Evolution of the Container Network Interface (CNI)

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Who am I?

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CNI maintainer
Rkt developer

The CNI

How it started

How it’s grown

New developments

What’s next

What is CNI?

A standard way to connect your containers to your network.

“Your network”

AWS? GCE? Bare Metal?

BGP? OSPF? OpenFlow? “API”?

Overlay networks?

Flat layer 2 space?

Specialized hardware?

What is CNI?

An API for networking vendors to implement.

A small library for runtimes to consume.

Contain the complexity

What is CNI?

A living, active open-source project with:

- 5 maintainers
- 60 contributors at 10+ companies
- 10+ plugin vendors
- 6+ runtimes

How did it start?

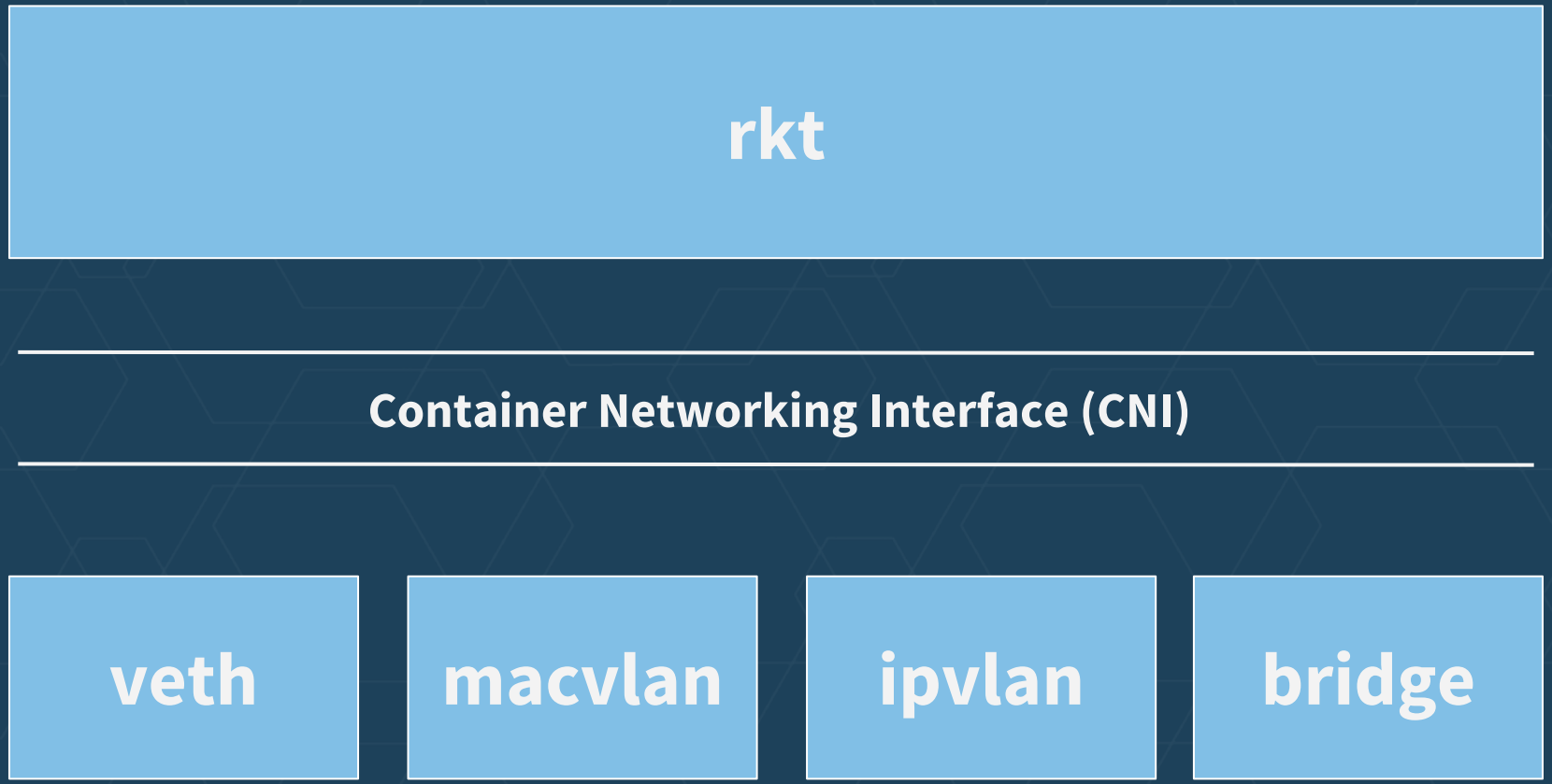
How did it start?

- Rkt is a daemonless container runtime
- No complicated data model or online DB
- Principle throughout rkt is “clean integration points”

How did it start?

