    20   0  718756  16140  11100 S   0.0  0.1   0:00.08                          `- /.supervisor/su
2976358 133332    25   5  297348  61372  29576 S   0.0  0.2   0:00.91                       `- /theia/node/bin/git
2976807 133332    25   5  238588  39580  28460 S   0.0  0.1   0:00.19                          `- /theia/node/bin
2973194 133332    26   6   12780   9852   3608 S   0.0  0.0   0:00.18                    `- /bin/bash -i -l
2977954 133332    30  10    5488    604    528 S   0.0  0.0   0:00.00                       `- sleep 1234
```

itpod

Challenge II

PID mapping



Gitpod

Challenge III

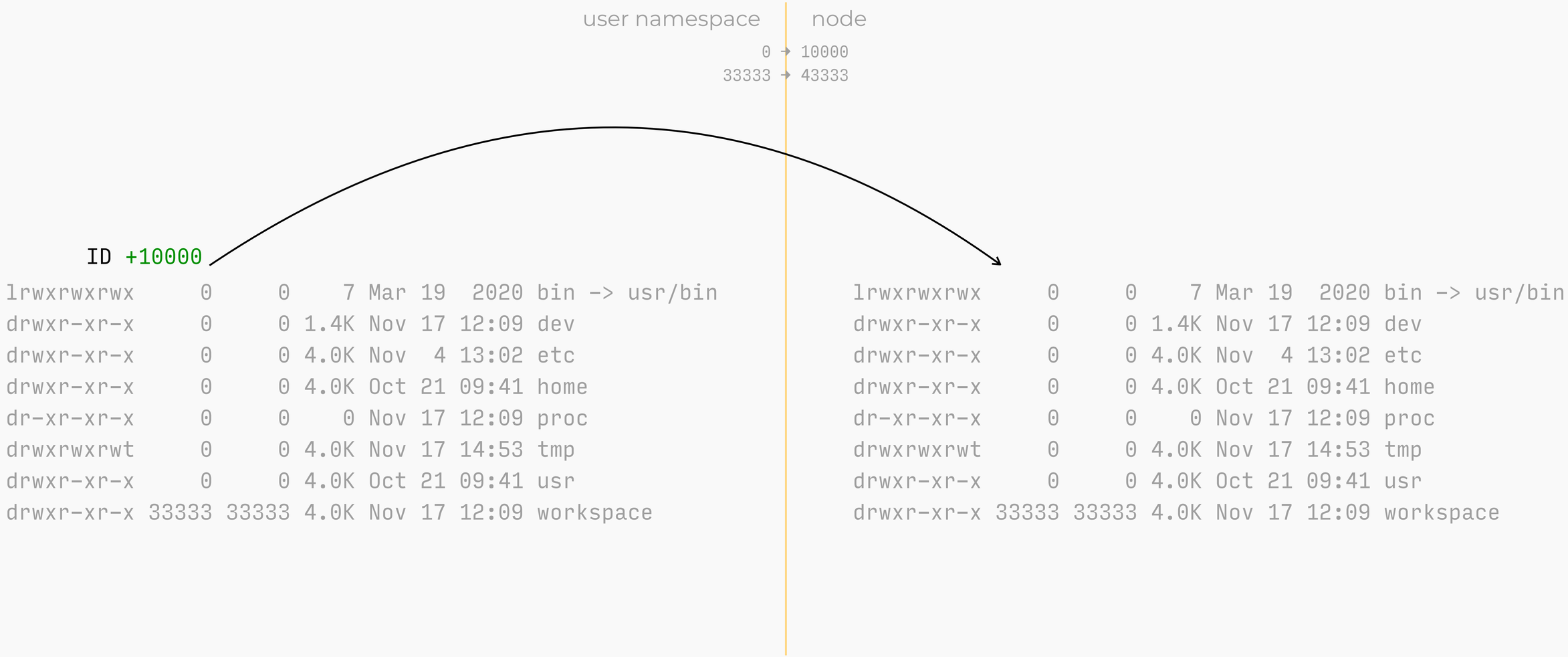
filesystem UID/GID shift

```
gitpod / $ unshare -U -r
root / # ls -lhn /
total 72K
lrwxrwxrwx   1 65534 65534    7 Mar 19  2020 bin -> usr/bin
drwxr-xr-x   2 65534 65534 4.0K Mar  6  2020 boot
drwxr-xr-x  10 65534 65534 1.4K Nov 17 12:09 dev
drwxr-xr-x   1 65534 65534 4.0K Nov  4 13:02 etc
