rkt and Kubernetes

What's new (and coming) with
Container Runtimes and Orchestration

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CoreOS

Why rkt and Kubernetes?

~~Why rkt and Kubernetes?~~
Why container runtimes and orchestration?

CoreOS, Inc (2013 - today)

Mission: "Secure the Internet"

Started at the OS level: CoreOS Linux

- Modern, minimal operating system
- Self-updating (read-only) image
- Updates must be *automatic* and *seamless*

Automatic and *seamless*

- If the OS is always updating, what about applications running on it?
- Classic use case for *containers* and *orchestration*
  - *containers* decouple the application and OS update lifecycles (update at different cadences)
  - *orchestration* decouples application and OS uptime (services can remain unaffected during OS downtime)

kernel
systemd
rkt
ssh
docker

python
java
nginx
mysql
openssl

distro distro distro distro distro distro distro distro

app

kernel
systemd
rkt
ssh
docker

distro distro distro distro distro distro

python
java
nginx
mysql
openssl

app

kernel
systemd
rkt
ssh
docker

distro distro distro distro distro distro

python openssl-A	app1
java openssl-B	app2
java openssl-B	app3

CoreOS

distro distro distro distro distro distro

container

container

container

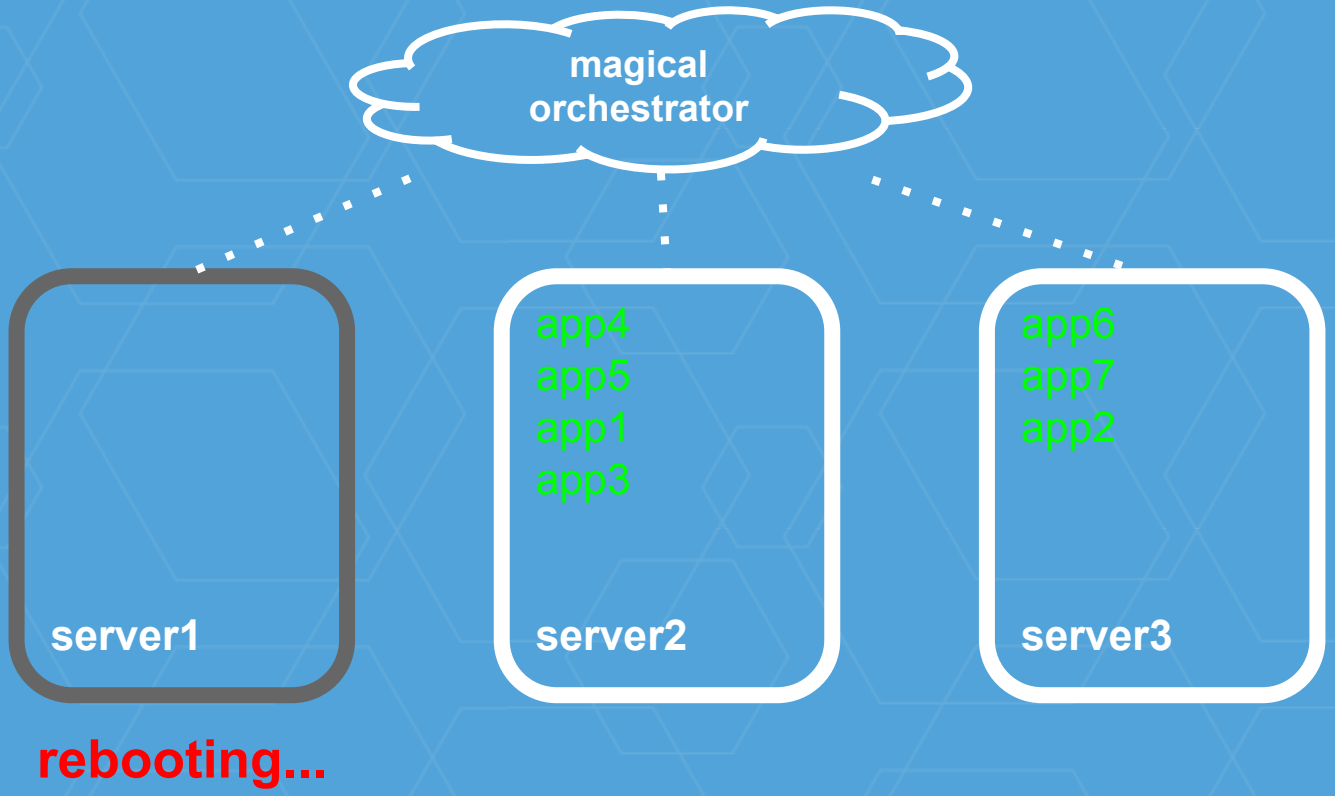

app1
app2
app3
server1
app4
app5
server2
app6
app7
server3

updating...

