Virtuozzo

CRIU mounts migration: problems and solutions

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Aug 2020

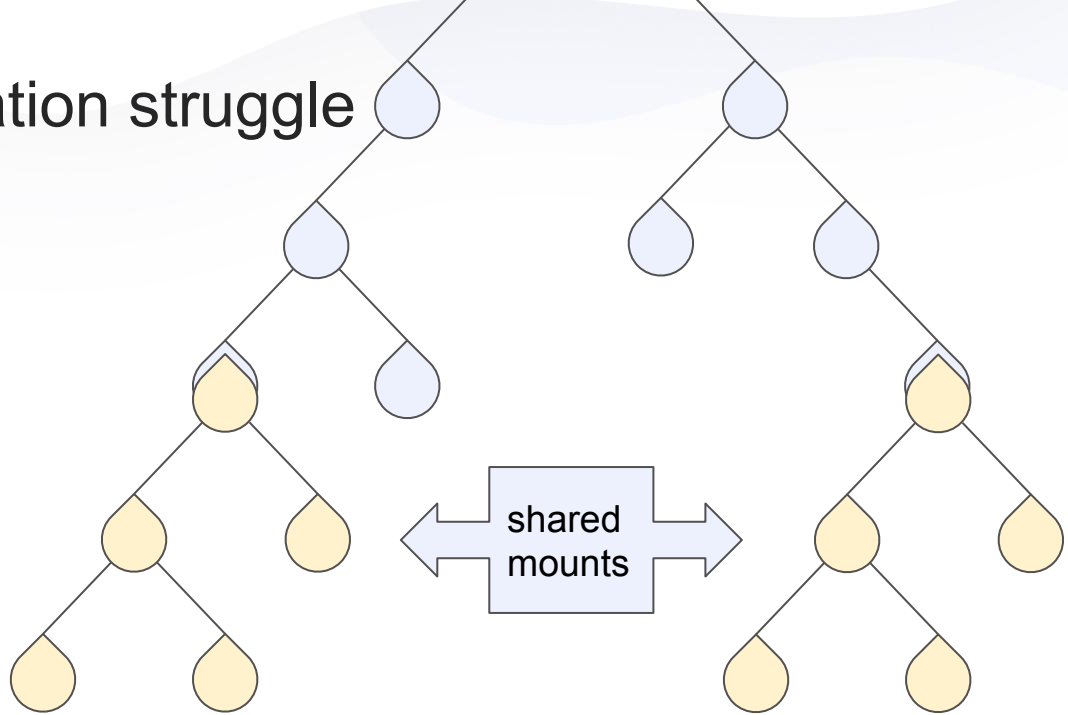
Agenda

- Problems we face with mounts in CRIU and solutions
  - Mount propagation struggle
  - Overmounting “/” and chroot problem
  - Opening overmounted files
  - Procfs from nested pidns
  - Mounts lack info about tagged namespaces

