Container Migration with Kubernetes and CRIU

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https://people.redhat.com/~areber/2021-lpd.pdf

Agenda

Background

Use cases

Details

Demos

Future

Red Hat

Checkpoint/Restore in Userspace

CRIU

Red Hat

Definition:

Container Live Migration

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Transfer Running Container

Red Hat

Serialize on Source System

Red Hat

Transfer to Destination System

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Background

Red Hat

Kubernetes

Red Hat

Container

Red Hat

Container

namespaces

Red Hat

Container

cgroups

Red Hat

Container

seccomp

Red Hat

Container Runtime

`runc` or `crun`

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Container Engine

`CRI-O` or `containerd` or `Podman`

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Container Orchestration

Kubernetes

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Use Cases

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Reboot and Save State

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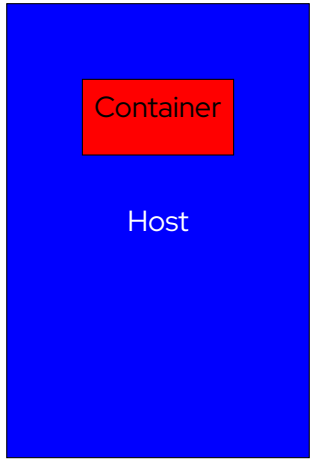
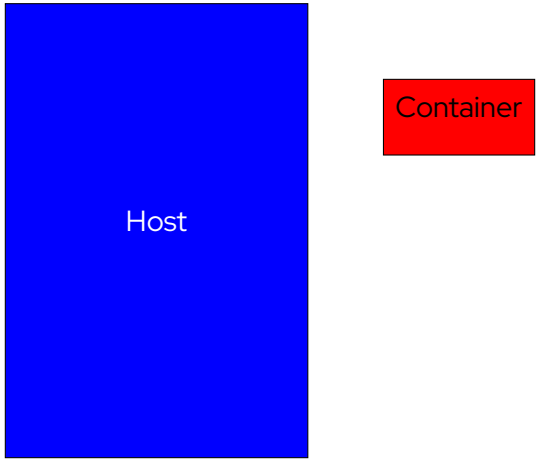
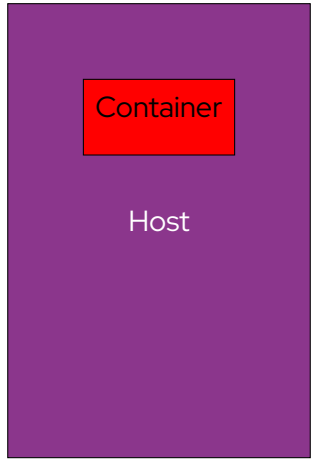


Red Hat



Red Hat

Red Hat



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Quick Startup

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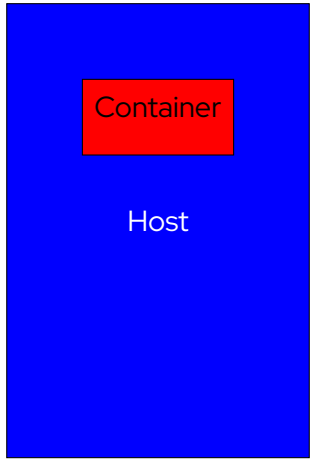

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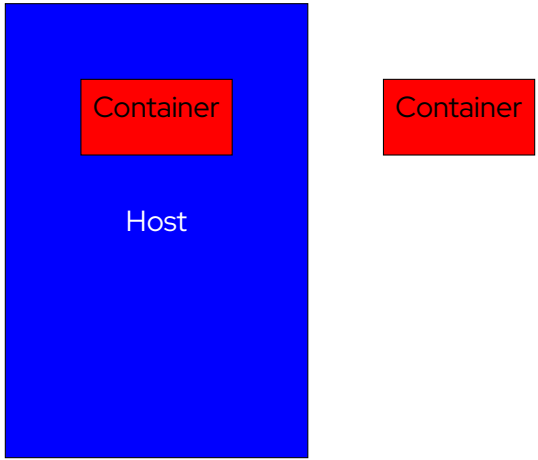

