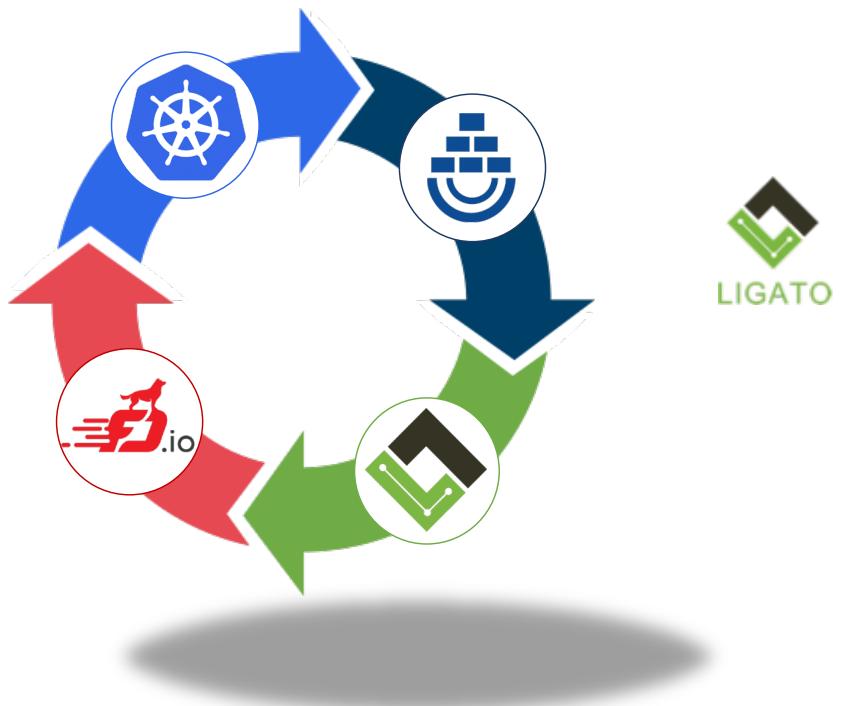


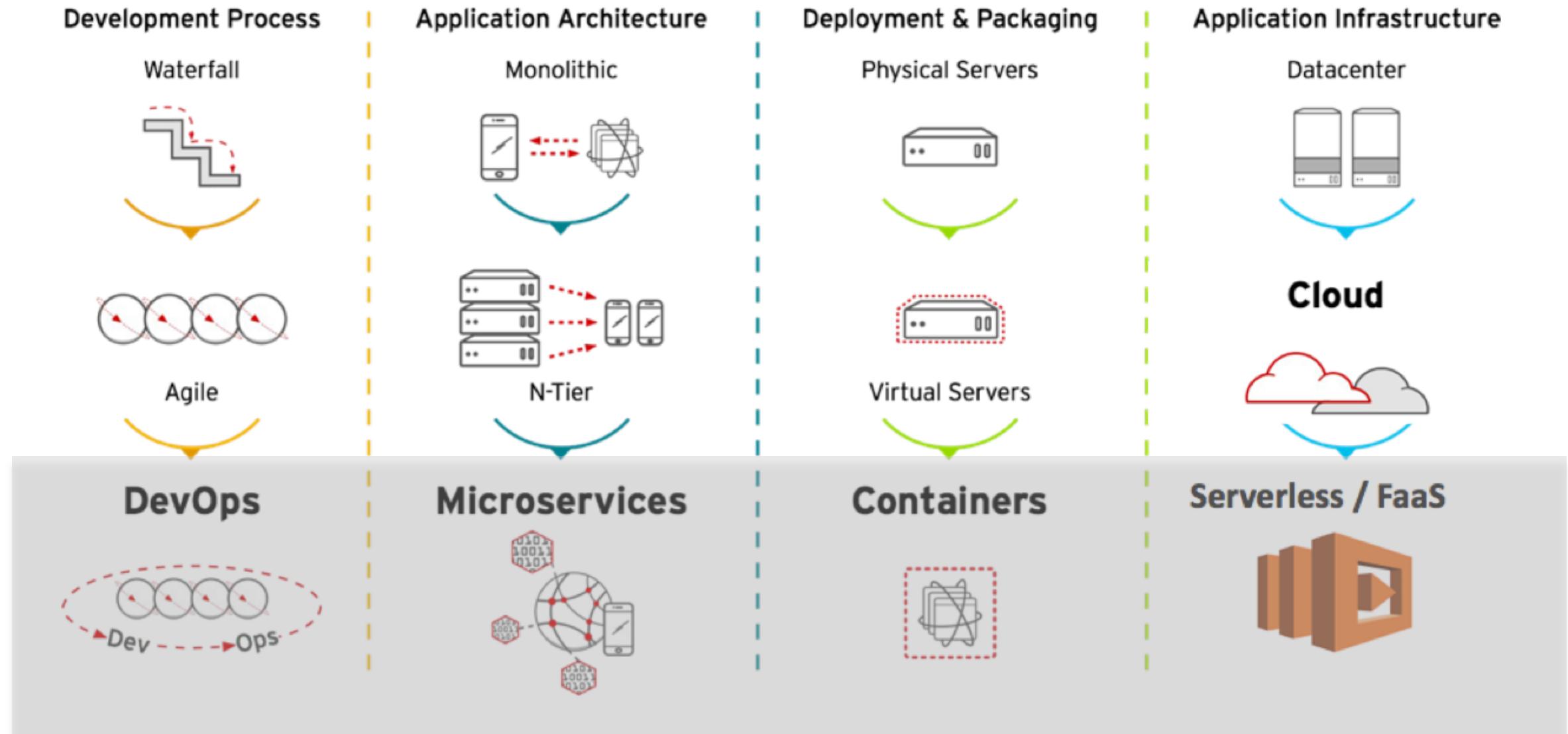
# Kubernetes deployment using Contiv-VPP



# Agenda

- Kubernetes Overview
- Contiv-VPP
  - Overview
  - Architecture
  - Hands-On
  - Load-Balancers and Service Meshes
- Ligato
  - Overview
  - Architecture
  - Hands-On
- The Future

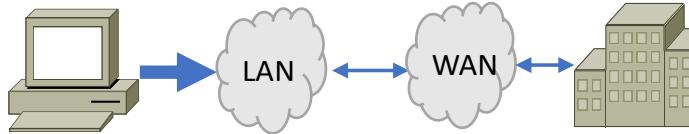
# The way Applications are developed & deployed... has changed.....



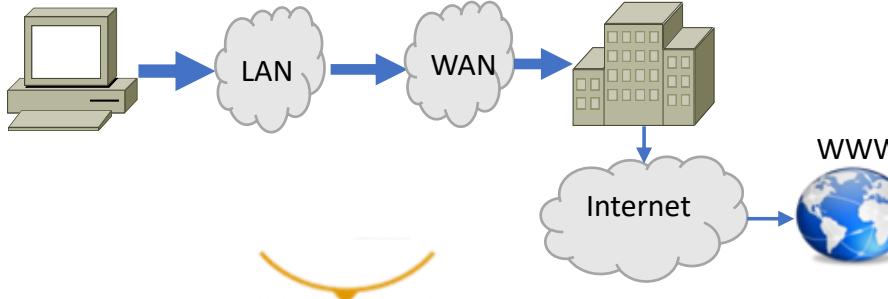
# The Way Networks are Deployed and Used... has Changed...

## Corporate LAN/WAN

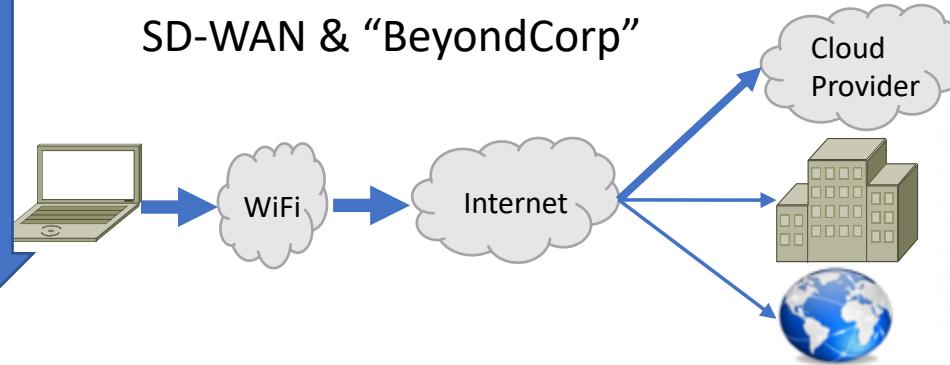
"80:20 rule"



## Intranets & Internet



## SD-WAN & "BeyondCorp"

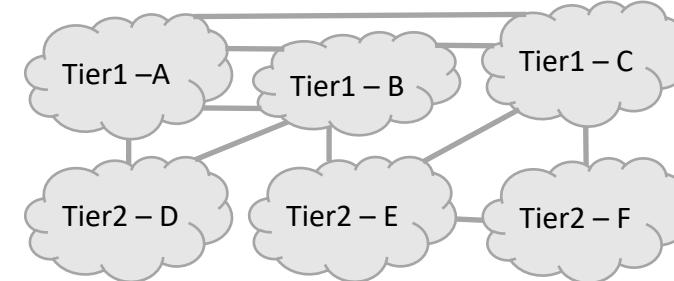


## Internet

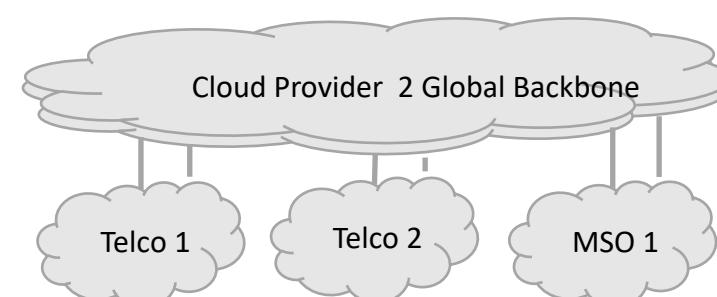
Internet exchanges & public peering



## Tiered Transit & Private Peering

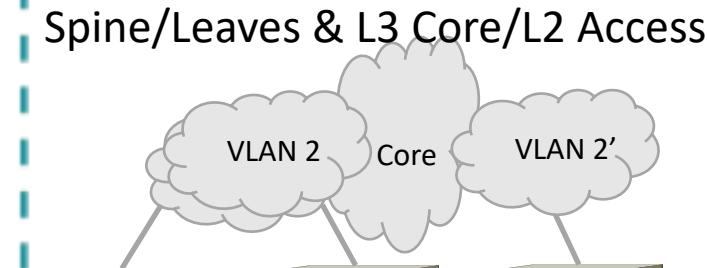
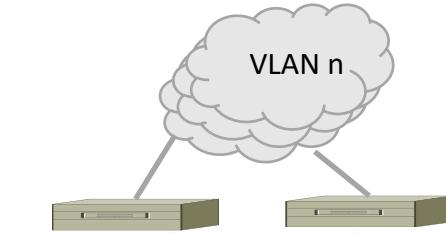