Problems we face with mounts in CRIU

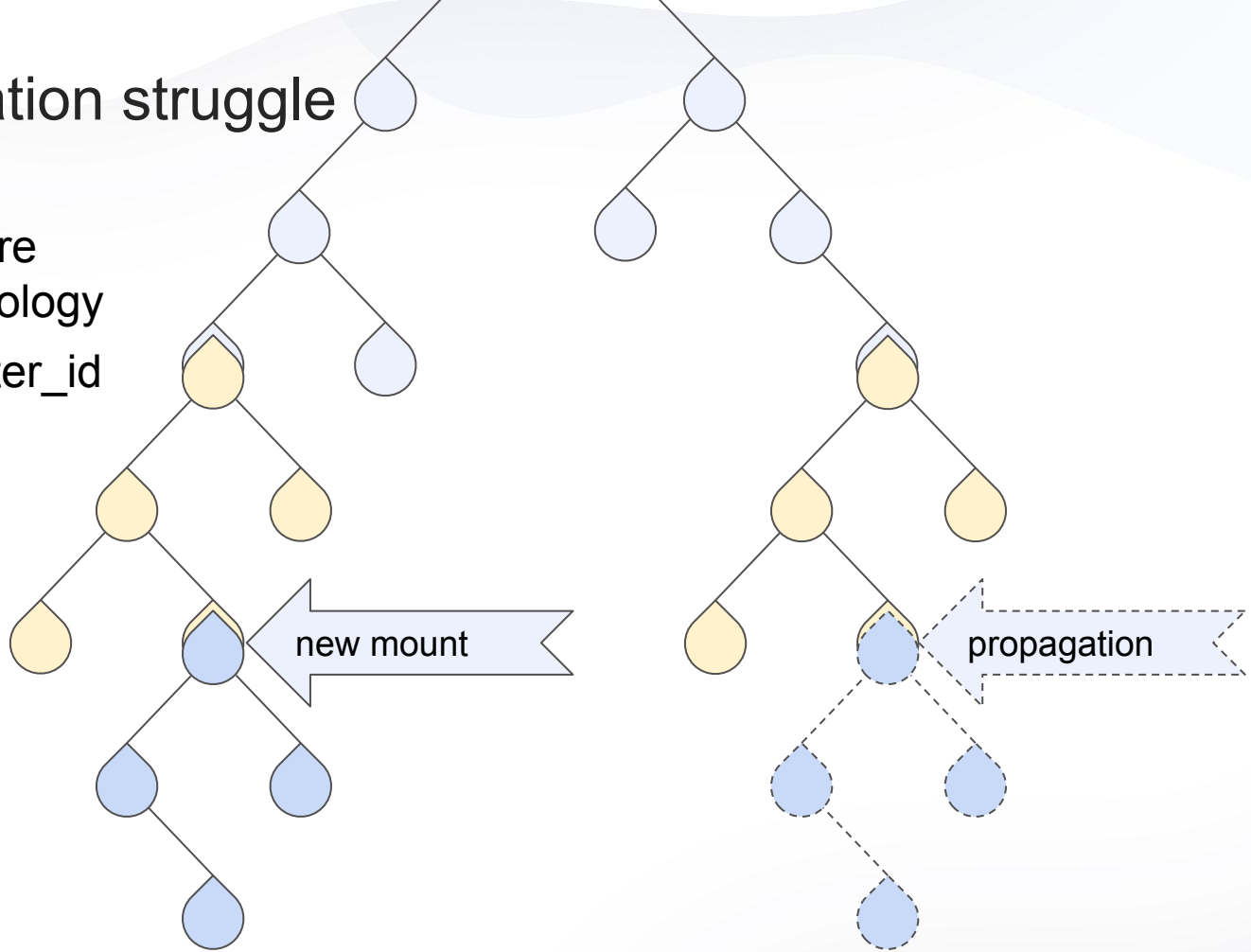
Mount propagation struggle #1

Mount propagation struggle



Mount propagation struggle

- We need to restore shared group topology
- shared_id + master_id
- ids can be only inherited



Mount propagation struggle

- This small example can create from 3 to >7 mounts depending on parent sharing:

```
mkdir a b
mount --bind a b
mount --bind a b
mount --bind a b
```