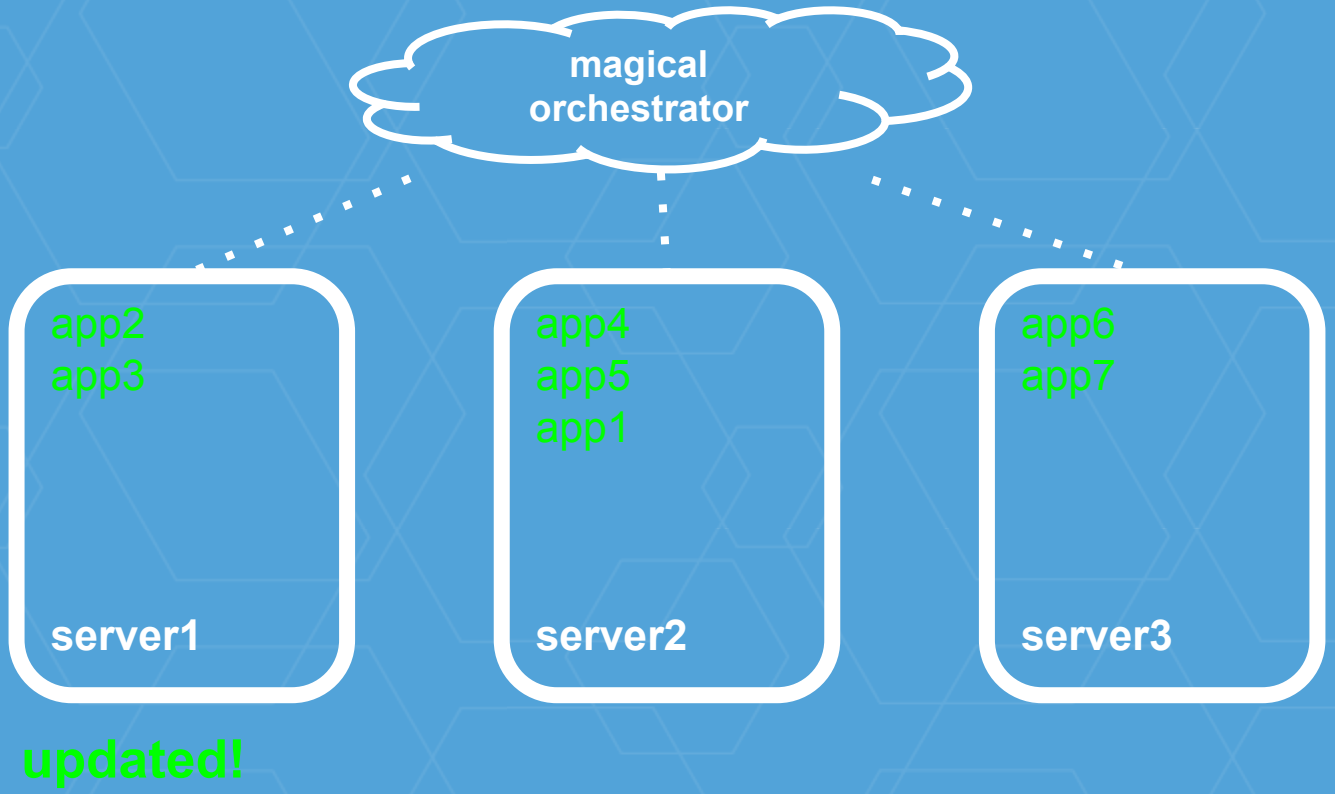
needs reboot

Without orchestration

With orchestration



With orchestration

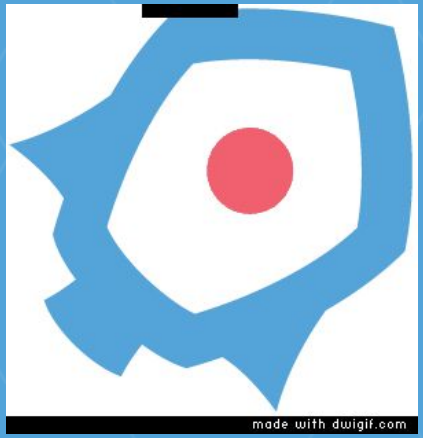


Why container runtimes and orchestration?

So we can provide *seamless updates* and push forward the security of application servers

Why rkt?

The simple answer:
Containers are cool



A long time ago in an ecosystem far, far away....

(2014, to be precise)

2014

- Large incumbent container tool (in CoreOS)
- *Common* practices, but few *best* practices
  - unsigned images (`curl | sudo sh -`)
  - inefficient/insecure images (`FROM ubuntu:14.04`)
  - PID1 or not to PID1 (zombie reaping problem)
- New platforms emerging, difficult to integrate
  - `systemd` + `dockerd` = sad times had by all

Enter `rkt` (and appc)

- Create an alternative container runtime (competition drives innovation)
- Emphasise the importance of *security*
- Spur the conversation around *standards* in the application container ecosystem

rkt

a modern, secure container runtime
a simple, composable tool
an implementation of an open standard

appc

a standard application container

open specification

associated tooling

appc

github.com/appc/spec
github.com/appc/acbuild
github.
com/appc/docker2aci
github.com/appc/cni
github.com/appc/...

appc

github.com/appc/spec ("appc spec")
github.com/appc/acbuild
github.com/appc/docker2aci
github.com/appc/cni (more on this later..)
github.com/appc/...

appc spec in a nutshell

- Image Format (ACI)
  - what does an application consist of?
- Image Discovery
  - how can an image be located?
- Pods
  - how can applications be grouped and run?
- Executor (runtime)
  - what does the execution environment look like?

appc spec in a nutshell

- Image Format (ACI)
  - what does an application consist of?
- Image Discovery
  - how can an image be located?
- **Pods**
  - **how can applications be grouped and run?**
- Executor (runtime)
  - what does the execution environment look like?

appc pods

- grouping of applications executing in a shared context (network, namespaces, volumes)
- shared fate
- the *only* execution primitive: single applications are modelled as singleton pods

appc pods ≈ Kubernetes pods

- grouping of applications executing in a shared context (network, namespaces, volumes)
- shared fate
- the *only* execution primitive: single applications are modelled as singleton pods

a modern, secure container runtime
a simple, composable tool (CLI)
an implementation of an open standard (appc)