Need for a simple way to “bring this namespace online”

- Handling namespaces in golang is painful
- Let’s initialize the network in a separate process
- And define an interface


rkt
Container Networking Interface (CNI)
veth
macvlan
ipvlan
bridge

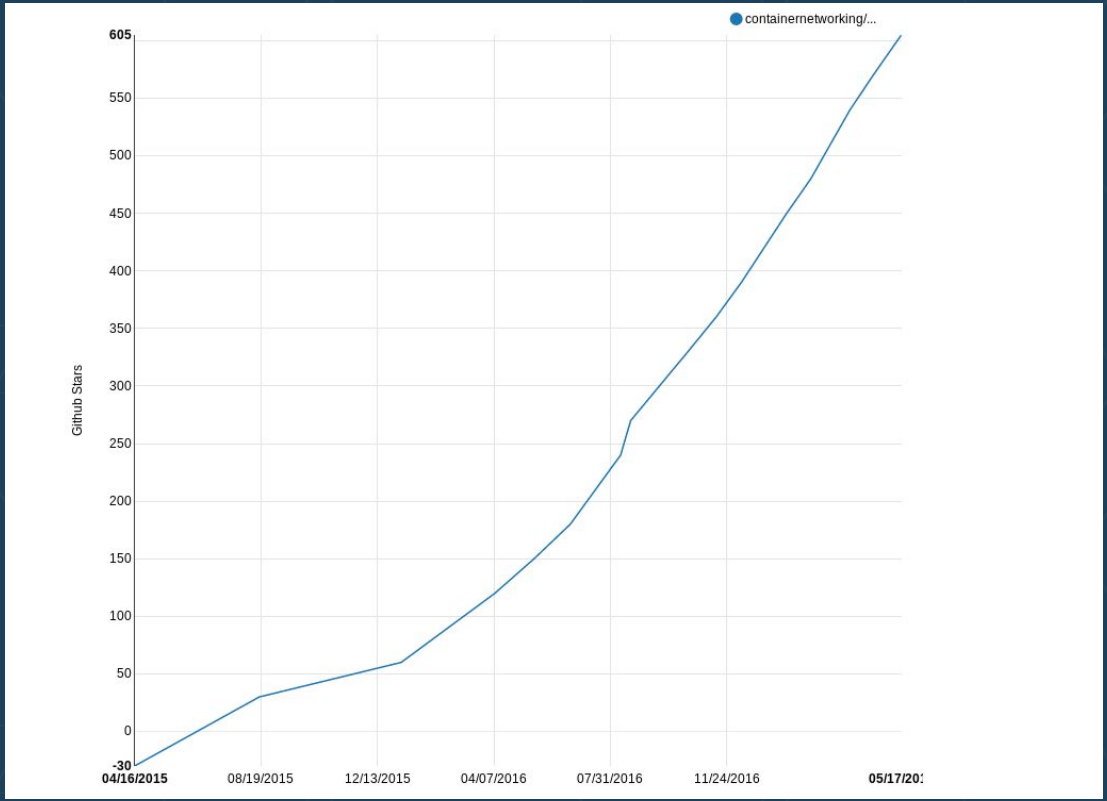
Adoption & Growth

- Spec separated from rkt April 2015
- Replaced Kubernetes network plugin API ~Oct 2015
- Mesos supports CNI from May 2016

Who uses it? - Vendors

- Canonical Kubernetes
- Tectonic by CoreOS
- Redhat Openshift
- “Kubenet” plugin

Science!


containernetworking/...
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11/24/2016
05/17/20