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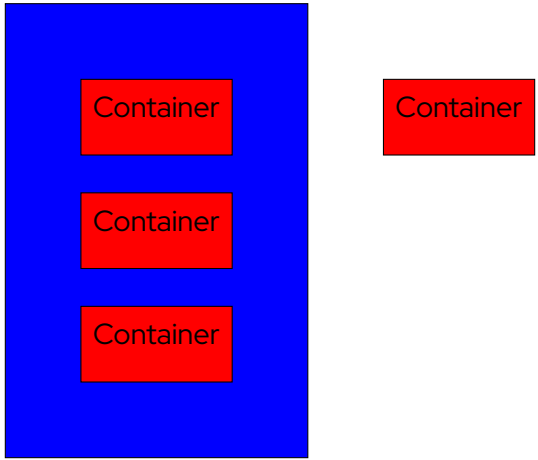

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Container Live Migration

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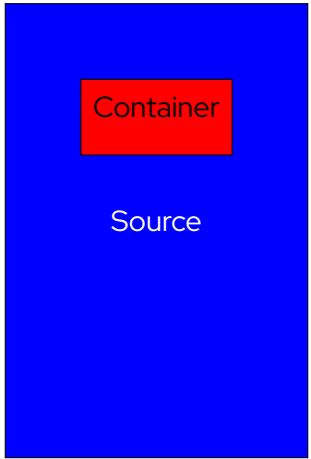

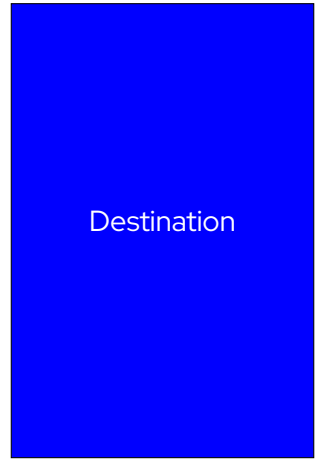

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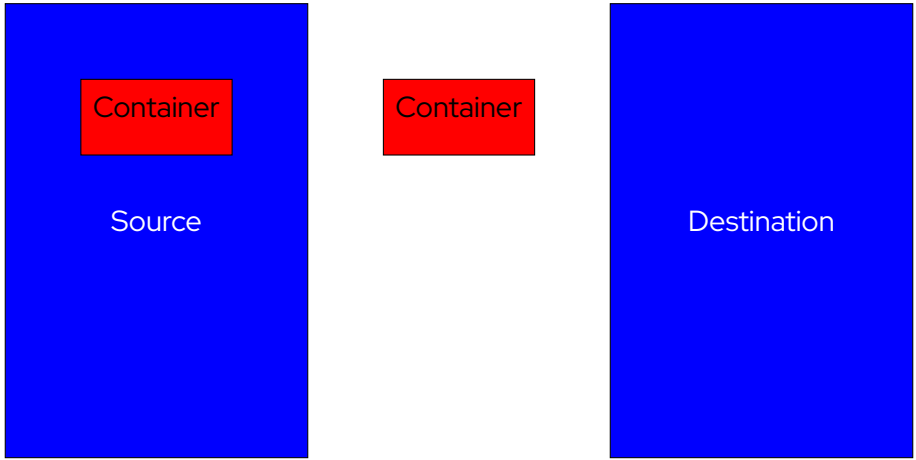