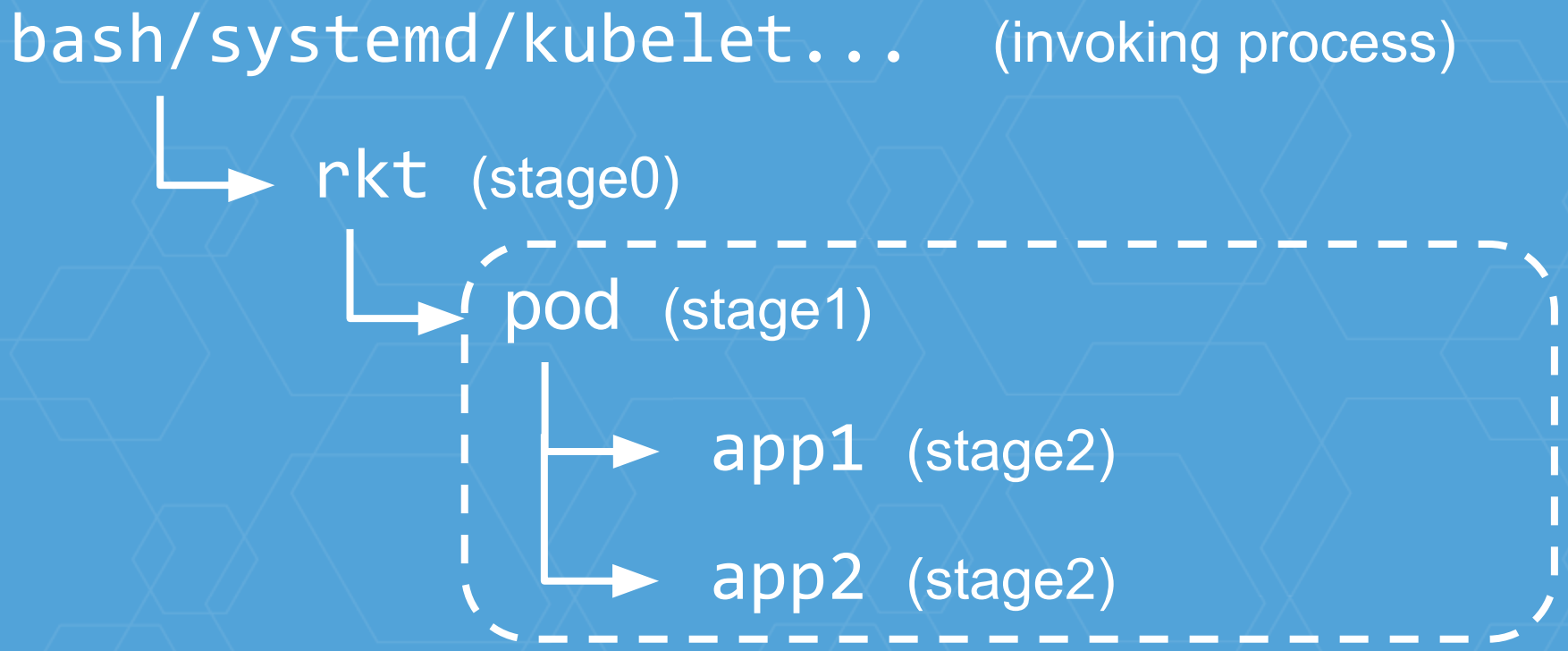
rkt - simple CLI tool

no central daemon
no (mandatory) API
apps run directly under spawning process

```
bash/systemd/kubelet
└─▶ rkt run ...
    └─▶ application(s)
```

rkt internals

modular architecture
execution divided into *stages*
stage0 → stage1 → stage2


bash/systemd/kubelet...
(invoking process)
rkt
(stage0)
pod
(stage1)
app1
(stage2)
app2
(stage2)

stage0 (rkt binary)

- primary interface to rkt
- discover, fetch, manage application images
- set up pod filesystems
- manage pod lifecycle
  - rkt run
  - rkt image list
  - rkt gc
  - ...

stage1 (swappable execution engines)

- default implementation
  - based on systemd-nspawn+systemd
  - Linux namespaces + cgroups for isolation
- kvm implementation
  - based on lkvm+systemd
  - hardware virtualisation for isolation
- others?

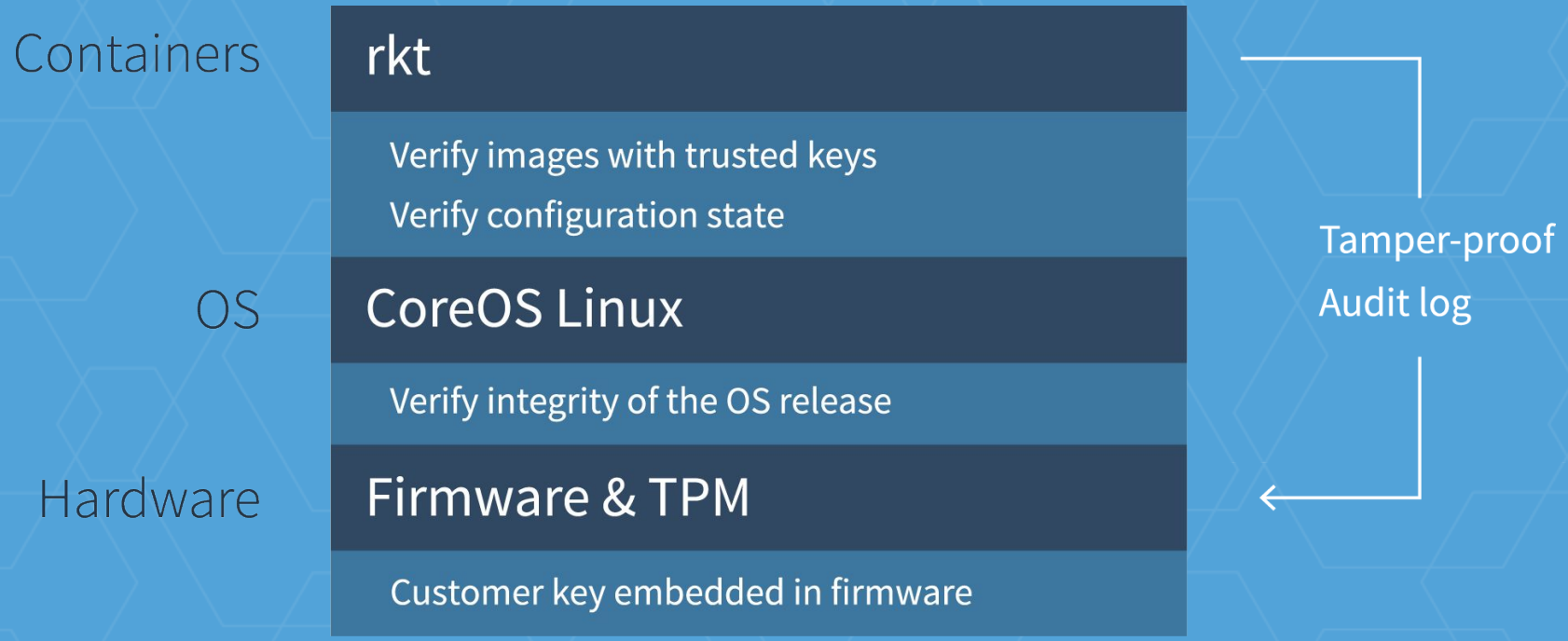
stage2 (inside the pod)

- actual app execution
- independent filesystems (`chroot`)
- shared namespaces, volumes, IPC, ...

rkt TPM measurement (new!)

- TPM, Trusted Platform Module: hardware module with cryptographic keys
- Used to "measure" system state
- Historically just use to verify bootloader/OS
- CoreOS added support to GNU Grub
- rkt can now record information about running pods in the TPM

rkt TPM measurement (new!)



rkt API service (new!)

- optional, gRPC-based API daemon
- exposes information on pods and images
- runs as unprivileged user
- read-only
- easier integration with other projects (ahem..)

Why rkt?

Secure
Standards
Composable

Why Kubernetes?

Why Kubernetes?

- Builds on incredible accumulated experience
  - (from the people who *created* Linux containers..)
- Wide industry and community support
- Extensible, versatile, all OSS
- The best is yet to come...
  - multi-cluster, federation
  - Deployment API
  - scalability and scheduling

+

kubernetes

rkt + Kubernetes

how does rkt <3 k8s? let me count the ways...