## Telco/Cable Access &, OTT/CDN Content

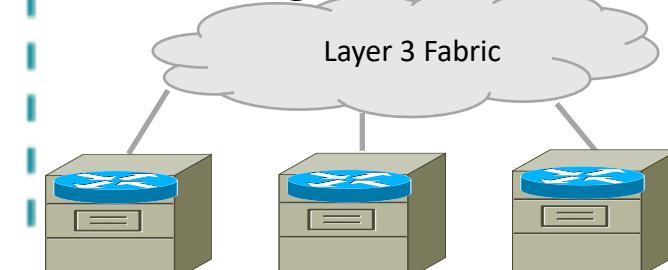


## Data-Center

Core/Distr/Access, VLAN based



## L3 Fabric/SW Overlay & Virt Networking



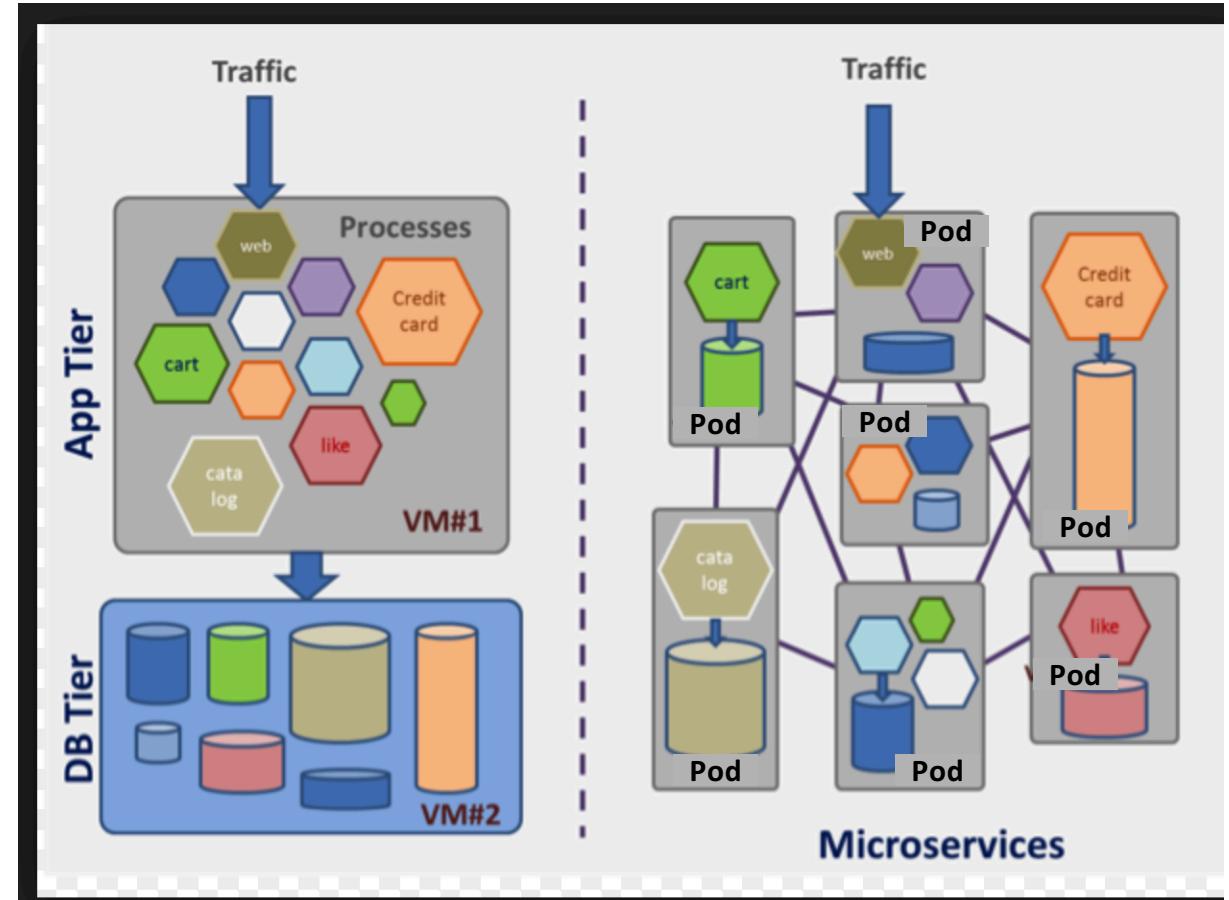
Time



# Microservices & Containers have changed many things...

- Applications are being developed and deployed very differently today.

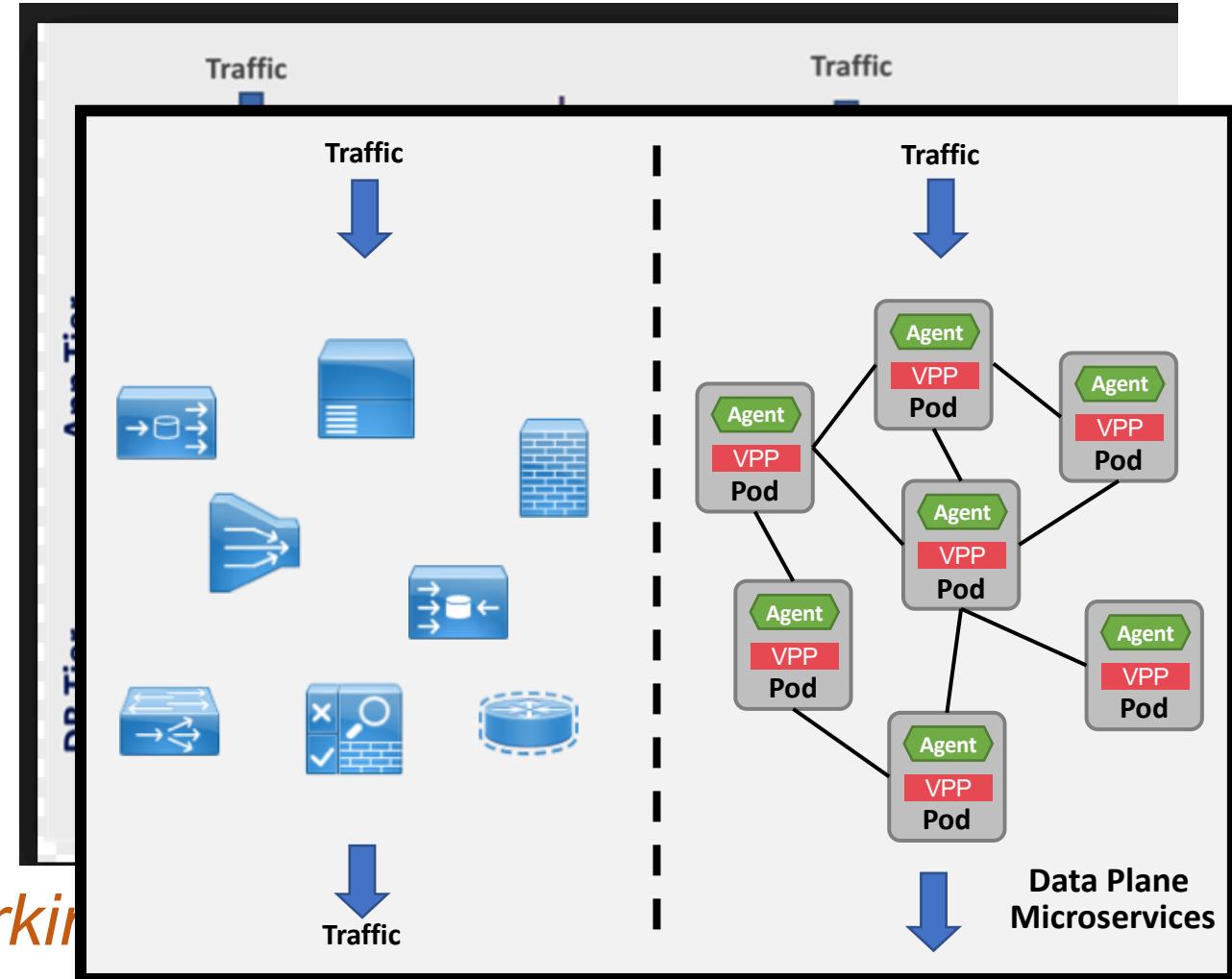
- Microservices allow you to split an application into many modular pieces, the network is how you stitch the pieces back together.
- The interconnection of the pieces results in a more complex application network which consumes lots of resources
- The performance of the cloud native network is crucial to the behavior of the overall application.



It's crucial we get "*Container Networking*" right!  
Let's not get "**Openstacked**"

# Microservices & Containers have changed many things...

- Applications are being developed and deployed very differently today.
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It's crucial we get "*Container Networking*"  
Let's not get "**Openstacked**"

# Kubernetes Overview

- "Kubernetes is a portable, extensible open-source platform for managing containerized workloads and services, that facilitates both declarative configuration and automation."
- Terminology:
  - **Node:** a host or VM on which pods can be scheduled
  - **Pod:** one or more co-resident linux containers with a single IP address (typically a /24 of address space is provided per node)
  - **Deployment:** a set of pods implementing the same application
  - **Service:** an abstraction providing a single persistent IP address for a deployment (Kubernetes provides mechanisms to load balance across multiple pods)
  - **Policy:** A specification of how groups of pods are allowed to communicate
- Kubernetes assumes seamless connectivity between pods, wherever it places them
- A networking plugin is needed to abstract the network

# Kubernetes Networking Fundamentals

- CNI (“Container Networking Interface”)
  - Container wiring
  - This is the “networking plugin” (not part of Kubernetes)
- Services
  - Service abstraction
  - Selector
  - Implemented using NAT in kube-proxy
- Policies
  - NetworkPolicy resource
    - Labels
    - Selectors

# Unleashing Innovation in Networking

- Container networking requires fast innovation cycles to deploy new models
- Kernel upgrades and ad hoc modules may cause problems in production environments
- Multiple options are being explored in the industry