Mount propagation struggle: mount reparenting

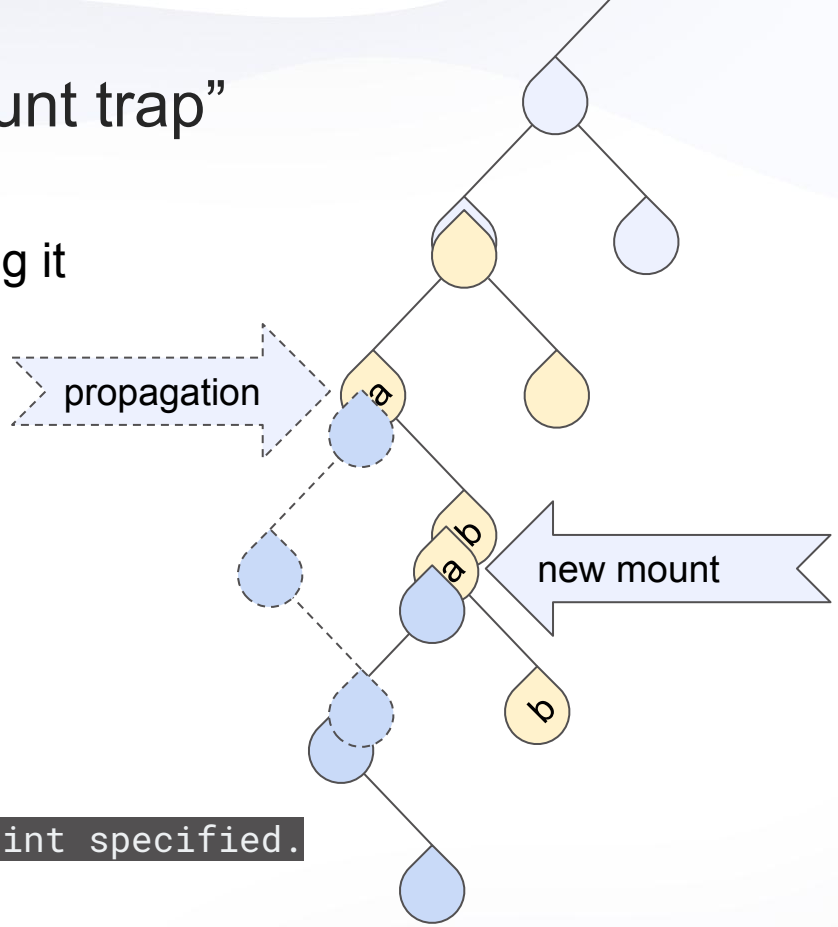
```
cat /proc/self/mountinfo | grep testdir
# 644 639 0:59 / /tmp/testdir rw,relatime shared:19 - tmpfs tmpfs rw
# 645 644 0:59 /a /tmp/testdir/b rw,relatime shared:19 - tmpfs tmpfs rw
# 646 645 0:59 /a /tmp/testdir/b rw,relatime shared:19 - tmpfs tmpfs rw
# 647 644 0:59 /a /tmp/testdir/a rw,relatime shared:19 - tmpfs tmpfs rw
mount --bind a b
cat /proc/self/mountinfo | grep testdir
# 644 639 0:59 / /tmp/testdir rw,relatime shared:19 - tmpfs tmpfs rw
# 645 644 0:59 /a /tmp/testdir/b rw,relatime shared:19 - tmpfs tmpfs rw
# 646 749 0:59 /a /tmp/testdir/b rw,relatime shared:19 - tmpfs tmpfs rw
# 647 750 0:59 /a /tmp/testdir/a rw,relatime shared:19 - tmpfs tmpfs rw
# 648 646 0:59 /a /tmp/testdir/b rw,relatime shared:19 - tmpfs tmpfs rw
# 750 644 0:59 /a /tmp/testdir/a rw,relatime shared:19 - tmpfs tmpfs rw
# 749 645 0:59 /a /tmp/testdir/b rw,relatime shared:19 - tmpfs tmpfs rw
# 748 647 0:59 /a /tmp/testdir/a rw,relatime shared:19 - tmpfs tmpfs rw
```

Mount propagation struggle: “Mount trap”

