Lazy Process Migration

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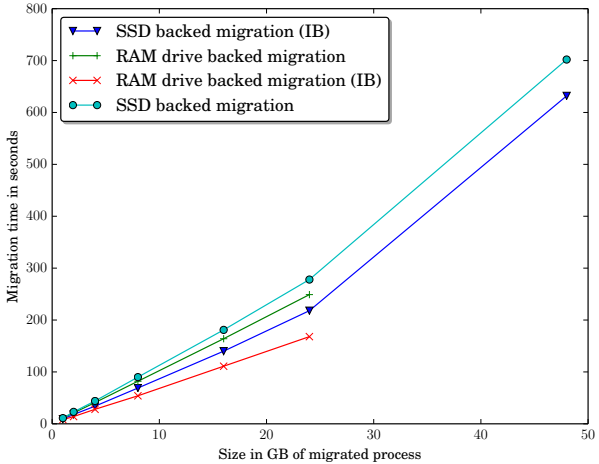
Background

Implementation

Future Plans

Process Downtime During Migration



Process Downtime During Migration

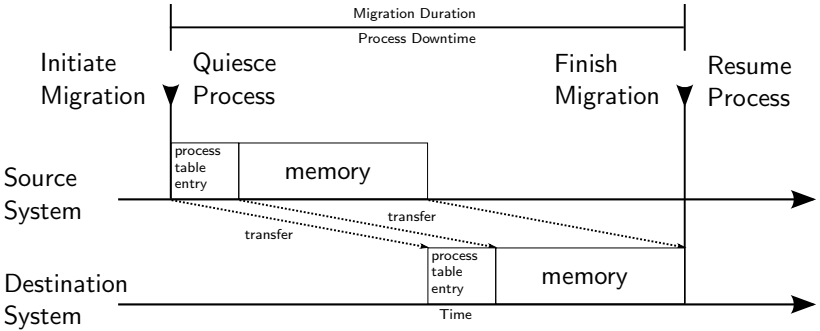


Figure: Process Migration

Optimizations - Pre-Copy

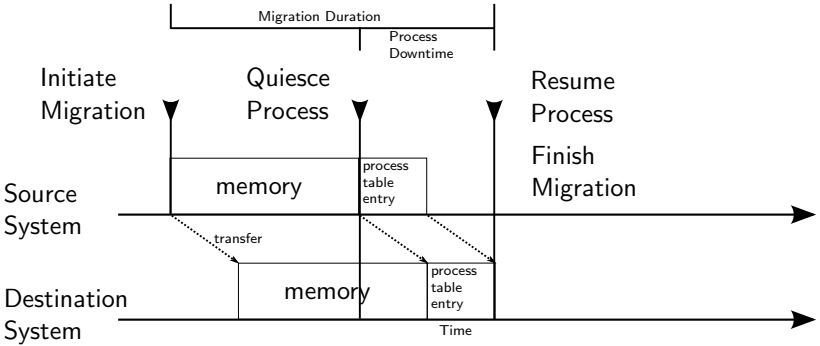
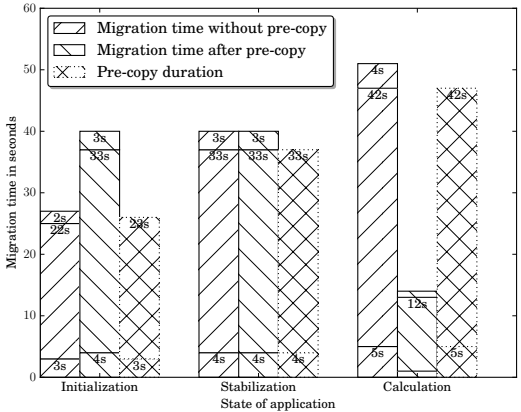
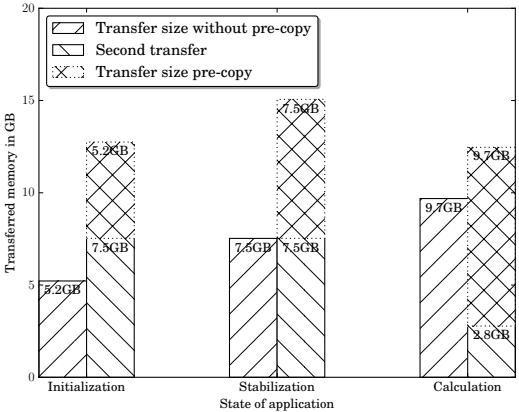