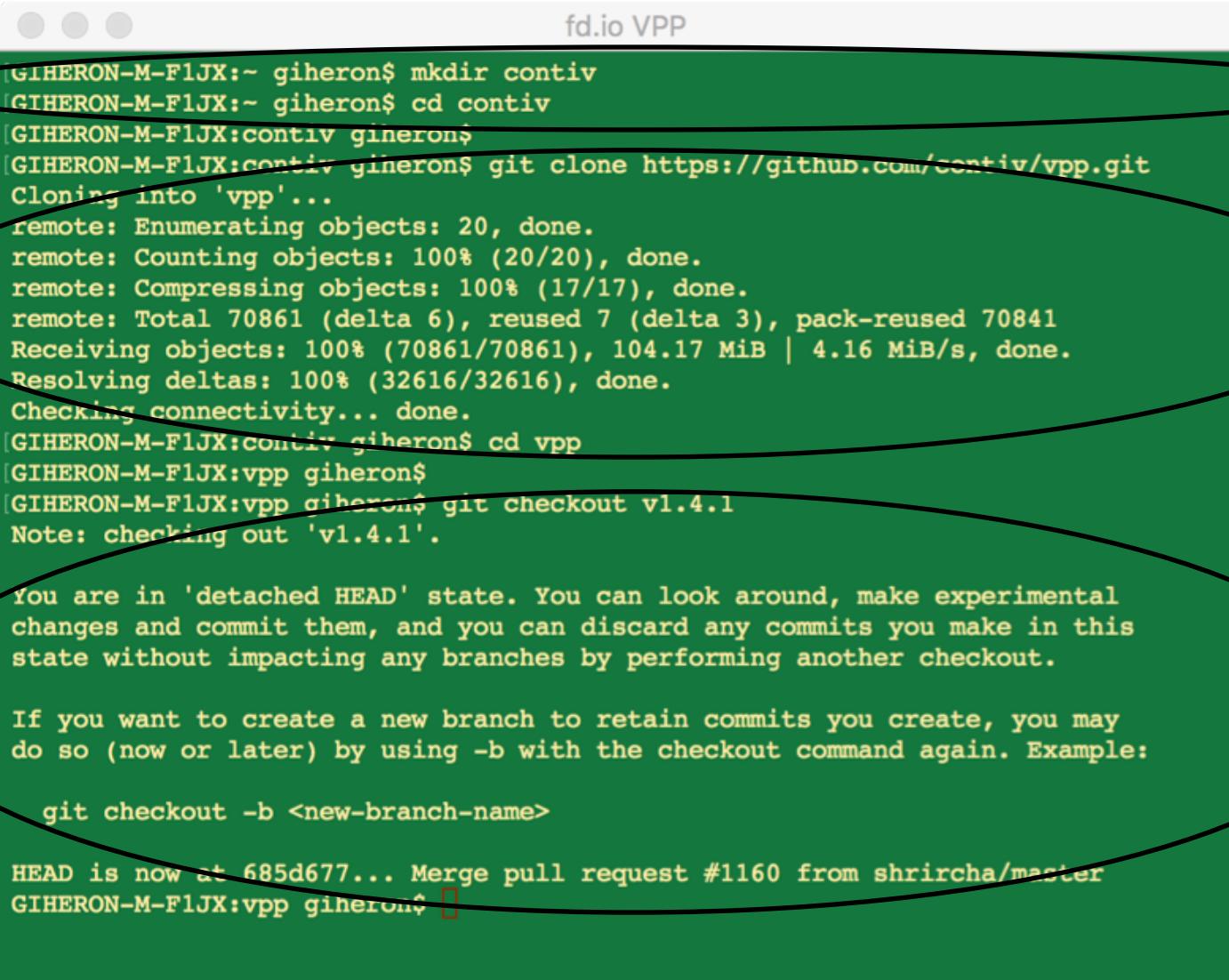
Technology	Programmability Model	Execution Context
OVS	OpenFlow lets users configure very granular data-path behaviour	Primarily kernel based Openflow model
eBPF+XDP	Packets handled by user coded eBPF programs running in a sandbox	Bypass kernel networking stack but still in kernel-mode Bytecode + JIT + kernel helpers
FD.io / VPP	Regular user-mode C program with user loadable plugins	User-mode, no kernel dependencies Native NIC drivers, Linux APIs, DPDK

# INTERRUPTION!!!

## (we need to start the hands-on early)

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- The Future

# Cloning Contiv-VPP



```
fd.io VPP
[GIHERON-M-F1JX:~ giheron$ mkdir contiv
[GIHERON-M-F1JX:~ giheron$ cd contiv
[GIHERON-M-F1JX:contiv giheron$ git clone https://github.com/contiv/vpp.git
  Cloning into 'vpp'...
  remote: Enumerating objects: 20, done.
  remote: Counting objects: 100% (20/20), done.
  remote: Compressing objects: 100% (17/17), done.
  remote: Total 70861 (delta 6), reused 7 (delta 3), pack-reused 70841
  Receiving objects: 100% (70861/70861), 104.17 MiB | 4.16 MiB/s, done.
  Resolving deltas: 100% (32616/32616), done.
  Checking connectivity... done.
[GIHERON-M-F1JX:contiv giheron$ cd vpp
[GIHERON-M-F1JX:vpp giheron$ git checkout v1.4.1
  Note: checking out 'v1.4.1'.

  You are in 'detached HEAD' state. You can look around, make experimental
  changes and commit them, and you can discard any commits you make in this
  state without impacting any branches by performing another checkout.

  If you want to create a new branch to retain commits you create, you may
  do so (now or later) by using -b with the checkout command again. Example:

    git checkout -b <new-branch-name>

  HEAD is now at 685d677... Merge pull request #1160 from shrircha/master
[GIHERON-M-F1JX:vpp giheron$ ]
```

The terminal window shows the following sequence of commands:

- mkdir contiv
- cd contiv
- git clone https://github.com/contiv/vpp.git
- cd vpp
- git checkout v1.4.1

Annotations with arrows point to specific parts of the terminal output:

- An arrow points to the first command (mkdir contiv) with the label "Create Directory".
- An arrow points to the "git clone" command with the label "Clone Contiv-VPP".
- An arrow points to the "git checkout v1.4.1" command with the label "Checkout Tag".

# Running Contiv-VPP using Vagrant

```
fd in VPP
[GIHERON-M-F1JX:vpp giheron$ cd vagrant
[GIHERON-M-F1JX:vagrant giheron$ ./vagrant-start
Please provide the number of workers for the Kubernetes cluster (0-50) or enter
[Q/q] to exit: 1

Please choose Kubernetes environment:
1) Production
2) Development
3) Quit
--> 1
You chose Production environment

Please choose deployment scenario:
1) Without StealTheNIC
2) With StealTheNIC
3) Quit
--> 1
You chose deployment without StealTheNIC

Creating a production environment, without STN and 1 worker node(s)

Creating VirtualBox DHCP server...
Bringing machine 'k8s-gateway' up with 'virtualbox' provider...
```

Go to Directory

Start Vagrant

Select Parameters

# Agenda

- Kubernetes Overview
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# Contiv-VPP Requirements

## Move Cloud Native Networking out of the Kernel to Userspace

- Userspace enables rapid upgradability, highly available (doesn't bring down node), no system call overhead, no dependency on linux kernel networking community for features, higher performance and scale
- FD.io (dataplane), DPDK (network), SPDK (Storage) are examples
- Cloud Native apps are all connected by the network – lots of network end points to be managed, userspace offers lower overhead and higher performance
- Meltdown/Spectre bugs add a new tax for kernel networking

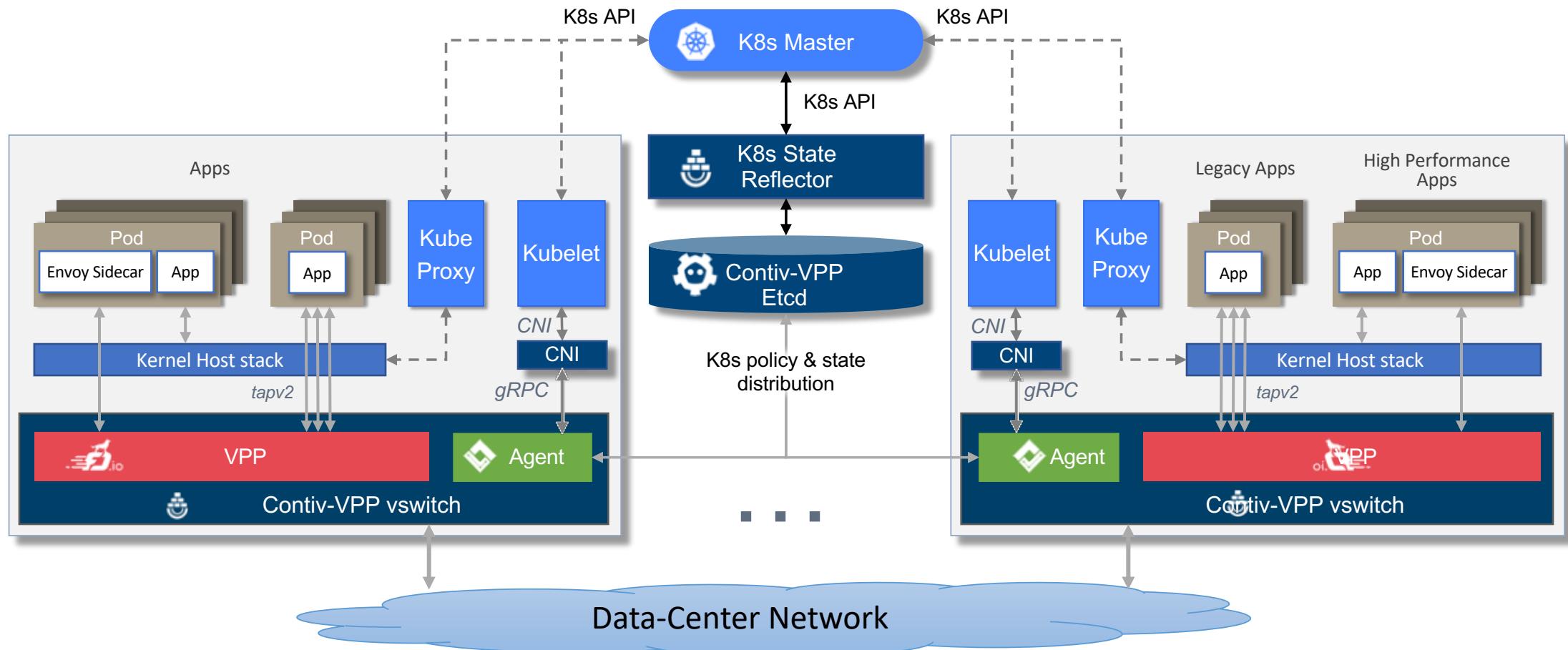
# Contiv-VPP Overview

- Kubernetes assumes seamless connectivity between pods, wherever it decides to place them. A networking plugin is needed to abstract the network
- Contiv-VPP is a networking plugin for Kubernetes that:
  - Allocates IP addresses to Pods (IPAM)
  - Programs the underlying infrastructure it uses (Linux TCP/IP stack, OVS, VPP, ...) to connect the Pods to other Pods in the cluster and/or to the external world.
  - Implements K8s network policies that define which pods can talk to each other.
  - Implements K8s services; a service exposes one or more (physical) service instances implemented as K8s pods to the other pods in the cluster and/or to external clients as a virtual instance (e.g. as a virtual “service” IP address).
- Contiv-VPP is a user-space based, high-performance, high-density networking plugin for Kubernetes - leveraging FD.io/VPP as the industry’s highest performance data plane