drwxr-xr-x   1 65534 65534 4.0K Oct 21 09:41 home
lrwxrwxrwx   1 65534 65534    7 Mar 19  2020 lib -> usr/lib
lrwxrwxrwx   1 65534 65534    9 Mar 19  2020 lib32 -> usr/lib32
lrwxrwxrwx   1 65534 65534    9 Mar 19  2020 lib64 -> usr/lib64
lrwxrwxrwx   1 65534 65534   10 Mar 19  2020 libx32 -> usr/libx32
drwxr-xr-x   2 65534 65534 4.0K Mar 19  2020 media
drwxr-xr-x   2 65534 65534 4.0K Mar 19  2020 mnt
drwxr-xr-x   1     0     0 4.0K Nov  4 12:52 opt
dr-xr-xr-x 674 65534 65534    0 Nov 17 12:09 proc
drwx------   2 65534 65534 4.0K Mar 19  2020 root
drwxr-xr-x   1 65534 65534 4.0K Apr 15  2020 run
lrwxrwxrwx   1 65534 65534    8 Mar 19  2020 sbin -> usr/sbin
drwxr-xr-x   2 65534 65534 4.0K Mar 19  2020 srv
dr-xr-xr-x  12 65534 65534    0 Nov 17 14:52 sys
drwxr-xr-x   1 65534 65534 4.0K Jul 14 21:18 theia
drwxrwxrwt   1 65534 65534 4.0K Nov 17 14:53 tmp
drwxr-xr-x   1 65534 65534 4.0K Oct 21 09:41 usr