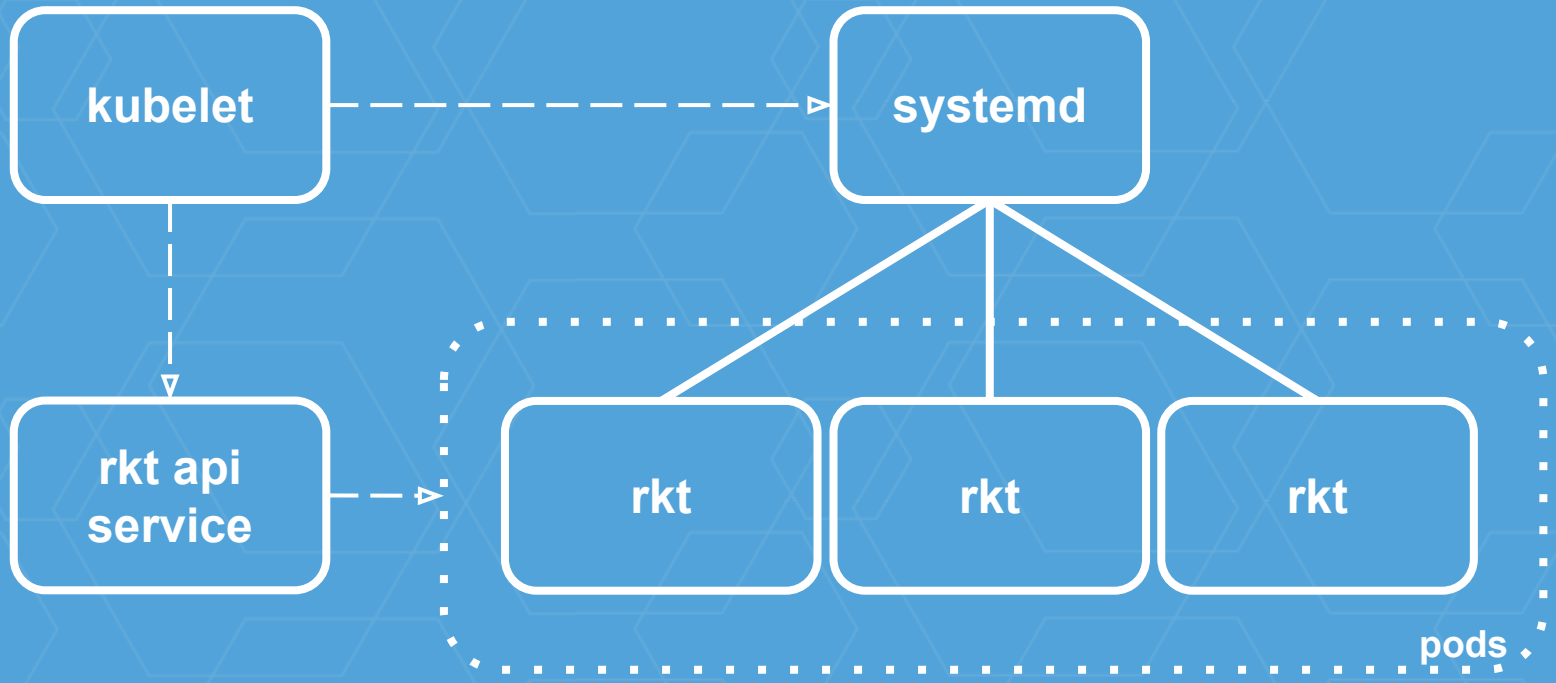
- rkt as container runtime (aka "*rktnetes*")
- rkt running Kubernetes ("*rkt fly*")
- rkt networking (CNI)

rktnetes

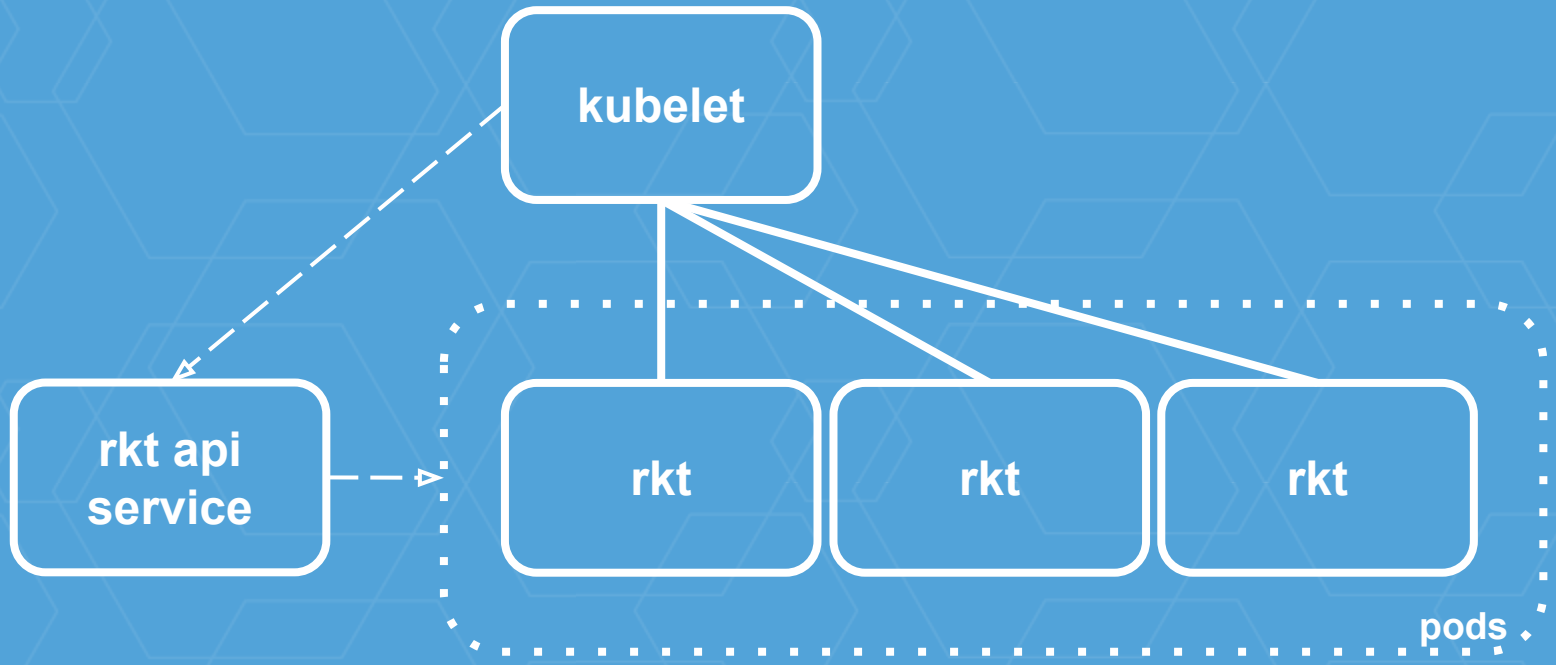
Using rkt as the kubelet's container runtime