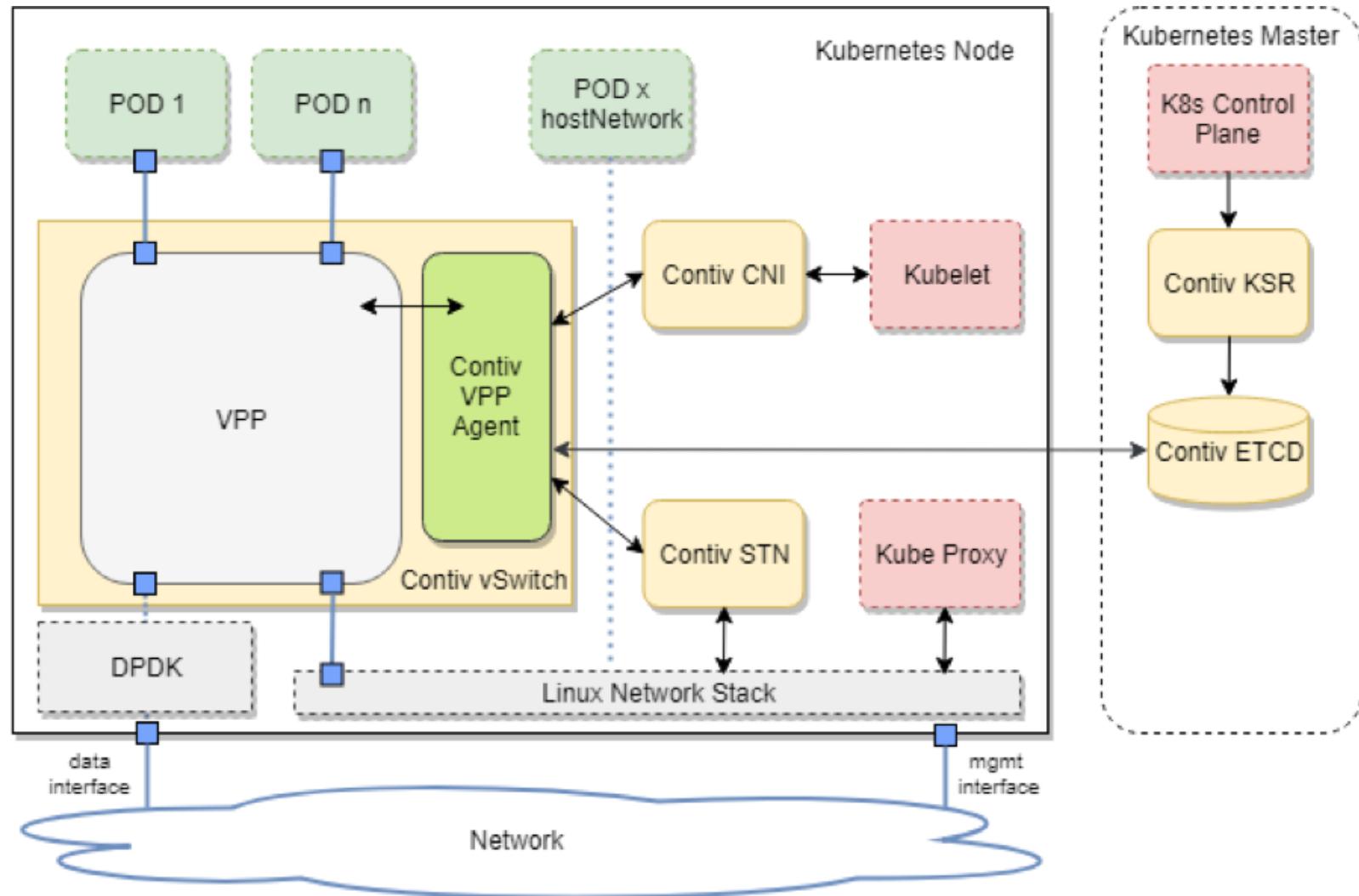
# Agenda

- Kubernetes Overview
- **Contiv-VPP**
  - Overview
  - Architecture
  - Hands-On
  - Load-Balancers and Service Meshes
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  - Overview
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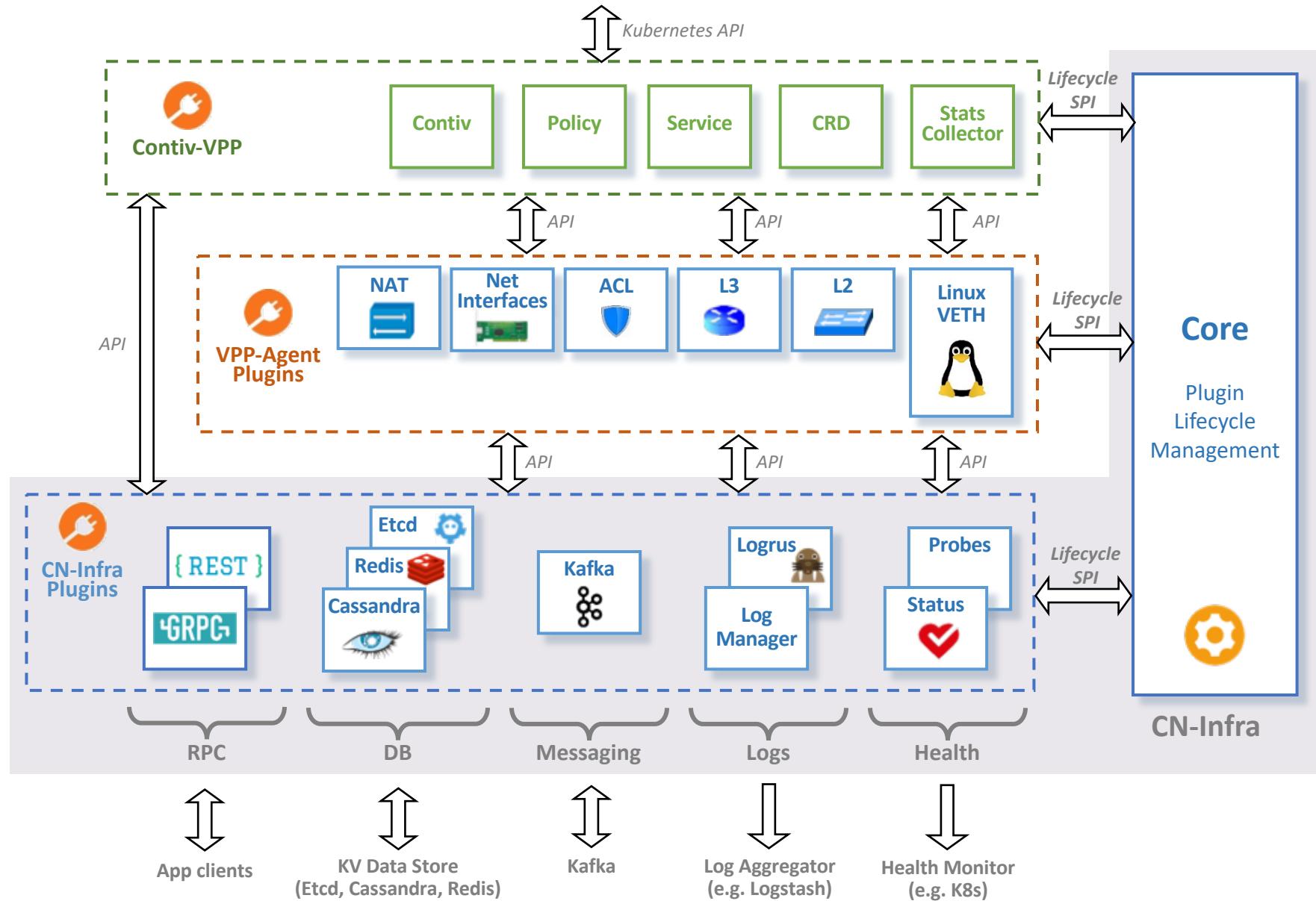
# Contiv-VPP Architecture