drwxr-xr-x   1 65534 65534 4.0K Nov  4 13:02 var
drwxr-xr-x   5     0     0 4.0K Nov 17 12:09 workspace
root / #
```

Gitpod

Challenge III

filesystem UID/GID shift



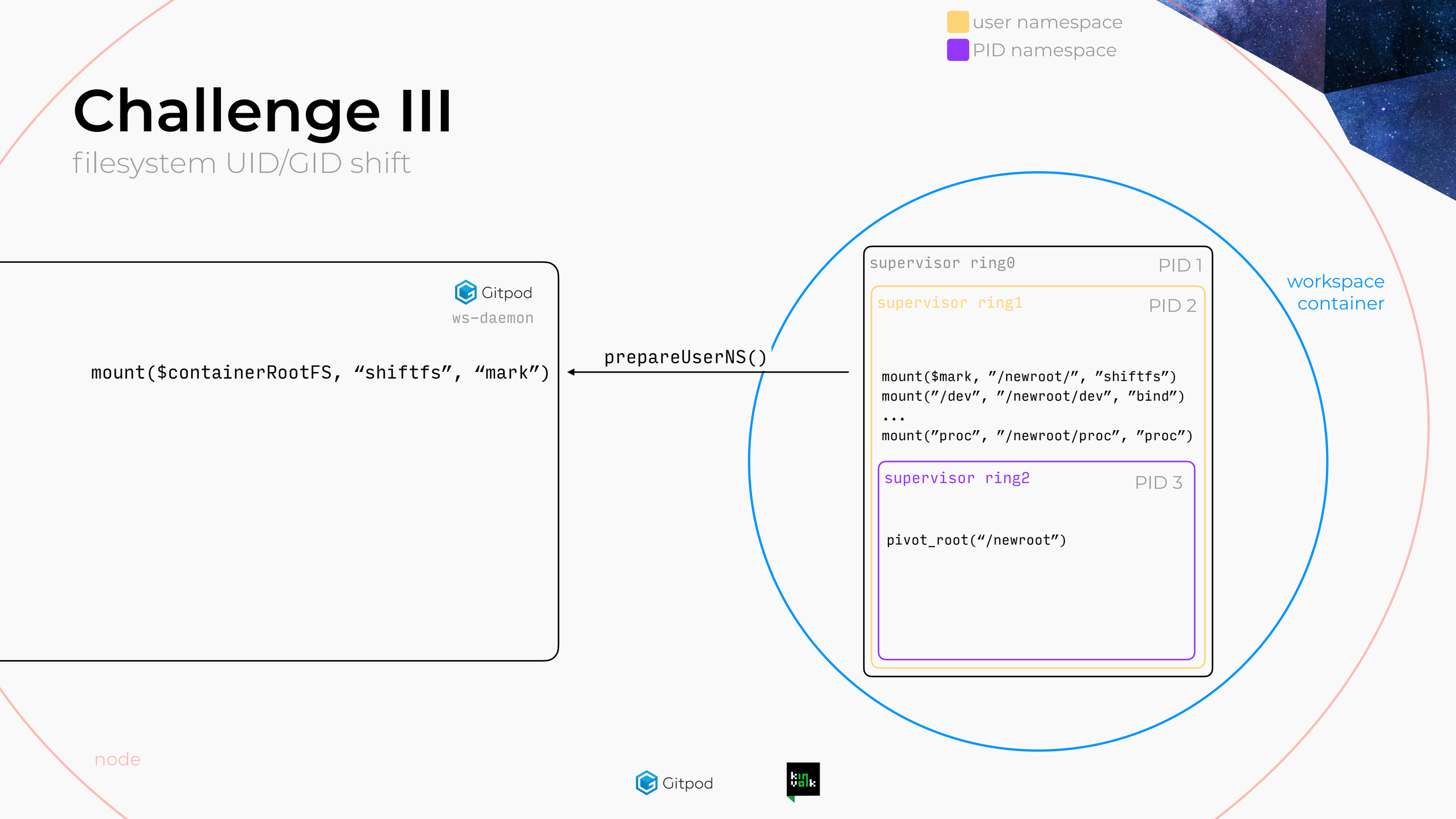
Gitpod

Challenge III

filesystem UID/GID shift

	fuse-overlayfs	overlayfs metacopy	shiftfs
Namespaced	★★★ yes	★★ yes - on Ubuntu	★ requires privileged mark mount
Upfront Cost	★★★ none	★ very high - `chown -R *`	★★★ none
Runtime Cost	★ very high - userland process	★★ comparatively low	★★★ virtually none
Platform Specific	★★★ no	★★ works best on Ubuntu	★ Ubuntu only

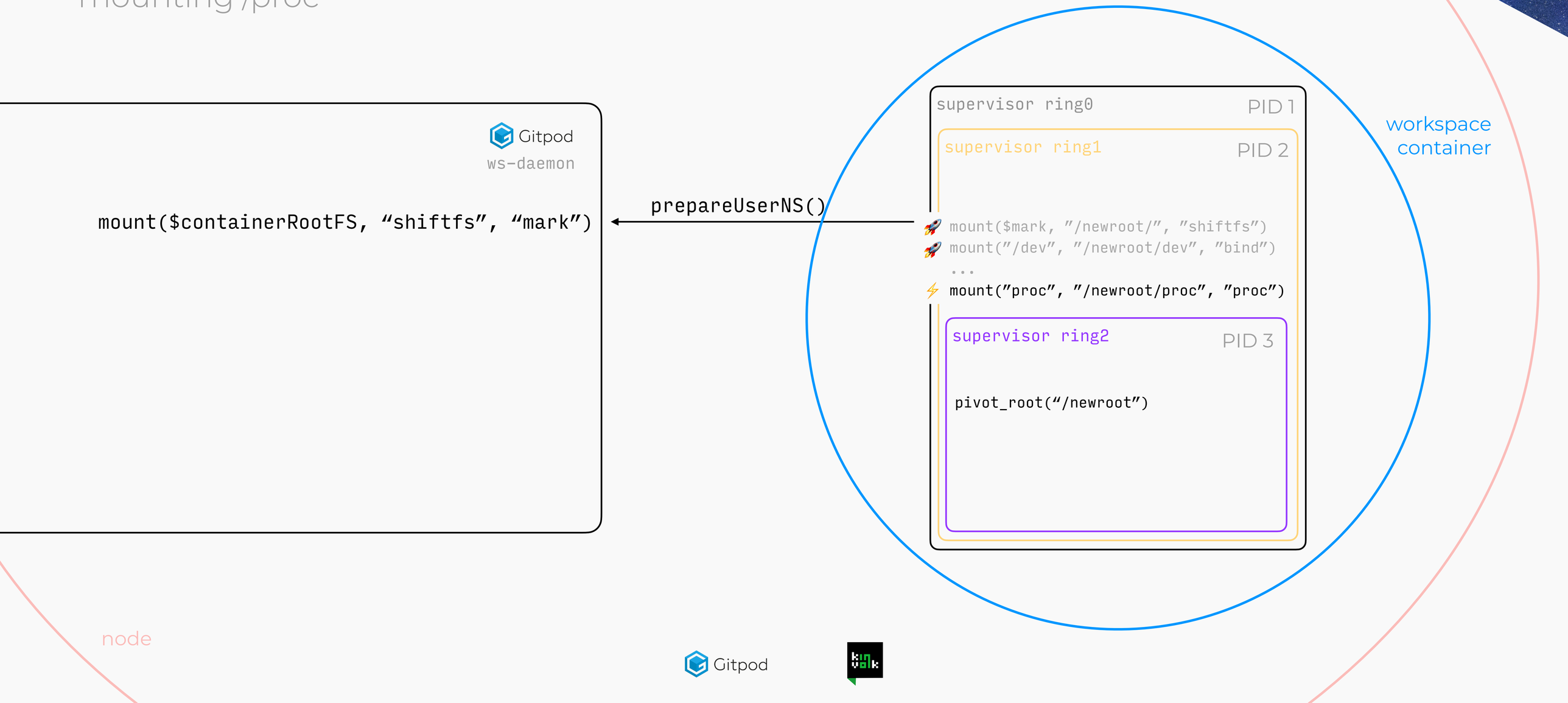
Gitpod


user namespace
PID namespace
Challenge III
filesystem UID/GID shift
Gitpod
ws-daemon
mount($containerRootFS, “shiftfs”, “mark”)
prepareUserNS()
supervisor ring0
PID 1
supervisor ring1
PID 2
mount($mark, ”/newroot/”, ”shiftfs”)
mount(”/dev”, ”/newroot/dev”, ”bind”)
...