Figure: Pre-Copy Migration

Possible Drawbacks Using Pre-Copy





Optimizations - Post-Copy

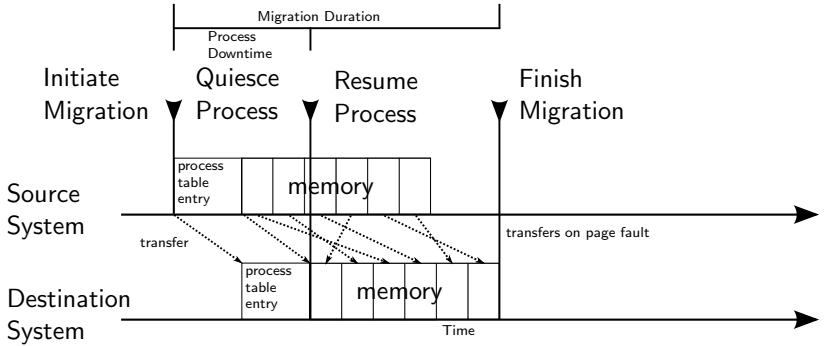


Figure: Post-Copy Migration

CRIU And Userfaultfd

- Userfaultfd (UFFD) integration into CRIU
- Most pages can be handled by UFFD
  - Anonymous private mappings are already supported
  - Shared memory is planned
- Process downtime can be decreased
- To restore a 200MB process
  - transfer 200MB without Post-Copy
  - transfer 116KB with Post-Copy

Lazy Migration Details 1

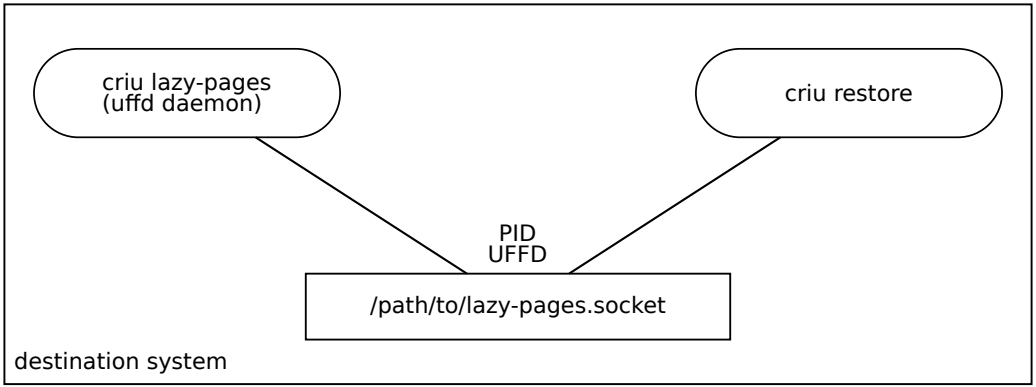
Source (dump)

- Memory pages are marked as `lazy` during `dump`
- `lazy` memory pages are not written to disk
- Source system waits for requests to transfer `lazy` memory pages via TCP

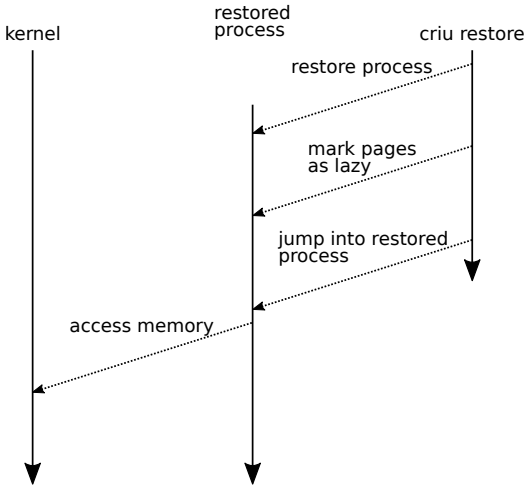
Destination (restore)