- A *pod-native* runtime
- First-class integration with systemd hosts
- *self-contained pods* process model = no SPOF
- Multiple-image compatibility (e.g. `docker2aci`)
- Transparently swappable container engines

Kubelet + rkt (rktnetes - with systemd)



Kubelet + rkt (rktnetes - without systemd)

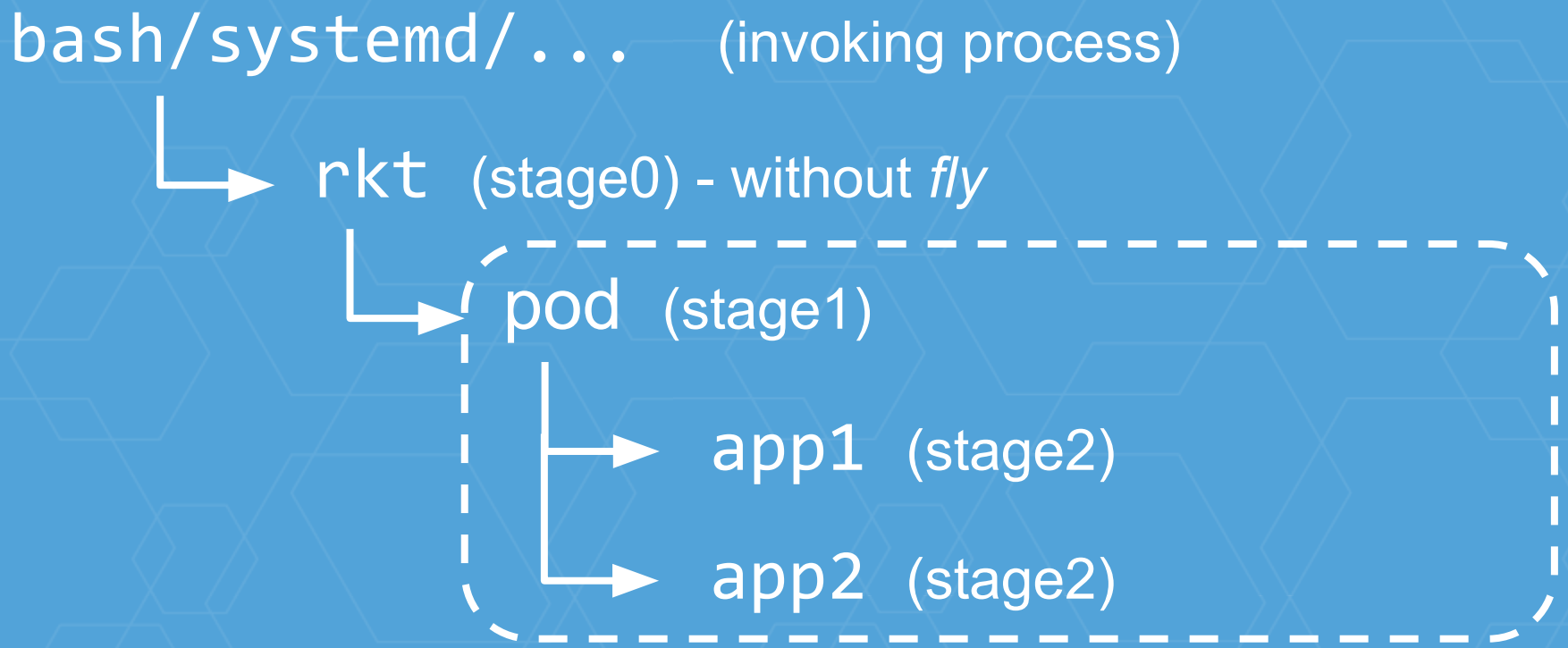


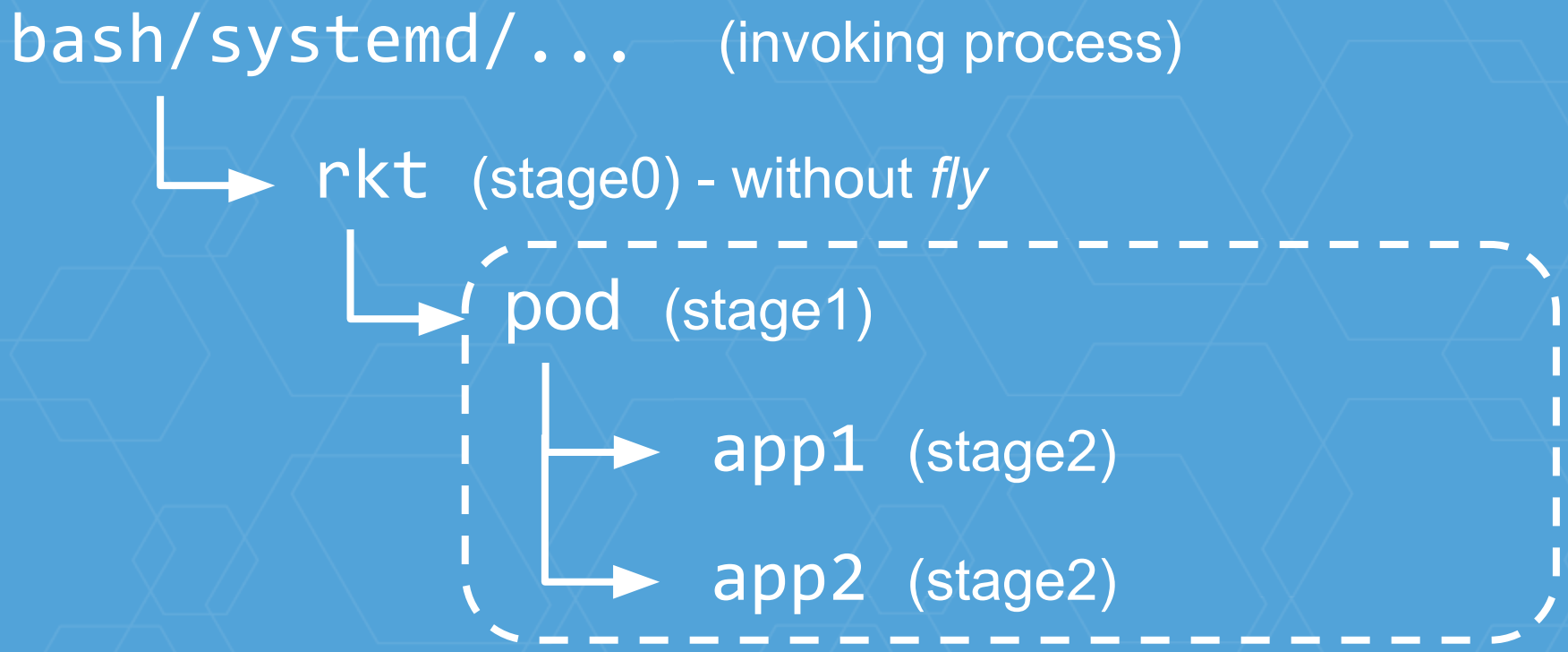
Using rkt to run Kubernetes

- Kubernetes components are largely self-hosting, but not entirely
- Need a way to bootstrap kubelet on the host
- On CoreOS, this means in a container..
- ... but kubelet has some unique requirements (like mounting volumes on the host)