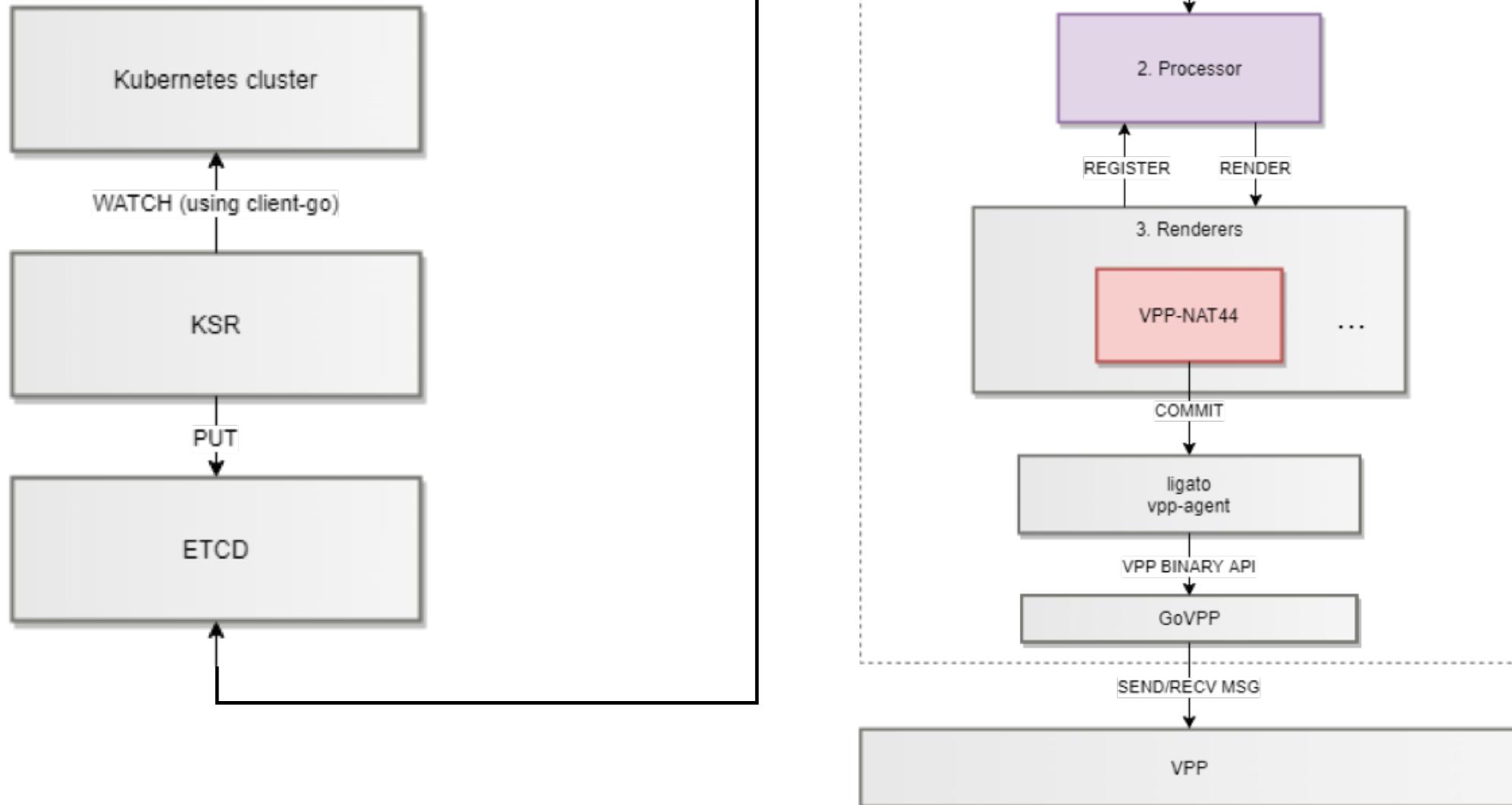
# Contiv-VPP Software Architecture



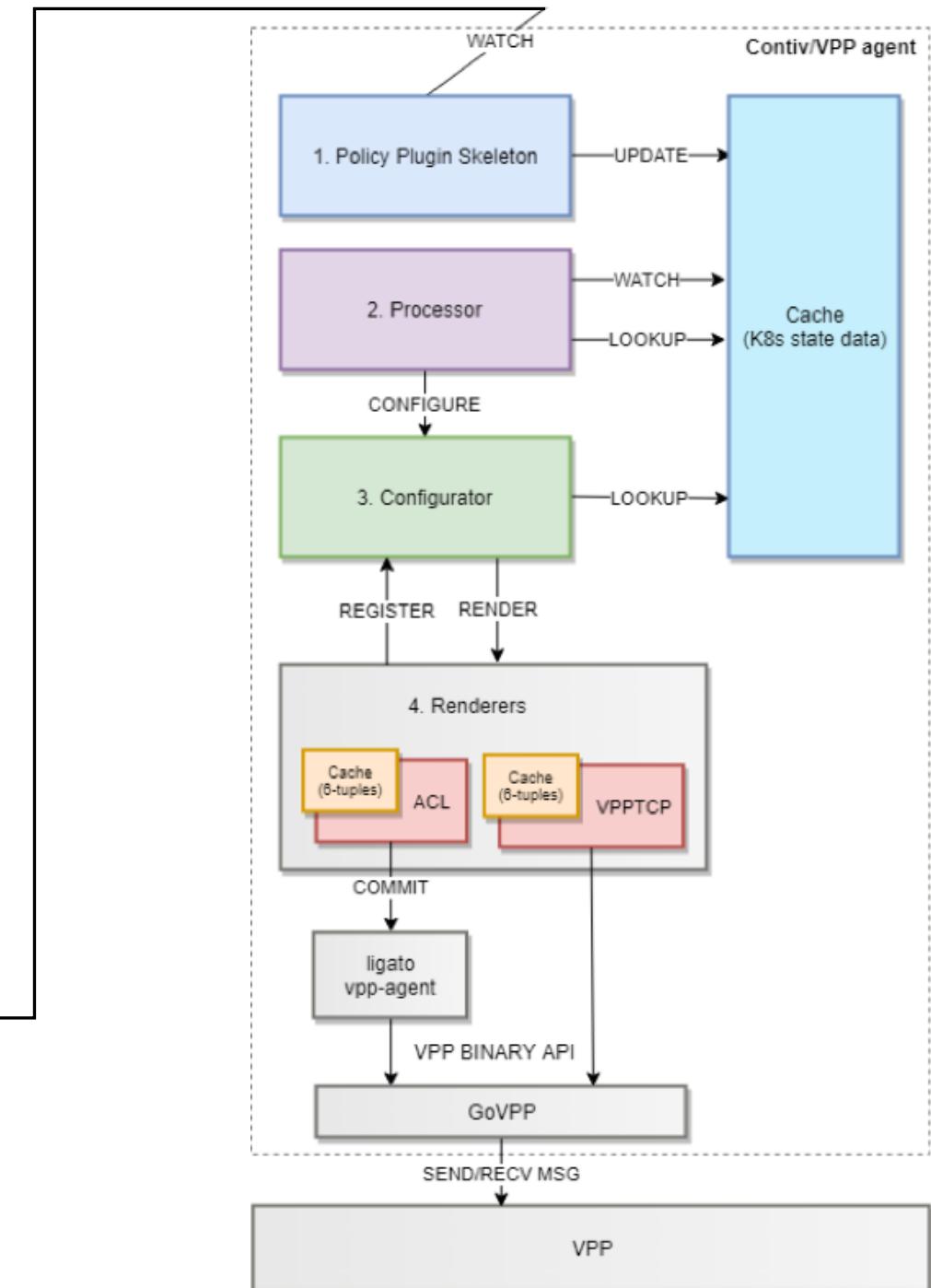
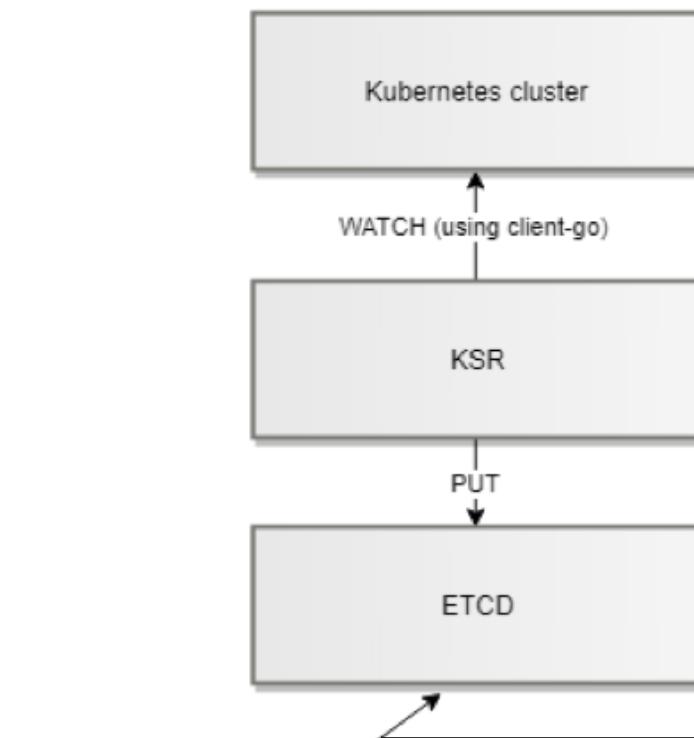
# Contiv-VPP internals