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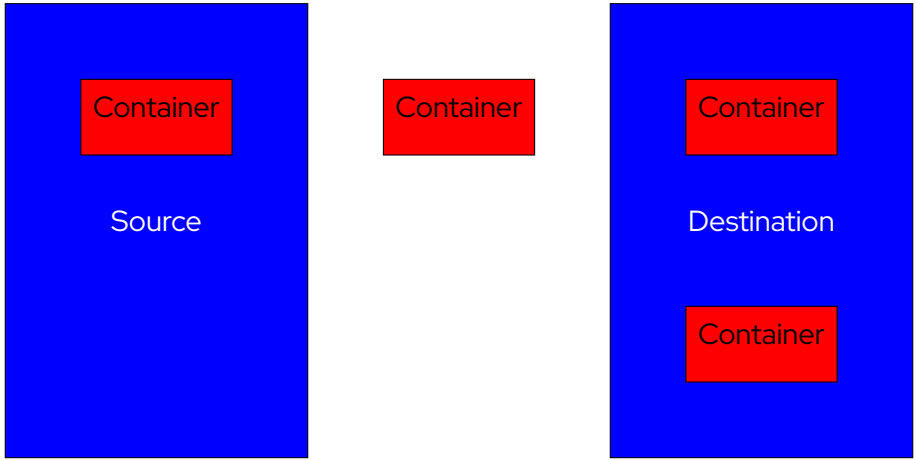
Container
Source
Container
Container
Destination
Container

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CRIU

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First Step: Checkpointing

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Seize Process Using

`ptrace()`

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Collect Details From

/proc/<PID>/*

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Parasite Code

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Parasite Code

Most favorite part

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Parasite Code

And the craziest

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Parasite Code

Injected into the process

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Parasite Code

Daemon waiting for commands

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Parasite Code

Removed after usage

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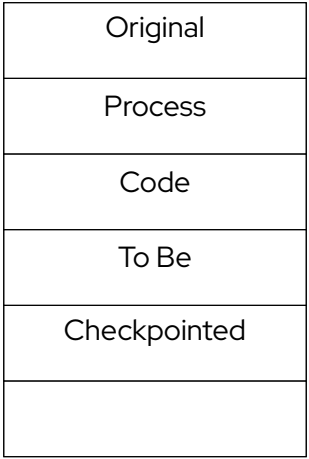

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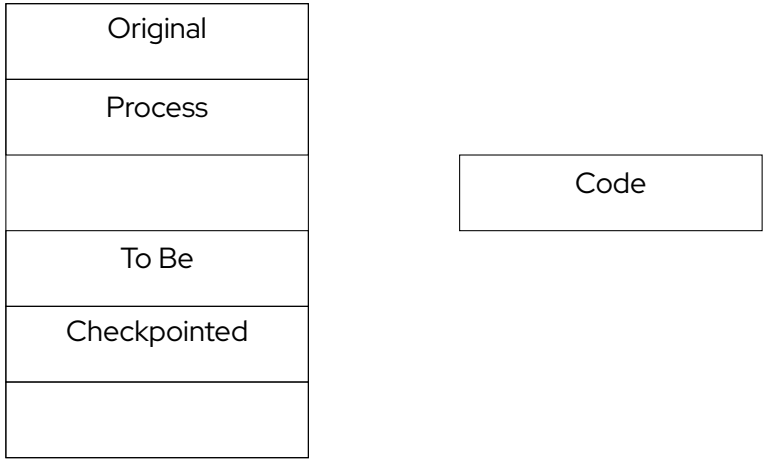

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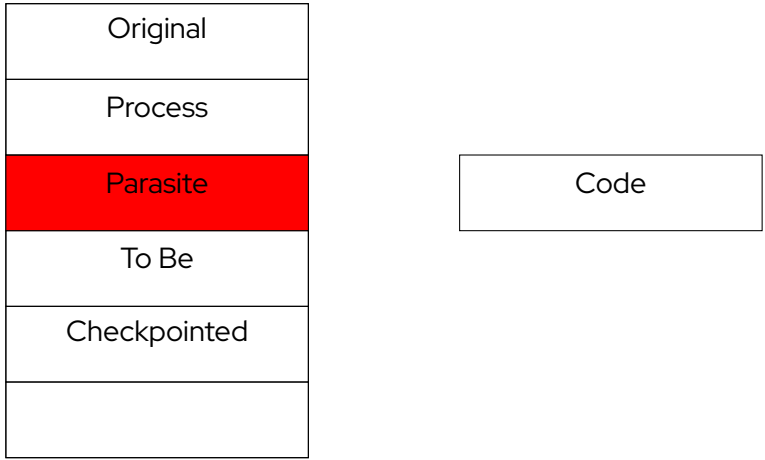