Using rkt to run Kubernetes

- `rkt` "fly" feature (new in rkt 0.15.0)
- unlike `rkt run`, does *not* execute pods
- execute a *single application* in an *unconstrained environment*
- all the other advantages of rkt (image discovery, signing/verification, management)


bash/systemd/...
(invoking process)
rkt
(stage0) - without *fly*
pod
(stage1)
app1
(stage2)
app2
(stage2)



Isolated mount (and PID, ...) namespace

`bash/systemd/...` (invoking process)

`rkt` (stage0) - with *fly*

application

`bash/systemd/...` (invoking process)

`rkt` (stage0) - with *fly*

application

Host mount (and PID, ...) namespace

`bash/systemd/...` (invoking process)

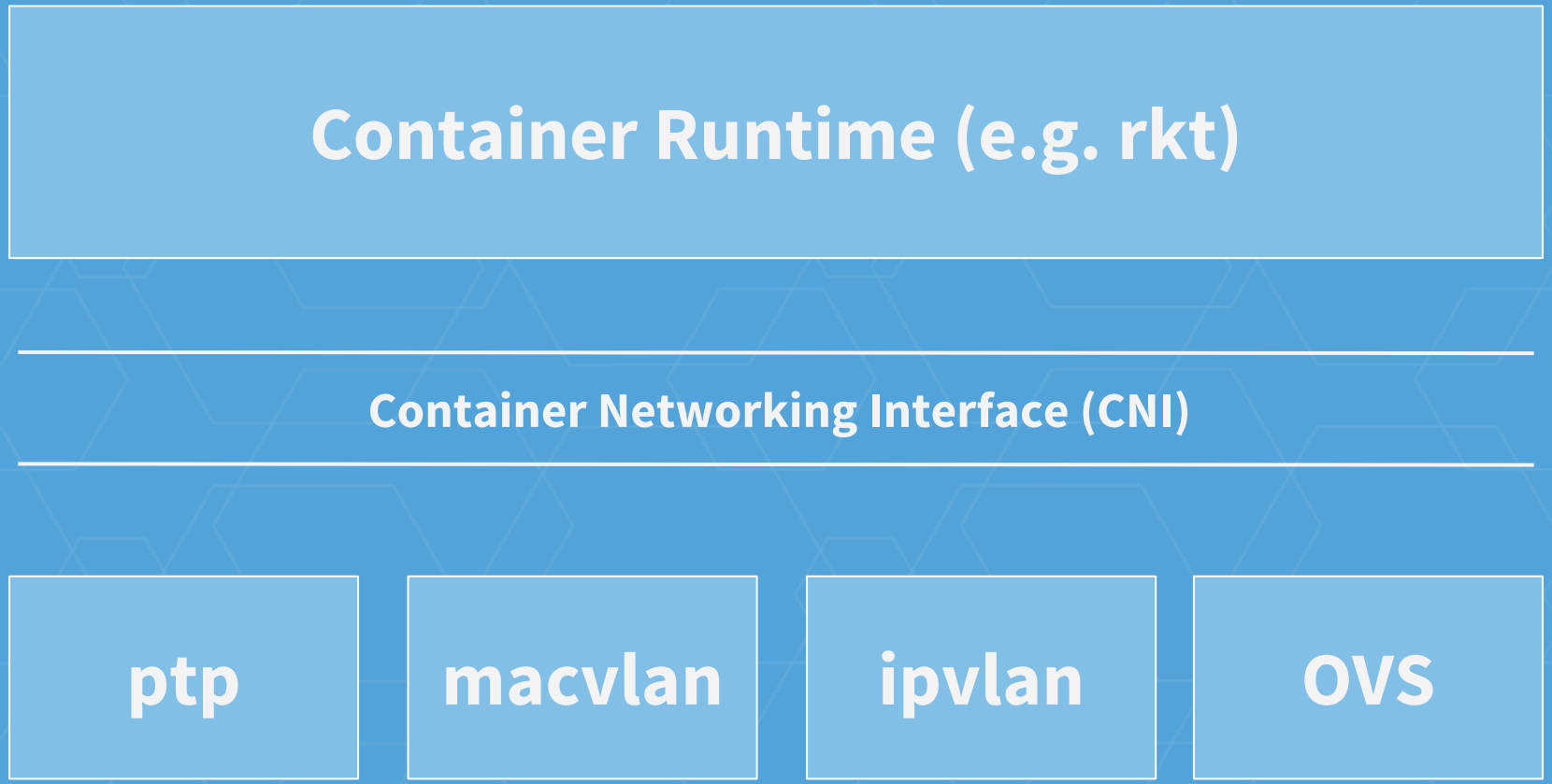
→ `rkt` (stage0) - with *fly*

→ `kubelet`

Host mount (and PID, ...) namespace

rkt networking

Plugin-based
IP(s)-per-pod
Container Networking Interface (CNI)


Container Runtime (e.g. rkt)
Container Networking Interface (CNI)
ptp
macvlan
ipvlan
OVS