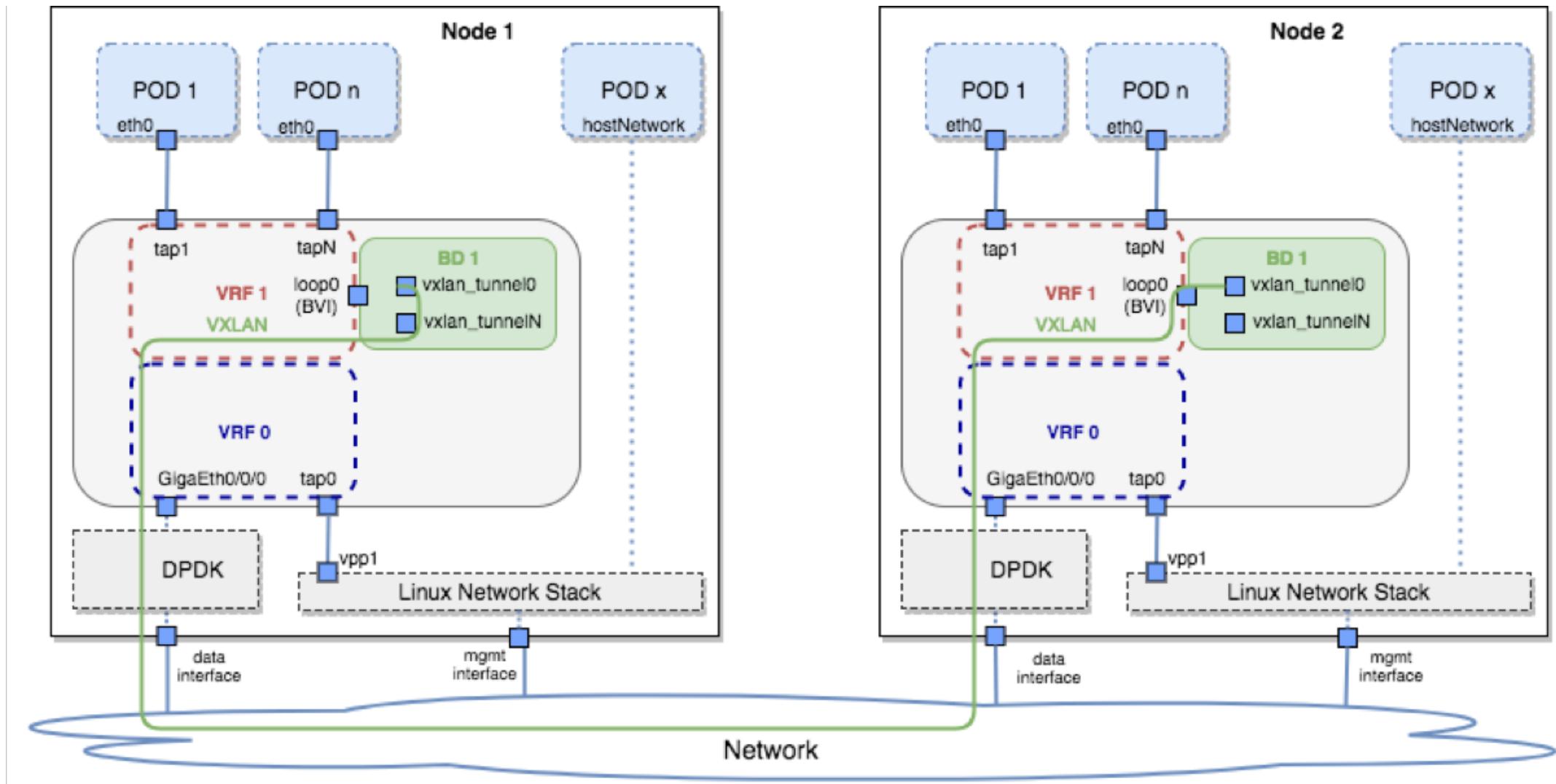
# K8s Service Engine



# K8s Policies in Contiv-VPP

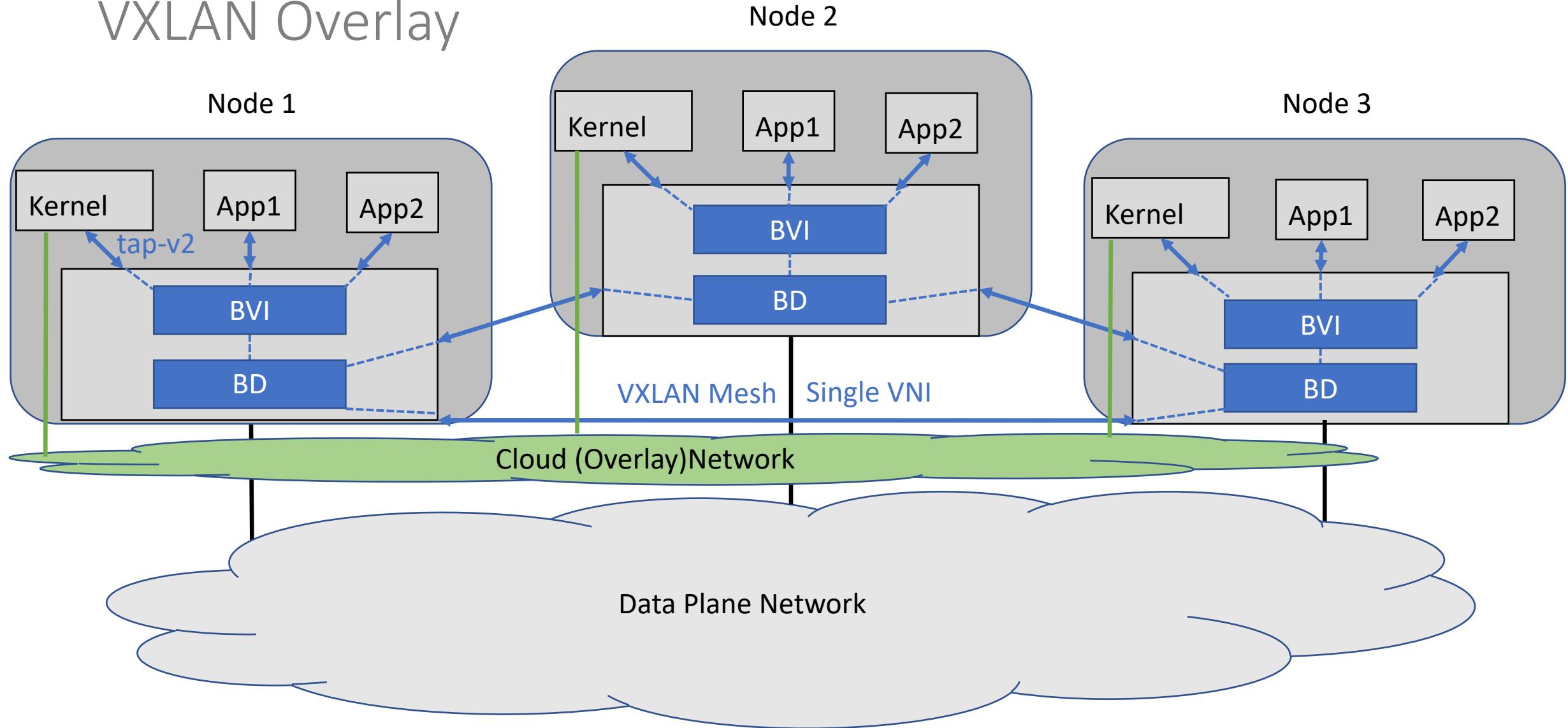


# Contiv-VPP Network Architecture



# Contiv-VPP Network Rendering

## VXLAN Overlay



# Creating Bridge Domain with BVI

```
xrvr@i2ss-c2201: ~
[xrvr@i2ss-c2201:~]$ sudo vppctl
[      ] [      ]
[vpp# create bridge-domain 1 learn 0 forward 1 uu-flood 0 flood 0 arp-term 0
bridge domain 1
[vpp# 
[vpp# 
[vpp# loopback create mac 1a:2b:3c:4d:5e:01
loop0
[vpp# set interface 12 bridge loop0 1 bvi 1
[vpp# set interface state loop0 up
[vpp# set interface ip table loop0 1
[vpp# set interface ip address loop0 192.168.30.1/24
vpp# ]
```

Create BD

Create BVI

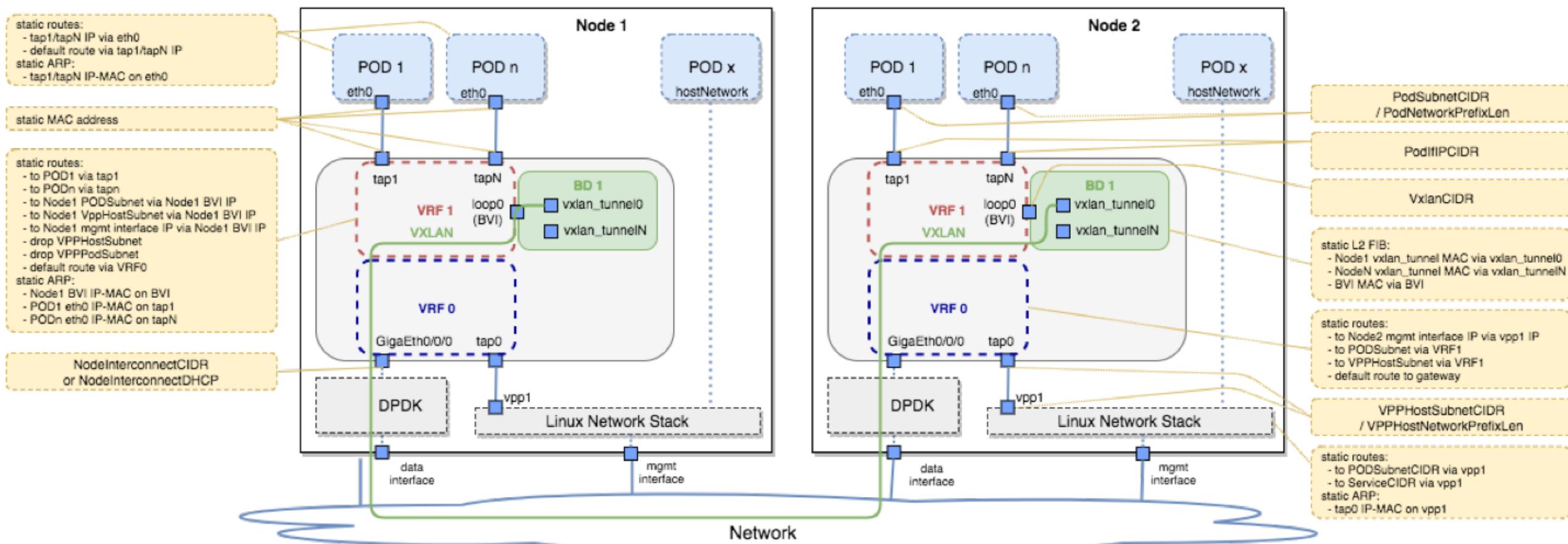
# Adding a Peer Node

```
xrvr@i2ss-c2201: ~
[xrvr@i2ss-c2201:~$ sudo vppctl
[vpp#]
[vpp#] create vxlan tunnel src 192.168.16.1 dst 192.168.16.2 vni 10 encap-vrf-id 0 decap-next 12
vxlan_tunnell1
[vpp#]
[vpp#] set interface 12 bridge vxlan_tunnell1 1 1
[vpp#]
[vpp#] 12fib add 1a:2b:3c:4d:5e:02 1 vxlan_tunnell1 static
[vpp#]
[vpp#] set ip arp loop0 192.168.30.2 1a:2b:3c:4d:5e:02 static no-fib-entry
[vpp#]
[vpp#] ip route add 10.1.2.0/24 table 1 via 192.168.30.2 vxlan_tunnell1
vpp# ]]
```

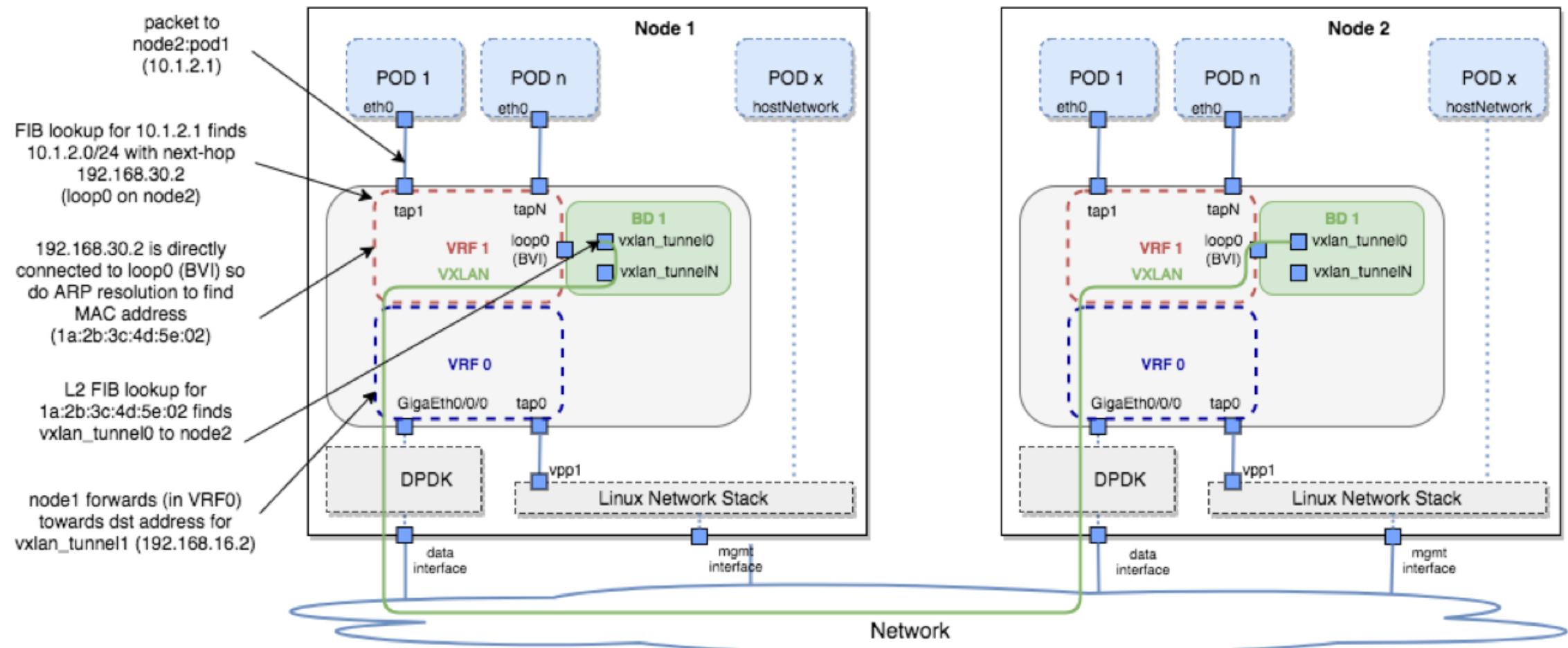
Diagram illustrating the sequence of VPP commands to add a peer node:

- Create VXLAN Tunnel**: `create vxlan tunnel src 192.168.16.1 dst 192.168.16.2 vni 10 encap-vrf-id 0 decap-next 12`
- Add tunnel to BD**: `set interface 12 bridge vxlan_tunnell1 1 1`
- Create L2FIB Entry**: `12fib add 1a:2b:3c:4d:5e:02 1 vxlan_tunnell1 static`
- Create ARP Entry**: `set ip arp loop0 192.168.30.2 1a:2b:3c:4d:5e:02 static no-fib-entry`
- Create Static Route**: `ip route add 10.1.2.0/24 table 1 via 192.168.30.2 vxlan_tunnell1`