- you can’t access mount just after mounting it

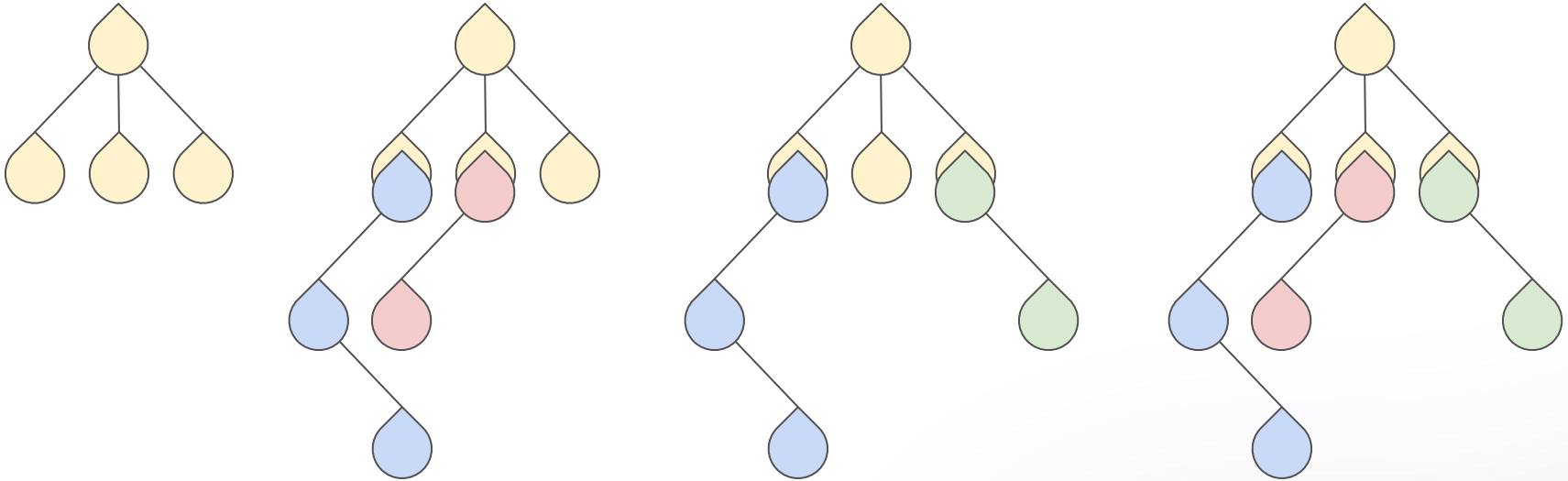
```
# Prepare shared parent
mkdir /tmp/testdir
mount -t tmpfs tmpfs /tmp/testdir
mount --make-private /tmp/testdir
mount --make-shared /tmp/testdir
cd /tmp/testdir

# Actual commands
mkdir a/b -p
mount --bind a a/b
mount -t tmpfs tmpfs a/b
umount a/b
# umount: /tmp/testdir/a/b: no mount point specified.
```



Mount propagation struggle: “Non-uniform” propagation

- Mount order - shared mount created after propagation
- Umount one of propagation mounts when others are locked with children mounts



Mount propagation struggle: and some more

- “Cross-namespace” sharing groups
  - Order shared group creation and namespace creation
- We don’t know history we see only final snapshot
- Mounts from propagation group can have complex sharing, see [4]

- All those problems/inconveniences make restoring sharing in mount tree almost impossible…

Mount propagation struggle: Solution

- Assume kernel supports mount flag MS_SET_GROUP to copy sharing [1]
- Assume all mounts mounted right but **without** sharing options
- Assume we have an opened fd on each mount's root dentry

Preparation:

- Group all mounts with same (shared_id, master_id) pair - sharing groups
- Put sharing groups in a trees where child->master_id == parent->shared_id
  - If two groups have same master_id mark them siblings (even if no parent)
  - If group has master_id but no parent - "external slavery"

Mount propagation struggle: Solution

Actual setup:

- Walk sharing group trees (parents before children)
  - Setup first (any) mount in a group
    - Is slave
      - Find any mount from parent sg or find external mount source
      - Copy sharing from it with MS_SET_GROUP
      - Make slave
    - Is shared - make it also shared
  - Setup other mounts - copy sharing from the first one