Technical introduction

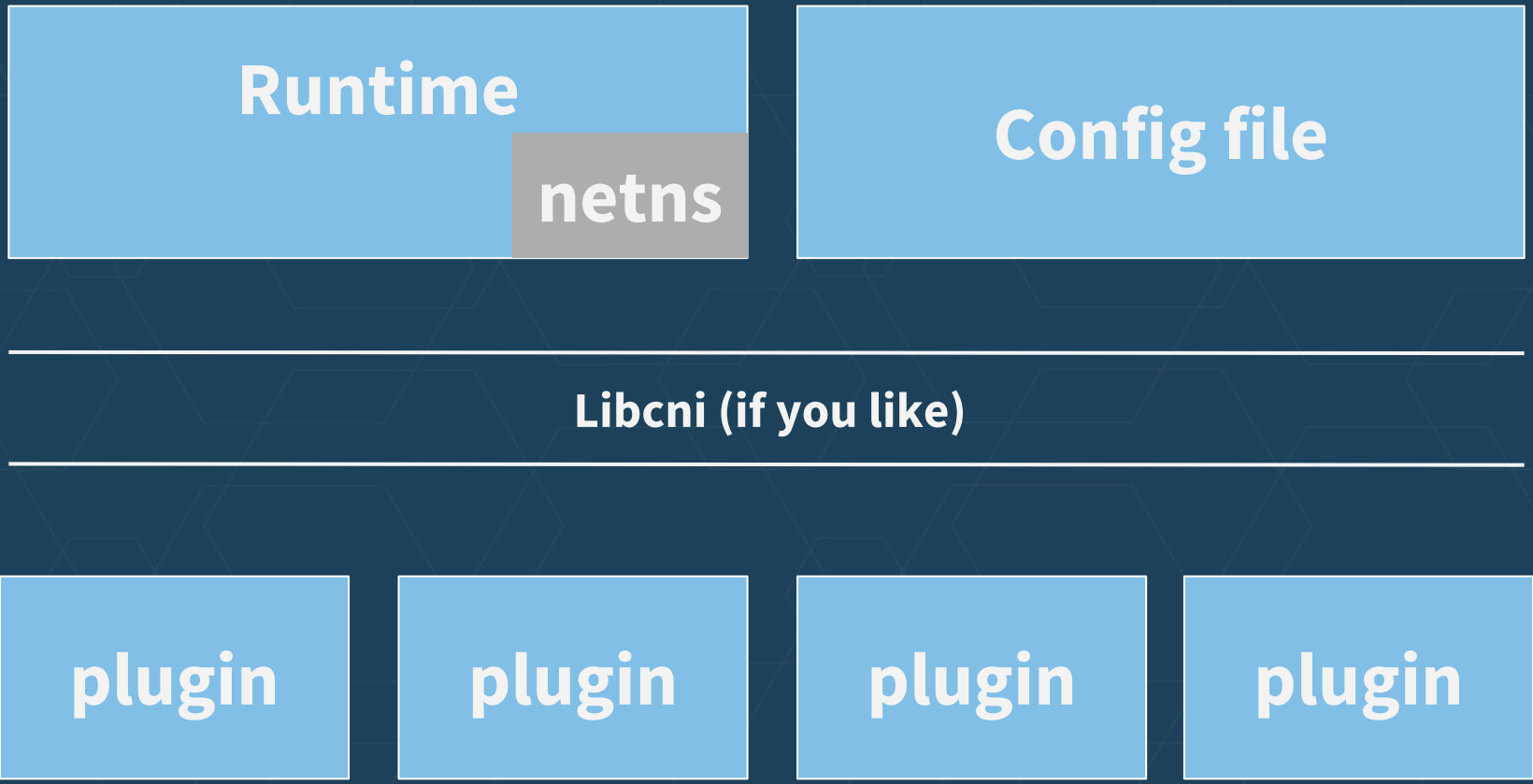
Technical Overview

Simple model:

- Runtime Config
- Network Config
- Plugin
- Result

Result:

- Interfaces
- Addresses
- Routes
- DNS


Runtime
netns
Config file
Libcni (if you like)
plugin
plugin
plugin
plugin

Example invocation

```
$ cat /etc/cni/net.d/10-net.conf
{ "name": "mynet",
  "type": "bridge",
  "ipam": {
    "type": "host-local",
    "subnet": "10.42.0.0/24" }
}
```

Example invocation

```
$ rkt run --net=mynet docker://redis
- Or -
$ kubelet … --network-plugin=cni …
```

Example invocation

```
$ rkt run --net=mynet …
```

Example invocation

```
# ip netns new test
# ip netns exec test /bin/bash
# ip link
1: lo: <LOOPBACK> …
#
```

Example invocation

```
CNI_COMMAND=ADD \
CNI_CONTAINERID=example \
CNI_NETNS=/var/run/netns/test \
CNI_IFNAME=eth0 \
CNI_PATH=/opt/cni/bin:. \
  ./bridge < 10-net.json
```

Example invocation

```
# ip link
1: lo: …
5: eth0@if9: …
# ip -4 addr show dev eth0
5: eth0@if9: …
    inet 10.42.0.107/24
```

CNI spec

- 3 commands: ADD, DELETE, and VERSION
- Configuration on stdin, results on stdout
- Runtime parameters via env
  - CNI_ARGS for arbitrary runtime params

CNI spec

- For golang runtimes, libcni implements most boilerplate.

- Response types are versioned
  - Lossy conversion between versions

CNI spec - IPAM

IPAM is an interesting case

- Needs to be separate plugin
- Solution: CNI!
  - Plugin uses CNI API to discover & execute IPAM plugin
- Ordering is subtle
  - DHCP: IF needs to exist to make request

Use cases & Plugins

What plugins exist?

Basic:

Bridge, veth

Muxing:

Macvlan, ipvlan

Overlay networks:

Flannel, Calico, Weave

IPAM:

Host-local, dhcp, Infoblox

What plugins exist?