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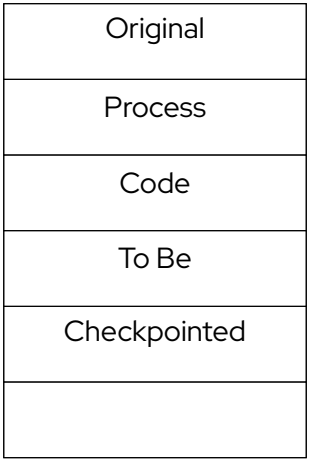

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Checkpointing Finished

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Checkpointing Finished

All relevant information written

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Checkpointing Finished

Target process is killed

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Checkpointing Finished

Or continues to run

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Second/Last Step: Restoring

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Read Checkpoint Images

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`clone()` For Each PID/TID

`clone3()` with Linux 5.5

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CRIU Morphs Itself

Open and position file descriptors

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CRIU Morphs Itself

Map memory pages

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CRIU Morphs Itself

Load security settings

Red Hat

CRIU Morphs Itself

Jump into restored process

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```
# podman run --rm -d adrianreber/wildfly-hello
699f33eb7fecbc5bbb00400be0aa79c888dbc63a54cac7bd2eed836a57d8a68a
# podman inspect -l --format "{{.NetworkSettings.IPAddress}}"
10.88.0.247
# curl 10.88.0.247:8080/helloworld/
0
# curl 10.88.0.247:8080/helloworld/
1
# podman container checkpoint -l --export=/tmp/chkpt.tar.gz
699f33eb7fecbc5bbb00400be0aa79c888dbc63a54cac7bd2eed836a57d8a68a
# scp /tmp/chkpt.tar.gz rhel08:/tmp
```


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```
# podman container restore --import=/tmp/chkpt.tar.gz
699f33eb7fecbc5bbb00400be0aa79c888dbc63a54cac7bd2eed836a57d8a68a
# podman inspect -l --format "{{.NetworkSettings.IPAddress}}"
10.88.0.247
# curl 10.88.0.247:8080/helloworld/
2
# curl 10.88.0.247:8080/helloworld/
3
```


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```
# podman container restore --import=/tmp/chkpt.tar.gz -n hello1
d02feeec894d77f66cc82484fe77ae369396a85f6d05594dc156c21e685942dd
# podman container restore --import=/tmp/chkpt.tar.gz -n hello2
735efb4fee6961d3eee069beb28dde5cbc6fc46c1a32a43ecc993d04c02015b2
# podman inspect --format "{{.NetworkSettings.IPAddress}}" hello1
10.88.0.248
# podman inspect --format "{{.NetworkSettings.IPAddress}}" hello2
10.88.0.249
# curl 10.88.0.248:8080/helloworld/
2
# curl 10.88.0.249:8080/helloworld/
2
```


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Future:

`kubectl migrate`

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Future:

Non-root checkpoint/restore

`CAP_CHECKPOINT_RESTORE`

Red Hat

Summary

- CRIU can checkpoint and restore containers
- Integrated in different containers engines
- Used in production
- Reboot into new kernel without losing container state
- Start multiple copies
- Migrate running containers

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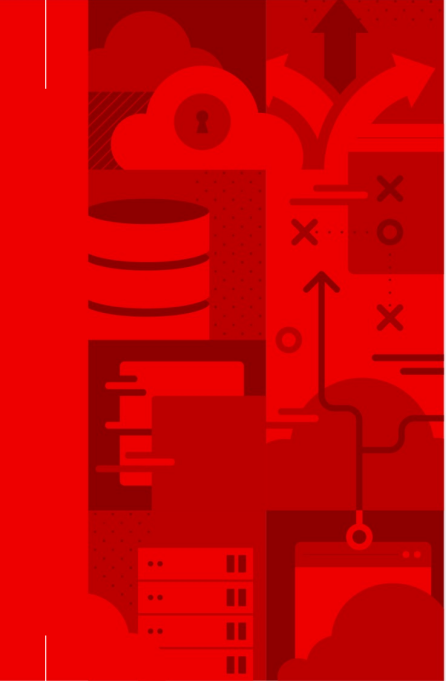

Thank you

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