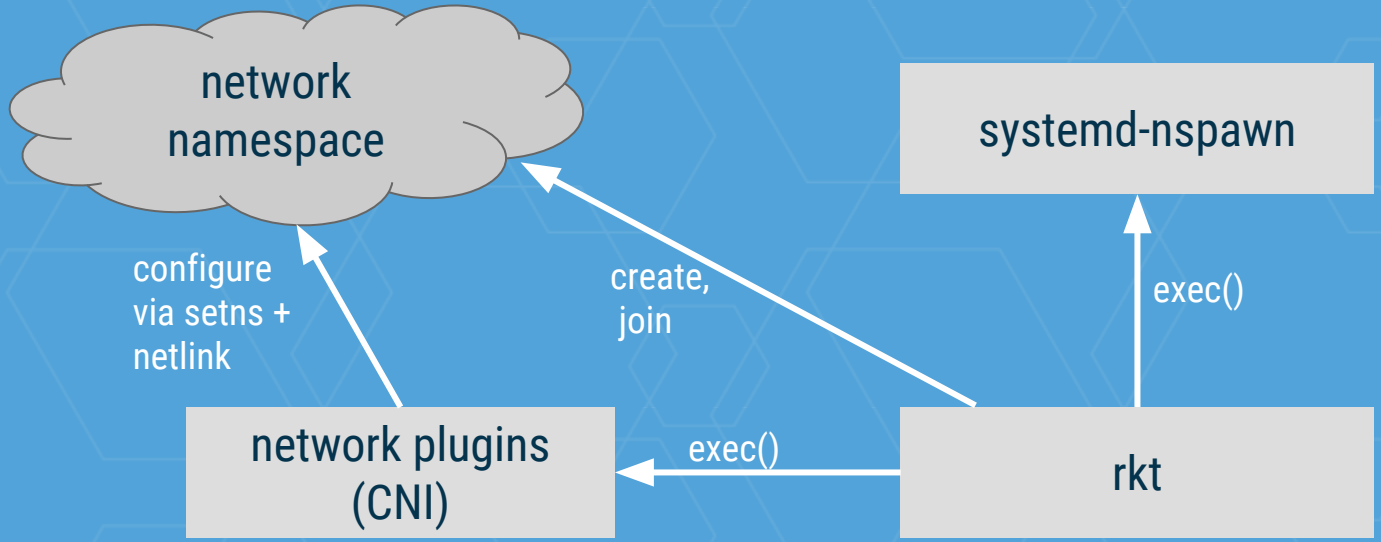
CNI in a nutshell

- Container can join multiple networks
- Network described by JSON config
- Plugin supports two commands
  - ADD container to the network
  - REMOVE container from the network

CNI: example configuration

```
{
    "name": "mynet",
    "type": "ptp",
    "ipam": {
        "type": "host-local",
        "subnet": "10.1.1.0/24"
    }
}
$ rkt run --net=mynet coreos.com/etcd
```

How rkt uses CNI



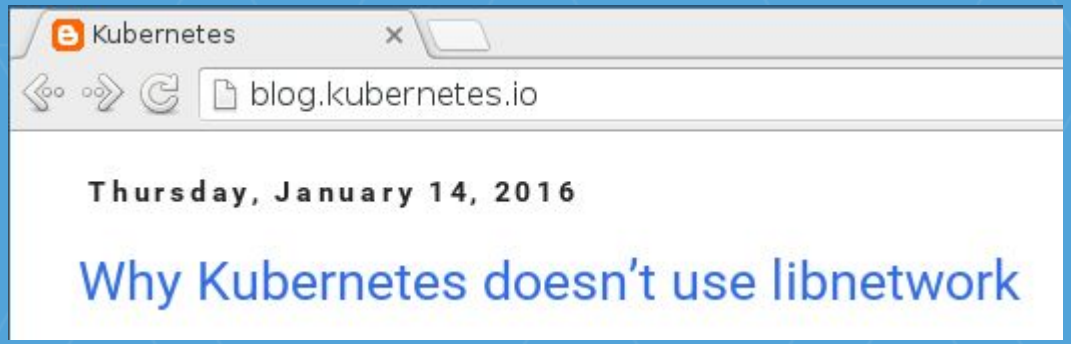
`/var/lib/rkt/pods/run/$POD_UUID/netns`

Kubernetes networking

Plugin-based (but never left alpha)
IP(s)-per-pod
(sound familiar?)

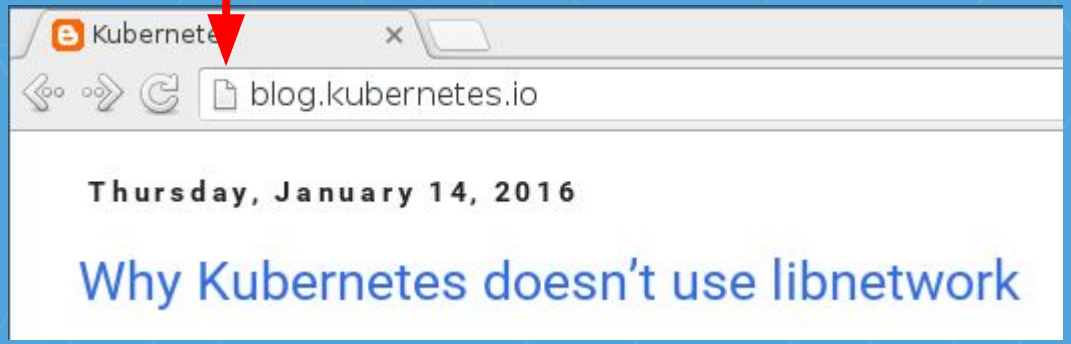
Kubernetes and CNI

Previously CNI was just another plugin type, but soon to be "*the* Kubernetes plugin model"



(sidenote: don't be like this)

:-(



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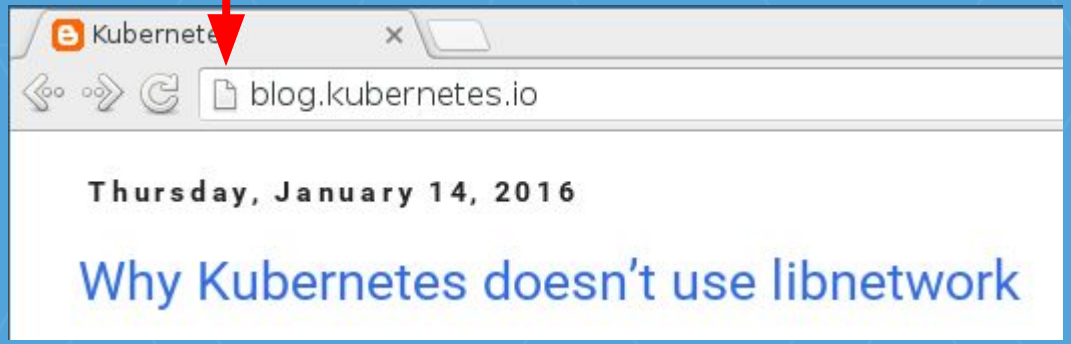
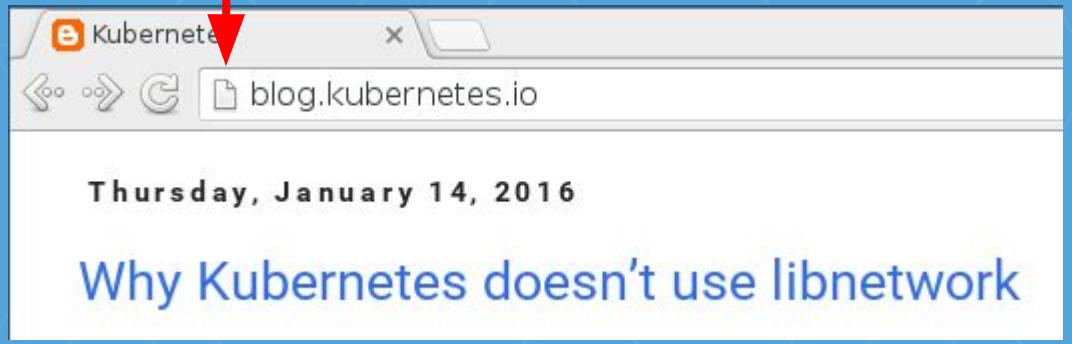



```
curl  -v https://kubernetes.io/
*   Trying 192.30.252.154...
```