Cilium: BPF-based networking

- No more iptables & conntrack!
- I want to give Mellanox all my money

SR-IOV: PCI sub-devices

- I am doing HFT and want to give Intel even more of my money

Common CNI setups

Bridge + port forwarding

- “I’ll use the host IP for everything”
- Pods not otherwise reachable

Common CNI setups

Macvlan + DHCP

- “I already have an expensive network”
- “And an expensive network admin”
- Watch those CAM tables!

Each pod directly connected to network

Common CNI setups

Flannel, Weave, or Calico

- “I have a network I can’t change”
  - E.g. AWS VPC
- Routes are distributed using some other database
  - Flannel: etcd
  - Calico: bgpd

What's new with CNI?

Spec version v0.3

Awesome logo (Thanks, LF!)

CNI

What's new in v0.3

- Type enhancements
- Plugin chaining
- Capability arguments

Type enhancements in v0.3

New result type adds:

- Multiple IPs
- Interfaces
  - Including host-side interface

ConfigLists / Plugin Chaining

IPAM separated some common behavior.

Add post-creation plugins too!

Plugin chaining

Motivating examples: anything that tweaks an existing interface or IP

- Port forwarding
- Sysctl tuning
- Traffic shaping
- SLAAC?

Plugin chaining

New configuration format

- Just a list of configuration blocks
- Runtime chains previous result

```
{ "name": "dbnet",
  "plugins": [
    { "type": "bridge",
      "ipam": {
        "type": "host-local",
        "subnet": "10.1.0.0/16" }
    },
    { "type": "tuning",
      "sysctl": {
        "net.core.somaxconn":
"500" }
    }
    ]
}
```

Chained plugins

Existing:

- Tuning
- Iptables-based port forwarding

Future:

- Bridge (for virtual machines, etc.)

Capability arguments

The problem:

I want to forward ports dynamically.

```
( curl http://127.0.0.1:8080 )
```

Capability arguments

The problem

- CNI_ARGS too freeform
- Don’t want to put rewrite logic in the runtime
- Don’t know *which* plugin does the forwarding
  - Remember Cilium?

Capability arguments

Need a way to pass in

- Dynamic (run-time)
- Structured
- Plugin-agnostic (sort of) configuration

To one or more plugins in a chain.

Capability Arguments

Don’t want

- Templating language
- Complicated runtime
- JSON in an environment variable

Capability arguments

Solution:

- Spec defines “capabilities”
- Plugins declare support
- Libcni patches arguments into config
  - Yes, it’s JSON manipulation, but it’s standardized

Capability arguments

```
{
  "type": "portmap-iptables",
  "capabilities": {"portMappings": true},
}
```

Becomes:

```
{ "type": "portmap-iptables",
  "runtimeConfig": {
    "portMappings": [
      {"hostPort": 80, "containerPort": 8080}
  ]},
}
```

Capability arguments

- Writing specs requires careful thought
- We all need to work together
- Many people contributed to the v0.3 upgrade
  - Esp. Kubernetes and Mesos devs

Putting it all together

```
LoadConfList( dir, name string)
  (*NetworkConfigList, error)

AddNetworkList(
  list *NetworkConfigList,
  rt *RuntimeConf) ->(Result, error)
```

What's Next?

New plugins!

I want YOU to write new plugins

- Firewalld integration
- Traffic shaping
  - Oh, and this is a new capability
- Better tuning
  - Some of you have some hard-learned TCP hacks

IPv6

Spec as written now makes v6 easy.

CNI-maintained plugins need some small tweaks.

A philosophical question: Is SLAAC an IPAM plugin?

Virtual machines

Spec does not actually require namespaces

Hyper and Intel working on this

Plugin chaining makes this a lot easier

CNCF

CNI (probably) going under the CNCF

Voting is underway now.

No real change, just formal recognition.

Splitting spec and code

Right now, all code under a single repository.

That was a mistake.

CNI-maintained plugins

In summary

In summary

CNI is a living, breathing project.

We’re entirely dependent on the community.

We want you to participate.

Participation

Write new plugins! It’s easy!

Document your use cases

File bugs, fix bugs

Join us in IRC (or slack…)

Cni-dev mailing list.

Monthly community sync.

CoreOS is running the world's containers

We're hiring (in Berlin!): careers@coreos.com

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rkt etcd

coreos.com

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Slack & IRC

More events: coreos.com/community

We're hiring: coreos.com/careers

Bonus slides

Example invocation

1. Rkt creates a network namespace
2. Rkt asks libcni to configure “mynet”
3. Libcni scans for file with “name: mynet”
4. Libcni parses out “type”; looks for binary
5. Libcni exec’s binary according to CNI spec
6. Binary creates network, returns result.