mount(”proc”, ”/newroot/proc”, ”proc”)
supervisor ring2
PID 3
pivot_root(“/newroot”)
workspace container
node
Gitpod

user namespace
PID namespace

Challenge IV

mounting /proc



Gitpod

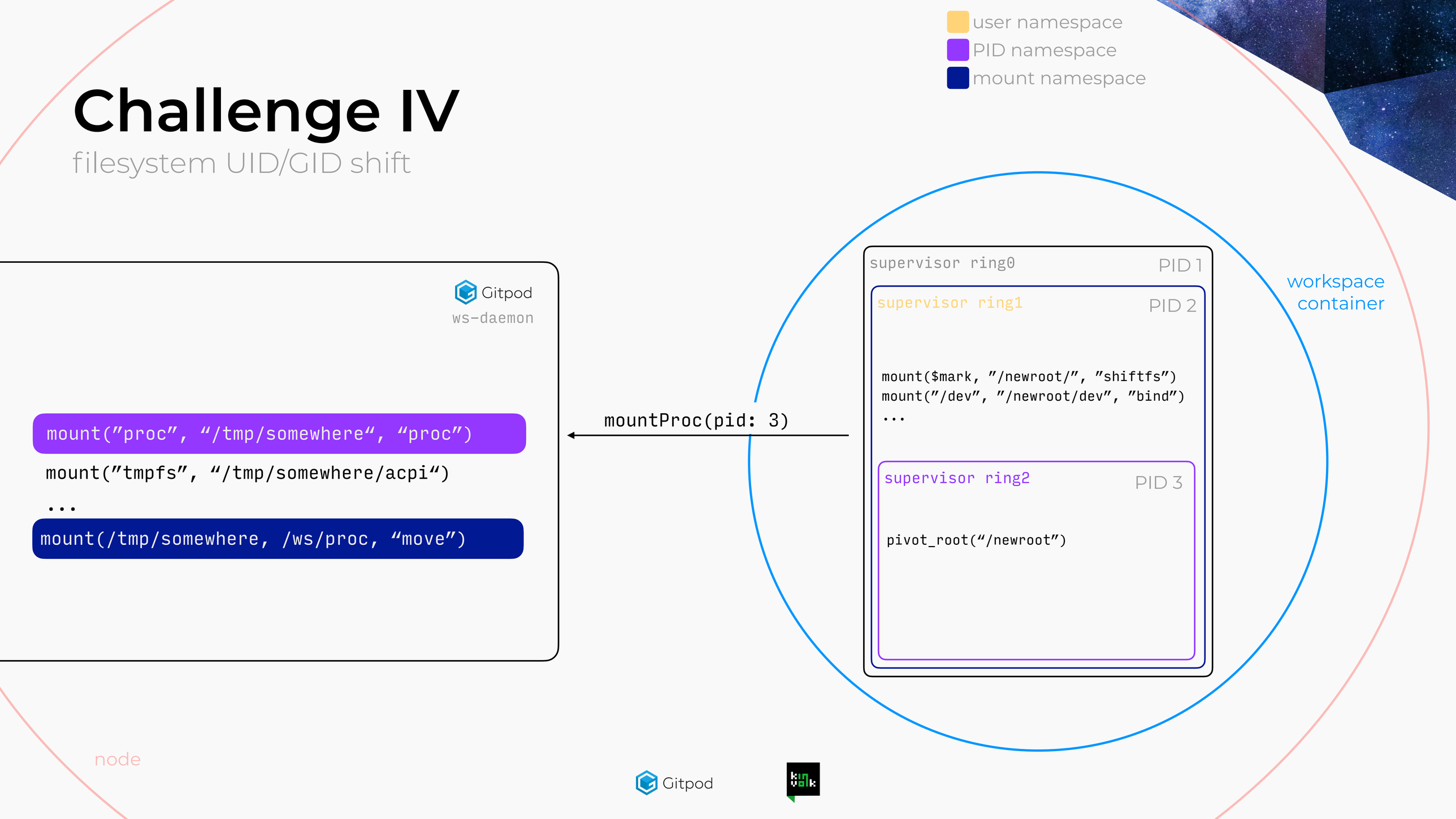
Challenge IV

mounting /proc

```
$ mount | grep proc
proc on /proc type proc (rw,nosuid,nodev,noexec,relatime)
proc on /proc/bus type proc (ro,relatime)
proc on /proc/fs type proc (ro,relatime)
proc on /proc/irq type proc (ro,relatime)
proc on /proc/sys type proc (ro,relatime)
proc on /proc/sysrq-trigger type proc (ro,relatime)
tmpfs on /proc/acpi type tmpfs (ro,relatime)
tmpfs on /proc/kcore type tmpfs (rw,nosuid,size=65536k,mode=755)
tmpfs on /proc/keys type tmpfs (rw,nosuid,size=65536k,mode=755)