Problems we face with mounts in CRIU
Overmounting “/” and chroot problem #2

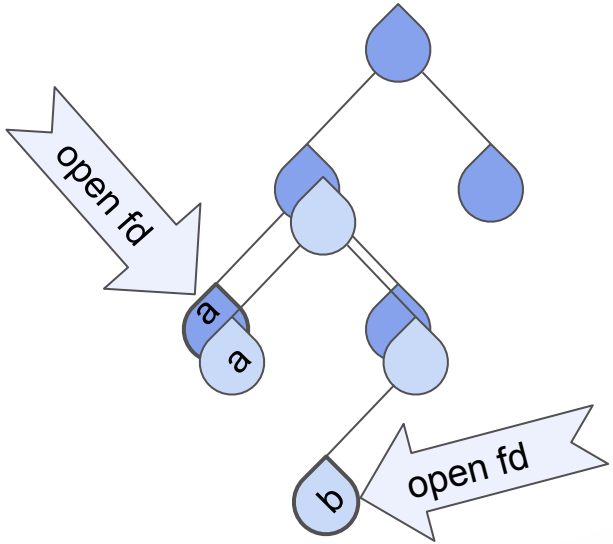
Overmounting “/” and chroot problem

- Container user overmounts “/”, e.g.:
  `mount -t tmpfs tmpfs /`
- There is currently no way to list files in this mount (without living ns)
  - Solution: O_MNT might help [5]
- Setns to such a mount namespace becomes chrooted
  - CRIU can chroot to proper root though not always
  - Solution: Maybe setns should not be chrooted?
- /proc/self/mountinfo is mangled for it
- Multiple overmount “/”
- Detached namespace with nsfs bindmount below chroot can become inaccessible

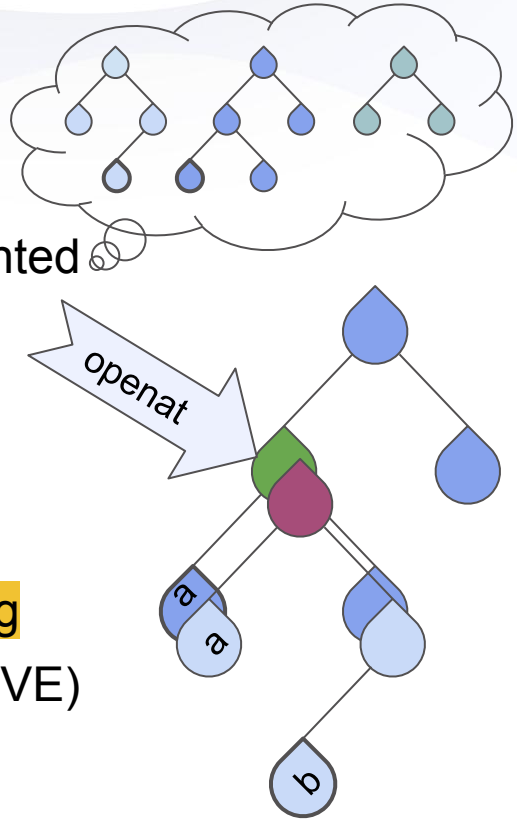
Problems we face with mounts in CRIU
Opening overmounted files #3

Opening overmounted files

- Fds should be reopened on the same mount + path which can be overmounted
- Also need to configure sharings with MS_SET_GROUP for overmounted mounts



Opening overmounted files: Solution



- All mounts of all mount namespaces are pre-mounted “plain” in service mntns
- For each mount namespace
  - Unshare new mntns copying all plain mounts
  - For each mount (tree order) in mntns
    - Open mp_fd to mountpoint before moving
    - Move mount to final mount tree (MS_MOVE)
    - Open mnt_fd to mountpoint after moving
      - Not always possible due to #2
  - Pivot_root to remove all extra mounts
- This way via mp_fd and mnt_fd all files can be openat

Problems we face with mounts in CRIU

Procfs from nested pidns #4

Procfs from nested pidns

- Procfs-es are per pid namespace
- Use /proc/1/ns/pid to detect
- Non root proc bindmount can be undetectable
    - Maybe need some ioctl?