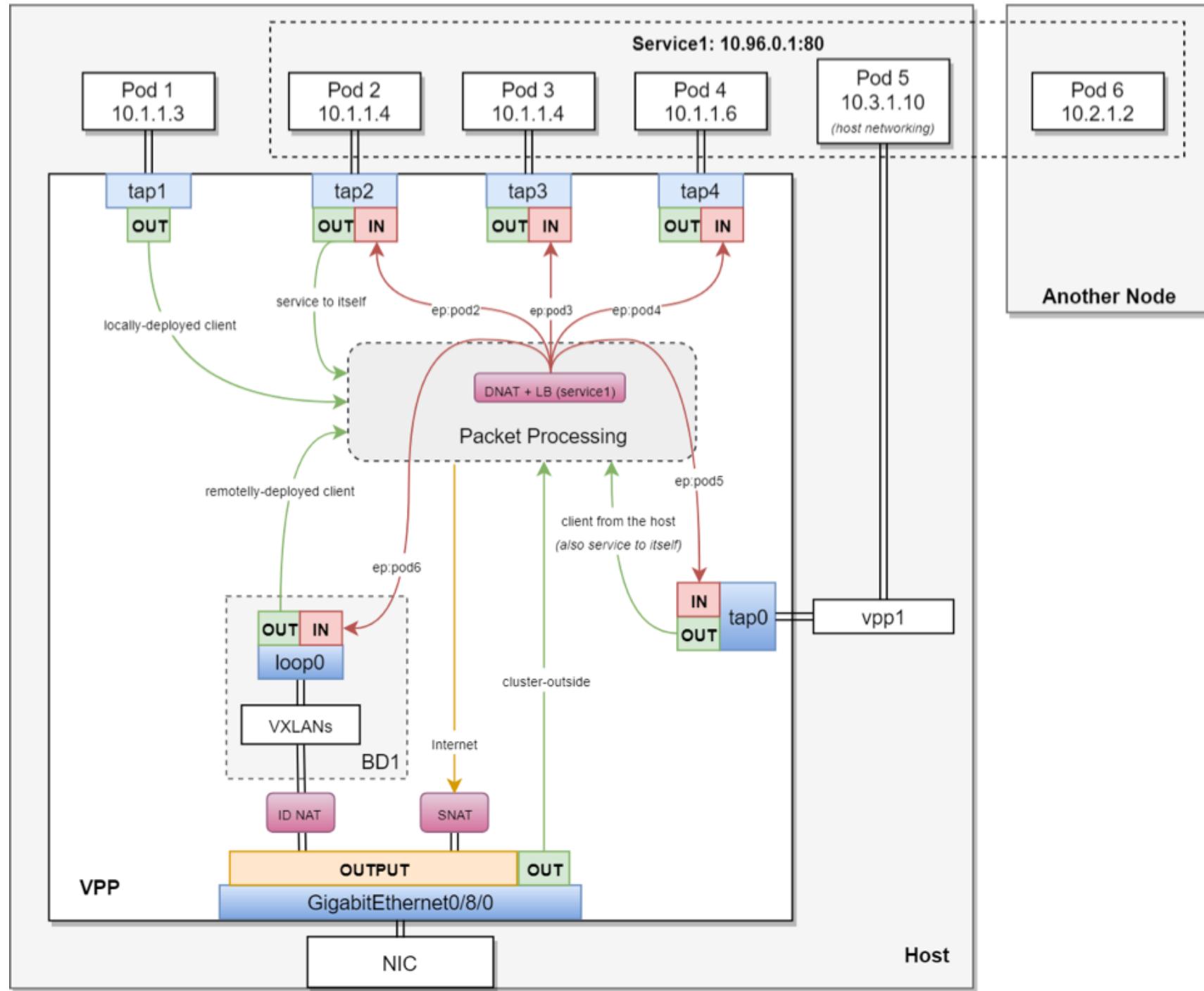
# Contiv-VPP VXLAN IP Addressing Overview



# Contiv-VPP VXLAN IP Forwarding Steps



# Adding Policies and Services...



# Contiv-VPP on Github

The screenshot shows the GitHub repository page for `contiv/vpp`. The page includes a navigation bar with links to Features, Business, Explore, Marketplace, Pricing, and a search bar. It also displays statistics such as 28 watches, 65 stars, and 42 forks. A prominent "Join GitHub today" banner is visible in the center. Below the banner, the repository description states: "Kubernetes CNI plugin based on the FD.io VPP". The repository has 3,063 commits, 5 branches, 12 releases, and 28 contributors. The Apache-2.0 license is indicated. The commit history lists several recent changes:

- R rastislavszabo Merge pull request #1185 from rastislavszabo/vpp-18.10 ... Latest commit 0191cf6 19 hours ago
- cmd Reenable statuscheck for ksr 2 days ago
- docker Move to newest VPP 18.10 2 days ago
- docs Update NAT startup config in documentation 12 days ago
- k8s re-generate arm64 yaml 2 days ago

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# Cloning Contiv-VPP

```
fd.io VPP
[GIHERON-M-F1JX:- giheron$ mkdir contiv
[GIHERON-M-F1JX:- giheron$ cd contiv
[GIHERON-M-F1JX:contiv giheron$
[GIHERON-M-F1JX:contiv giheron$ git clone https://github.com/contiv/vpp.git
Cloning into 'vpp'...
remote: Enumerating objects: 9, done.
remote: Counting objects: 100% (9/9), done.
remote: Compressing objects: 100% (7/7), done.
remote: Total 70985 (delta 2), reused 3 (delta 2), pack-reused 70976
Receiving objects: 100% (70985/70985), 165.49 MiB | 2.49 MiB/s, done.
Resolving deltas: 100% (32702/32702), done.
Checking connectivity... done.
[GIHERON-M-F1JX:contiv giheron$
[GIHERON-M-F1JX:contiv giheron$ cd vpp
[GIHERON-M-F1JX:vpp giheron$
[GIHERON-M-F1JX:vpp giheron$ git checkout TPT2018
Branch TPT2018 set up to track remote branch TPT2018 from origin.
Switched to a new branch 'TPT2018'
GIHERON-M-F1JX:vpp giheron$ █
```

Create Directory

Clone Contiv-VPP

Checkout Branch

# Running Contiv-VPP using Vagrant

```
fd in VPP
[GIHERON-M-F1JX:vpp giheron$ cd vagrant
[GIHERON-M-F1JX:vagrant giheron$ ./vagrant-start
Please provide the number of workers for the Kubernetes cluster (0-50) or enter
[Q/q] to exit: 1

Please choose Kubernetes environment:
1) Production
2) Development
3) Quit
--> 1
You chose Production environment

Please choose deployment scenario:
1) Without StealTheNIC
2) With StealTheNIC
3) Quit
--> 1
You chose deployment without StealTheNIC

Creating a production environment, without STN and 1 worker node(s)

Creating VirtualBox DHCP server...
Bringing machine 'k8s-gateway' up with 'virtualbox' provider...
```

Go to Directory

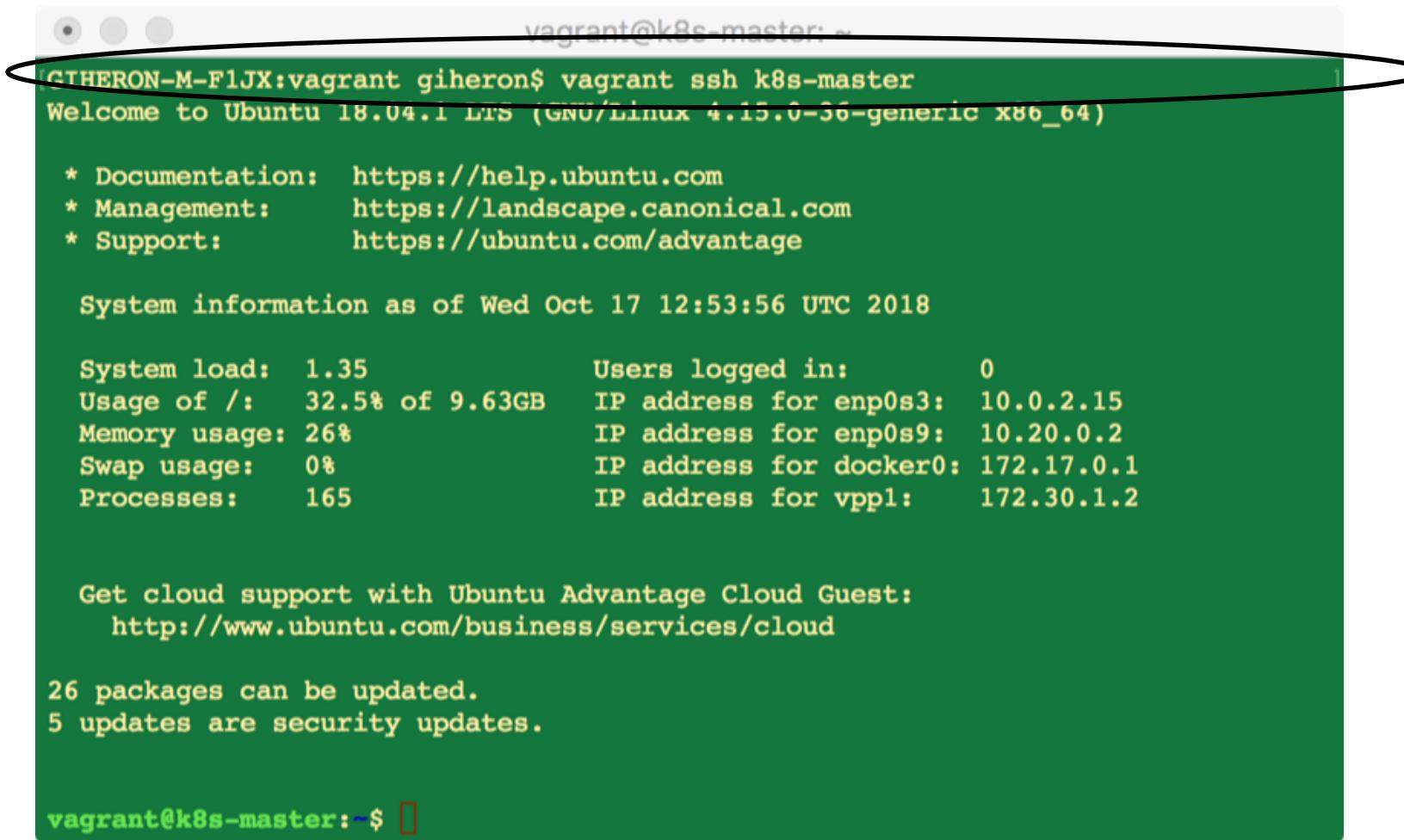
Start Vagrant

Select Parameters

# Is it Finished?

```
vagrant@k8s-master: ~  
  k8s-worker1: [discovery] Successfully established connection with API Server  
"10.20.0.2:6443"  
  k8s-worker1: [kubelet] Downloading configuration for the kubelet from the "k  
ubelet-config-1.11" ConfigMap in the kube-system namespace  
  k8s-worker1: [kubelet] Writing kubelet configuration to file "/var/lib/kubel  
et/config.yaml"  
  k8s-worker1: [kubelet] Writing kubelet environment file with flags to file "  
/var/lib/kubelet/kubeadm-flags.env"  
  k8s-worker1: [preflight] Activating the kubelet service  
  k8s-worker1: [tlsbootstrap] Waiting for the kubelet to perform the TLS Boots  
trap...  
  k8s-worker1: [patchnode] Uploading the CRI Socket information "/var/run/dock  
ershim.sock" to the Node API object "k8s-worker1" as an annotation  
  k8s-worker1:  
  k8s-worker1: This node has joined the cluster:  
  k8s-worker1: * Certificate signing request was sent to master and a response  
k8s-worker1:   was received.  
  k8s-worker1: * The Kubelet was informed of the new secure connection details  
.  
  k8s-worker1:  
  k8s-worker1: Run 'kubectl get nodes' on the master to see this node join the  
cluster.  
==> k8s-worker1: Configuring cache buckets...  
GIHERON-M-F1JX:vagrant giheron$
```