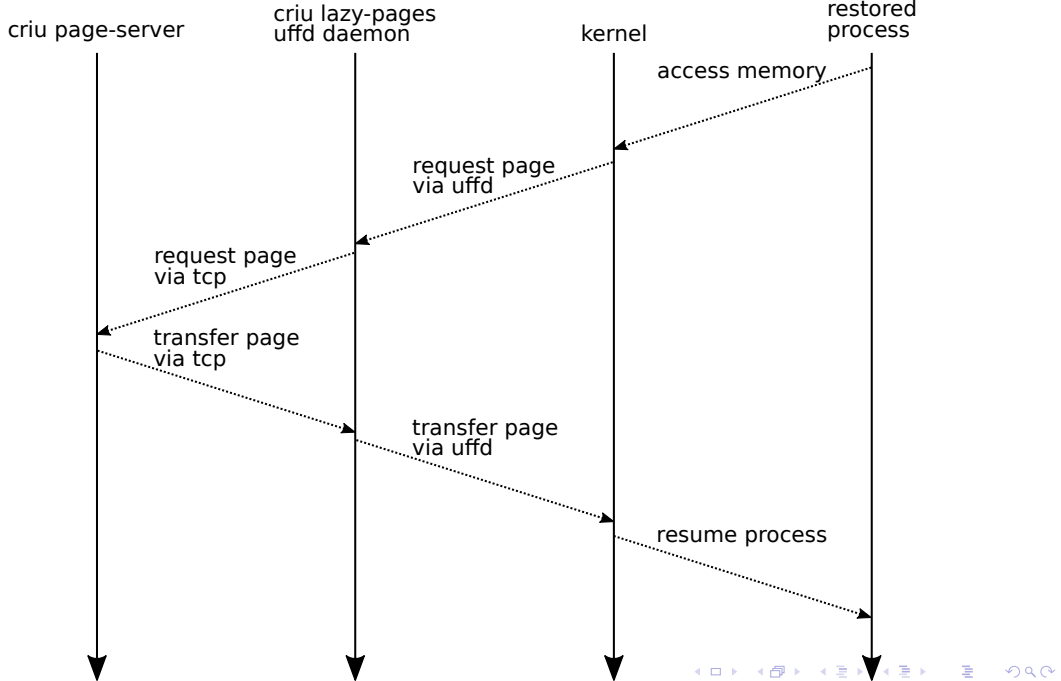
- CRIU registers memory areas with userfaultfd and connects to the source
- The process is restored with no memory
- Process accesses to memory generate page faults which are handled by the UFFD daemon

Lazy Migration Details 2



Lazy Migration Details 3




criu page-server
criu lazy-pages
uffd daemon
kernel
restored
process
access memory
request page
via uffd
request page
via tcp
transfer page
via tcp
transfer page
via uffd
resume process

Current status

- In criu-dev branch:
  - local lazy restore works
  - remote lazy restore works
  - combination of pre-copy and post-copy works
- Kernel patches for userfaultfd[1] are under review on linux-mm[2]
  - non-cooperative mode (support for `fork()` and other events)
  - support for shared memory

[1] `https://git.kernel.org/cgit/linux/kernel/git/andrea/aa.git/aa.git`
[2] `http://www.spinics.net/lists/linux-mm/msg115992.html`

Limitations

- A process that executes `fork()`, `madvise(MADV_DONTNEED)` or `mremap` will fail
- Shared (tmpfs) and hugeltbfs mappings cannot be handled by userfaultfd
- Post-copy performance is far from optimal

Future plans

- Add post-copy support to *p.haul*, *runc*, *lxc*
- Non-cooperative userfaultfd (`fork()` and other events) in CRIU and in the kernel
- Shared memory post-copy
- Nested userfaultfd
- Optimizations

The end.

Thanks for listening.