tmpfs on /proc/timer_list type tmpfs (rw,nosuid,size=65536k,mode=755)
tmpfs on /proc/sched_debug type tmpfs (rw,nosuid,size=65536k,mode=755)
tmpfs on /proc/scsi type tmpfs (ro,relatime)
```

Challenge IV

filesystem UID/GID shift



We got root - but no Docker yet

Gitpod

Docker in rootless workspaces

Heaps of prior art

Akihiro Suda

@_AkihiroSuda_

https://kinvolk.io/blog/2018/04/
towards-unprivileged-container-builds/

Rootless Containers

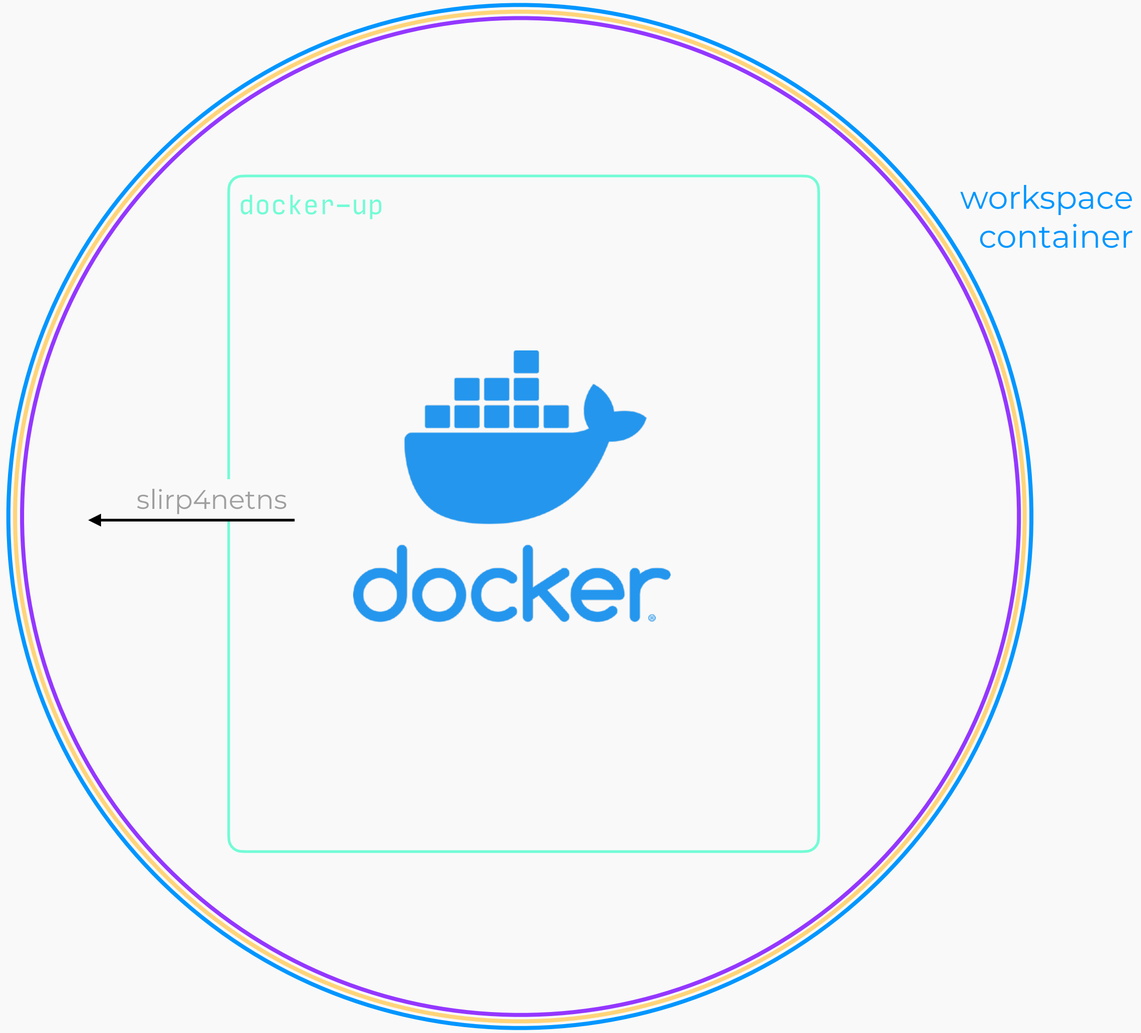
https://rootlesscontaine.rs/

Gitpod

user namespace
PID namespace
Network namespace

Docker in rootless workspaces

Networking

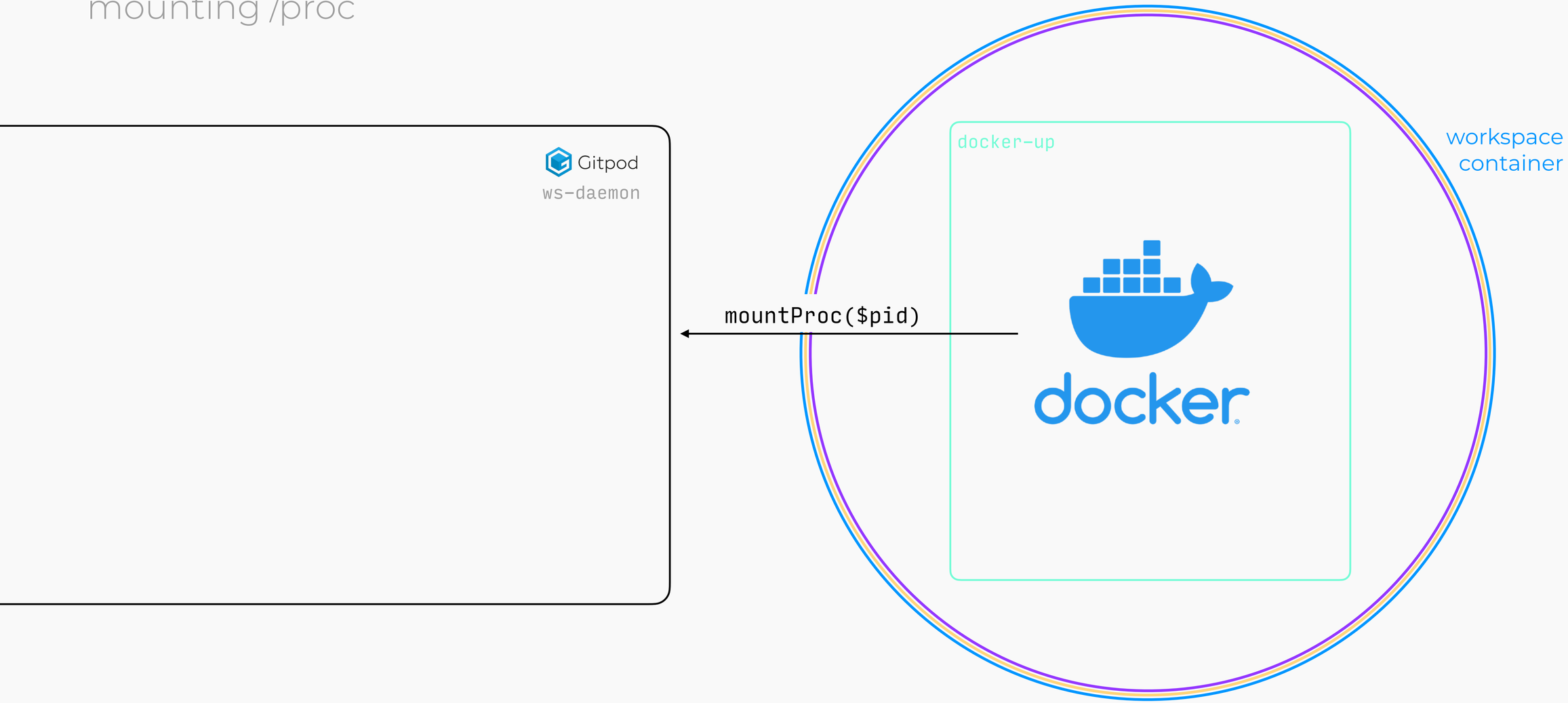


Gitpod