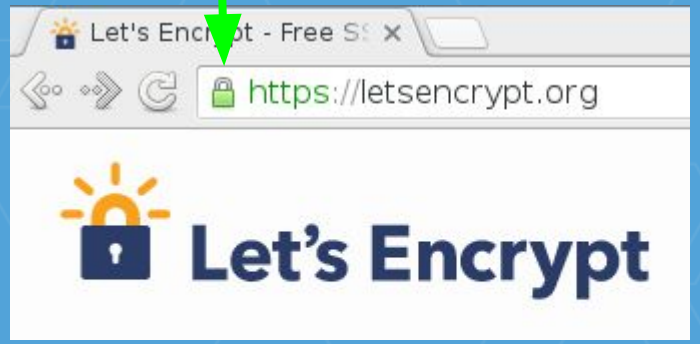
(sidenote: don't be like this)

:-(




```
curl  -v https://kubernetes.io/
*   Trying 192.30.252.154...
```

:-)



Looking ahead

What's coming up for rkt and Kubernetes

First things first...

get things stable

rkt v1.0.0

very, very soon...
stable API, CLI, on-disk format
ready to use in production!

rkt v1.0.0

very, very soon...
stable API, CLI, on-disk format
recommended to use in production!

rktnetes 1.0

2016Q1

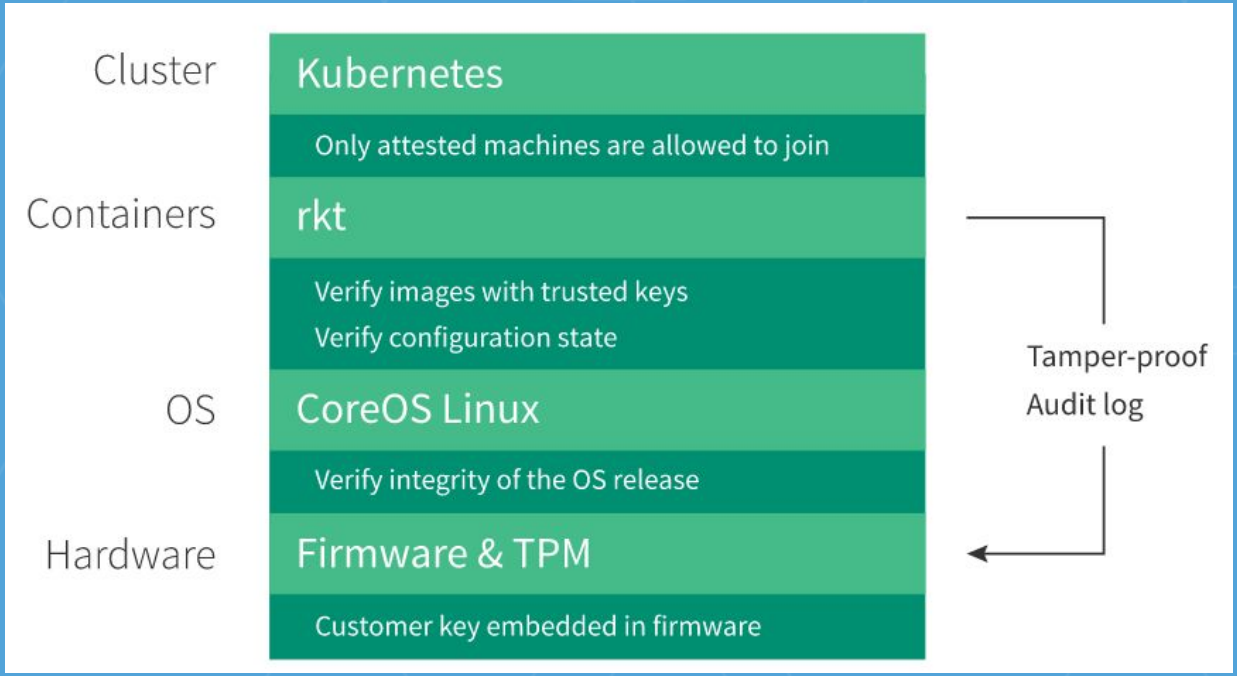
Fully supported, full feature parity

Automated testing on CoreOS

rktnetes 1.0+

LKVM backend by default
Native support for ACIs in Kubernetes
TPM at the Kubernetes level

Tectonic Trusted Computing



https://coreos.com/blog/coreos-trusted-computing.html

Kubelet upgrades

- Remember from CoreOS mission:
  "updates must be *automatic* and *seamless"*
- If kubelet is in OS, must be upgraded in lock-step
- But mixed-version clusters don't always work

(e.g. upgrading from 1.07 - 1.1.1: https://github.com/kubernetes/kubernetes/issues/16961)

Kubelet upgrades

- Solution: API driven upgrades
- Small agent living on host, invoking kubelet (using rkt fly)
- Reading annotations from the kubelet API server
- Follow along:

https://github.com/coreos/bugs/issues/1051

tl;dr:

- Use `rkt` (it's secure, cool, (soon to be) stable)
- Use Kubernetes (for all those earlier reasons)

- Get involved and help define the future of application containers

May 9 & 10, 2016 - Berlin, Germany

coreos.com/fest - @coreosfest

Questions?

Join us!

contribute: github.com/coreos/rkt
careers: coreos.com/careers *(now in Berlin!)*

rkt security ("secure by default")

- image signature verification
- privilege separation
    - e.g. fetch images, expose API (new!) as non-root
- SELinux integration (although </3 overlayfs..)
- lkvm stage1 for true hardware isolation
- TPM attestation (new!)