- procfs: tasks -> pidns -> mount
- COW mappings: mounts -> tasks

Procfs from nested pidns: Solution

- Extra preparations:
  - Remove all procfs (with nested pidns) and their ancestors from the tree
  - Add “internal yard” tmpfs mount to the tree
  - Add host proc mount to internal yard
  - For each removed non-proc add helper mount
- Actual mounting: new stage after forking all processes
  - For each mntns: mount required procfs (entering proper pidns)
  - Reconstruct ancestors by bind-mounting from helpers
  - Use mnt_fd and mp_fd to resolve all paths and open them for new mounts

Problems we face with mounts in CRIU

Mounts lack info about tagged namespaces #5

Mounts lack info about tagged namespaces

- Proc’s /proc/<pid>/ns/pid is not always reliable
- Sysfs, nfs, mqueue mounts are tagged with other namespaces (e.g. sysfs - net)
- Solution: Maybe we need some general ioctl for it? [6]

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Links:

1. Patch "mnt: allow to add a mount into an existing group": https://lkml.org/lkml/2017/1/23/712
2. Mounts v2 implementation: https://src.openvz.org/projects/OVZ/repos/criu/commits?until=v3.12.3.12 https://src.openvz.org/projects/OVZ/repos/criu/browse/criu/mount-v2.c?at=refs%2Fheads%2Fvz7-u15
3. Check-mounts: https://src.openvz.org/projects/OVZ/repos/criu/commits/5770d09b34c2
4. Complex sharing options test: https://src.openvz.org/projects/OVZ/repos/criu/browse/test/zdtm/static/mount_complex_sharing.c?at=refs%2Fheads%2Fvz7-u15
5. O_MNT https://patchwork.kernel.org/patch/11243249/
6. Sysfs ioctl to get netns tag https://patchwork.criu.org/patch/13168/
7. **Mounts-v2** full algorithm https://criu.org/Mounts-v2

Additional materials...

A few words about Virtuozzo

- Working on container virtualization since 1999
- Here are our current logos together with some logos we were a part of previously
- Virtuozzo containers are System containers
- CRIU is our core technology for container migration

Virtuozzo

Parallels™

Odin

SWSOFT™

Why mounts c/r is at all important?

- We can’t let mounts disappear under running process
- System container can have “everything” inside
  - Complex mounts created by user
  - Mount namespaces per-service from systemd
  - Docker app containers
  - All this mixes up due to propagation

Mounts-v2 intro [2]

- --check-mounts[3] detects many problems with mount c/r on our tests
- Previously I had several attempts to improve old mounts algorithm (sharing)
  - Helped in small cases
  - New heuristics added - hard to understand
  - Not merged in mainstream CRIU
- Mounts-v2 started from Andrew's out of tree patch (MS_SET_GROUP [1])

And some more…

- … problems:
  - MNT_LOCKED should not (dis)appear (userns)
  - No fs-root mount
  - MS_MOVE fails with deleted mount and shared parent
  - Distinguishing file/dir bind-mounts (deleted)
  - External slavery == unexpected external mounts
  - Detached mounts

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Links:

1. Patch "mnt: allow to add a mount into an existing group": https://lkml.org/lkml/2017/1/23/712
2. Mounts v2 implementation: https://src.openvz.org/projects/OVZ/repos/criu/commits?until=v3.12.3.12 https://src.openvz.org/projects/OVZ/repos/criu/browse/criu/mount-v2.c?at=refs%2Fheads%2Fvz7-u15
3. Check-mounts: https://src.openvz.org/projects/OVZ/repos/criu/commits/5770d09b34c2
4. Complex sharing options test: https://src.openvz.org/projects/OVZ/repos/criu/browse/test/zdtm/static/mount_complex_sharing.c?at=refs%2Fheads%2Fvz7-u15
5. O_MNT https://patchwork.kernel.org/patch/11243249/
6. Sysfs ioctl to get netns tag https://patchwork.criu.org/patch/13168/
7. **Mounts-v2** full algorithm https://criu.org/Mounts-v2