user namespace
PID namespace
Network namespace

Docker in rootless workspaces

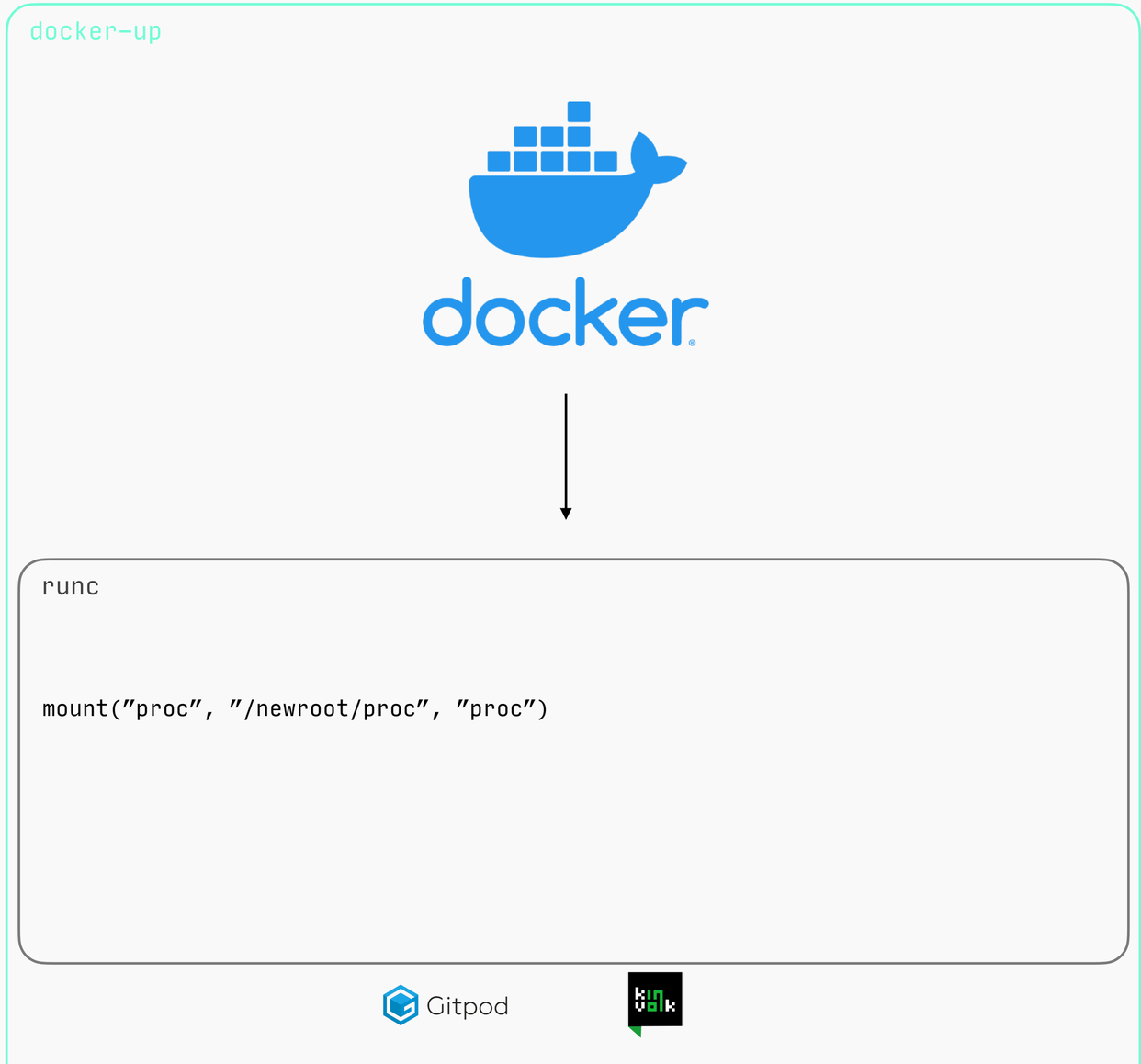
mounting /proc



user namespace
PID namespace
Network namespace

Docker in rootless workspaces

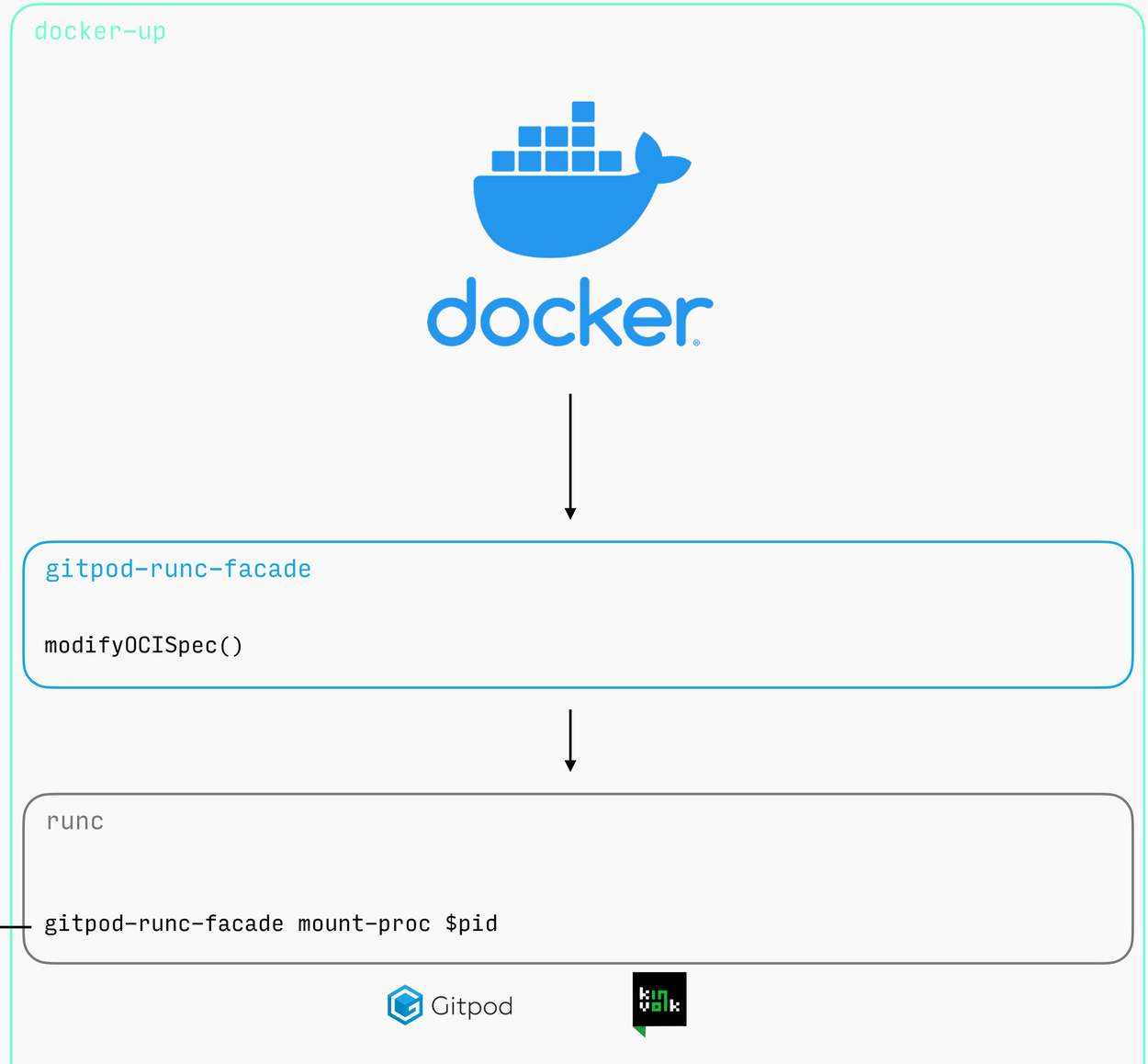
mounting /proc



user namespace
PID namespace
Network namespace

Docker in rootless workspaces

mounting /proc

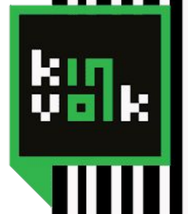


mountProc($pid)

Gitpod

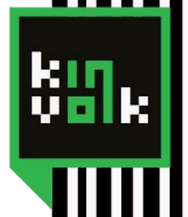
Idmapped mounts

- Currently, Gitpod uses shiftfs from a kernel module, not in Linux upstream
- New: ID-mapped mounts patch set
  - Attach idmappings to bind mounts
  - Shifting of a container rootfs or base image without having to mangle every file
  - Sharing of data between host with underprivileged containers



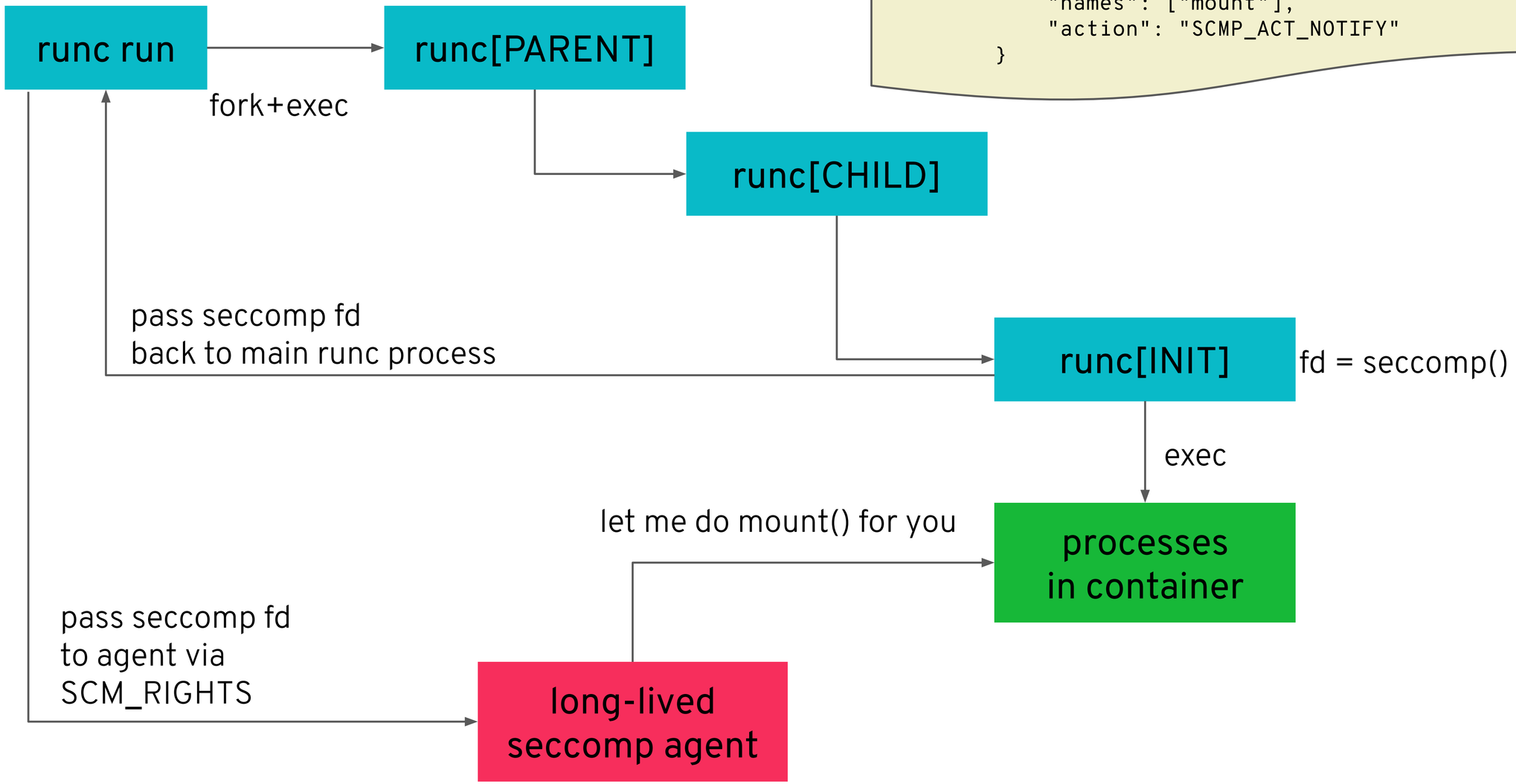
Using a Seccomp Agent for privileged ops

- Currently, the workspace executes some privileged operations via gRPC methods to ws-daemon
  - **prepareUserNS()**
    `mount($containerRootFS, “shiftfs”, “mark”)`
  - **mountProc()**
    `mount(”proc”, “/tmp/somewhere“, “proc”)`
- Soon, runc will support Seccomp Notify for deferring some syscalls (e.g. mount) to a seccomp agent



Seccomp Notify

```
"seccomp": {
    "defaultAction": "SCMP_ACT_ALLOW",
    "listenerPath": "/run/seccompagent.sock",
    "syscalls": [
        {
            "names": ["mount"],
            "action": "SCMP_ACT_NOTIFY"
        }
```



New tech in this space

- Kubernetes KEPs
  - KEP-127: Support User Namespaces
    https://github.com/kubernetes/enhancements/pull/2101
  - KEP-2033: Rootless mode
    https://github.com/kubernetes/kubernetes/pull/92863
- Rootlesskit:
  - https://github.com/rootless-containers/
  - Rootlesskit, Usernetes, slirp4netns, bypass4netns
- Seccomp Notify in Kubernetes
  - OCI Runtime Spec: https://github.com/opencontainers/runtime-spec/pull/1074
  - runc: https://github.com/opencontainers/runc/pull/2682
  - crun: https://github.com/containers/crun/pull/438
  - conmon: https://github.com/containers/conmon/pull/190
  - Seccomp Agent https://github.com/kinvolk/seccompagent