# Logging into k8s-master in Vagrant



The screenshot shows a terminal window titled "vagrant@k8s-master: ~". The command "vagrant ssh k8s-master" has been run, and the output is displayed. A black oval highlights the first line of the output, which shows the host machine's name and the command used to connect.

```
vagrant@k8s-master: ~
GTHERON-M-F1JX:vagrant giheron$ vagrant ssh k8s-master
Welcome to Ubuntu 18.04.1 LTS (GNU/Linux 4.15.0-36-generic x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/advantage

System information as of Wed Oct 17 12:53:56 UTC 2018

System load: 1.35              Users logged in:      0
Usage of /: 32.5% of 9.63GB   IP address for enp0s3: 10.0.2.15
Memory usage: 26%              IP address for enp0s9: 10.20.0.2
Swap usage: 0%                IP address for docker0: 172.17.0.1
Processes: 165                IP address for vppl:   172.30.1.2

Get cloud support with Ubuntu Advantage Cloud Guest:
http://www.ubuntu.com/business/services/cloud

26 packages can be updated.
5 updates are security updates.

vagrant@k8s-master: ~ $
```

# Using kubectl to see nodes/pods

```
vagrant@k8s-master: ~
```

```
[vagrant@k8s-master:~]$ kubectl get nodes
NAME        STATUS   ROLES      AGE     VERSION
k8s-master   Ready    master     11m    v1.11.3
k8s-worker1  Ready    <none>    8m     v1.11.3
[vagrant@k8s-master:~]$ 
[vagrant@k8s-master:~]$ kubectl get pods -o wide --all-namespaces
NAMESPACE   NAME          READY   STATUS    RESTARTS   AGE     IP           NODE   NOMINATED
NODE
kube-system contiv-crd-kqsb6   1/1     Running   0          10m    10.20.0.2   k8s-master   <none>
kube-system contiv-etcd-0     1/1     Running   0          10m    10.20.0.2   k8s-master   <none>
kube-system contiv-ksr-n4t4h  1/1     Running   0          10m    10.20.0.2   k8s-master   <none>
kube-system contiv-vswitch-96r6v 1/1     Running   0          10m    10.20.0.2   k8s-master   <none>
kube-system contiv-vswitch-hjhc2 1/1     Running   0          8m     10.20.0.10  k8s-worker1  <none>
kube-system coredns-78fcdf6894-4646x 1/1     Running   0          10m    10.1.1.2    k8s-master   <none>
kube-system coredns-78fcdf6894-k4hhv 1/1     Running   0          10m    10.1.1.3    k8s-master   <none>
kube-system etcd-k8s-master     1/1     Running   0          10m    10.20.0.2   k8s-master   <none>
kube-system kube-apiserver-k8s-master 1/1     Running   0          10m    10.20.0.2   k8s-master   <none>
kube-system kube-controller-manager-k8s-master 1/1     Running   0          10m    10.20.0.2   k8s-master   <none>
kube-system kube-proxy-2r7db     1/1     Running   0          8m     10.20.0.10  k8s-worker1  <none>
kube-system kube-proxy-x6g64     1/1     Running   0          10m    10.20.0.2   k8s-master   <none>
kube-system kube-scheduler-k8s-master 1/1     Running   0          9m     10.20.0.2   k8s-master   <none>
```

# Using contiv-netctl to see nodes/addresses

```
vagrant@k8s-master: ~  
[vagrant@k8s-master:~]$ contiv-netctl nodes  
ID NODE-NAME VPP-IP HOST-IP START-TIME STATE BUILD-VERSION BUILD-DATE  
1 k8s-master 192.168.16.1 10.20.0.2 Wed Oct 17 12:47:04 2018 1 v1.4.2-alpha-52-g099f098 Wed Oct 17 12:19:00 2018  
2 k8s-worker1 192.168.16.2 10.20.0.10 Wed Oct 17 12:49:51 2018 1 v1.4.2-alpha-52-g099f098 Wed Oct 17 12:19:00 2018  
[vagrant@k8s-master:~]$  
[vagrant@k8s-master:~]$ contiv-netctl ipam  
ID NODE-NAME VPP-IP RVT-IP POD-NET-CIDR VPP-2-HOST-CIDR POD-IFIP-CIDR POD-SUBNET-CIDR  
1 k8s-master 192.168.16.1 192.168.30.1 10.1.1.0/24 172.30.1.0/24 10.2.1.0/24 10.1.0.0/16  
2 k8s-worker1 192.168.16.2 192.168.30.2 10.1.2.0/24 172.30.2.0/24 10.2.1.0/24 10.1.0.0/16  
vagrant@k8s-master:~$
```

# Using contiv-netctl to see pods

```
vagrant@k8s-master: ~  
[vagrant@k8s-master: ~]$ contiv-netctl pods  
k8s-master (10.20.0.2):  
-----  
POD-NAME           NAMESPACE   POD-IP     VPP-IP      IF-IDX  IF-NAME    INTERNAL-IF-NAME  
contiv-crd-kqsb6  kube-system  10.20.0.2  
contiv-etcd-0     kube-system  10.20.0.2  
contiv-ksr-n4t4h  kube-system  10.20.0.2  
contiv-vswitch-96r6v  kube-system  10.20.0.2  
coredns-78fcdf6894-4646x  kube-system  10.1.1.2   10.2.1.2   4       tap1      tap91a1a5c6e658bb9  
coredns-78fcdf6894-k4hhv  kube-system  10.1.1.3   10.2.1.3   5       tap2      tap987bb9447948d20  
etcd-k8s-master    kube-system  10.20.0.2  
kube-apiserver-k8s-master  kube-system  10.20.0.2  
kube-controller-manager-k8s-master  kube-system  10.20.0.2  
kube-proxy-x6g64    kube-system  10.20.0.2  
kube-scheduler-k8s-master  kube-system  10.20.0.2  
  
k8s-worker1 (10.20.0.10):  
-----  
POD-NAME           NAMESPACE   POD-IP     VPP-IP      IF-IDX  IF-NAME    INTERNAL-IF-NAME  
contiv-vswitch-hjhc2  kube-system  10.20.0.10  
kube-proxy-2r7db    kube-system  10.20.0.10  
  
vagrant@k8s-master: ~ $
```

# Using contiv-netctl to issue VPP commands

```
xrvr@i2ss-c2201: ~
[xrvr@i2ss-c2201:~] contiv-netctl vppdump i2ss-c2202
Command usage: netctl vppdump i2ss-c2202 <cmd>.
cmd 0: acl/ip
cmd 1: acl/macip
cmd 2: ipsec/spd
cmd 3: ipsec/sa
cmd 4: ipsec/tunnel
cmd 5: interfaces
cmd 6: interfaces/loopback
cmd 7: interfaces/ethernet
cmd 8: interfaces/memif
cmd 9: interfaces/tap
cmd 10: interfaces/vxlan
cmd 11: interfaces/afpacket
cmd 12: bd
cmd 13: bdid
cmd 14: fib
cmd 15: xc
cmd 16: routes
cmd 17: arps
cmd 18: proxyarp/interfaces
cmd 19: proxyarp/ranges
cmd 20: sessions
xrvr@i2ss-c2201:~$
```

# Using contiv-netctl vppdump example



```
xrvr@i2ss-c2201:~$ contiv-netctl vppdump i2ss-c2202 bd
vppdump i2ss-c2202 bd
{
  "1": {
    "bridge_domain": {
      "name": "vxlanBD",
      "forward": true,
      "interfaces": [
        {
          "name": "vxlanBVI",
          "bridged_virtual_interface": true,
          "split_horizon_group": 1
        },
        {
          "name": "vxlan1",
          "split_horizon_group": 1
        },
        {
          "name": "vxlan3",
          "split_horizon_group": 1
        }
      ]
    },
    "bridge_domain_meta": {
      "bridge_domain_id": 1,
      "bridge_domain_id_to_name": {
        "3": "vxlanBVI",
        "4": "vxlan1",
        "5": "vxlan3"
      }
    }
  }
}
xrvr@i2ss-c2201:~$
```

# Using contiv-netctl vppcli

```
xrvr@i2ss-c2201:~$ contiv-netctl vppcli i2ss-c2202 show bridge-domain
vppcli i2ss-c2202 show bridge-domain
  BD-ID  Index  BSN  Age(min)  Learning  U-Forwrd  UU-Flood  Flooding  ARP-Term  BVI-Intf
    1      1      0      off        off       on        drop      off       off      loop0

[xrvc@i2ss-c2201:~$ contiv-netctl vppcli i2ss-c2202 show bridge-domain 1 detail
vppcli i2ss-c2202 show bridge-domain 1 detail
  BD-ID  Index  BSN  Age(min)  Learning  U-Forwrd  UU-Flood  Flooding  ARP-Term  BVI-Intf
    1      1      0      off        off       on        drop      off       off      loop0

  Interface          If-idx  ISN  SHG  BVI  TxFlood  VLAN-Tag-Rewrite
  loop0              3      2      1     *     *           none
  vxlan_tunnel0      4      1      1     -     *           none
  vxlan_tunnel1      5      3      1     -     *           none

BD-Tag: vxlanBD

xrvr@i2ss-c2201:~$
```

# Deploying an application

```
vagrant@k8s-master: /vagrant
[vagrant@k8s-master: /vagrant$ cd /vagrant
[vagrant@k8s-master: /vagrant$ 
[vagrant@k8s-master: /vagrant$ 
[vagrant@k8s-master: /vagrant$ kubectl apply -f nginx.yaml
deployment.apps/nginx created
service/nginx created
[vagrant@k8s-master: /vagrant$ 
[vagrant@k8s-master: /vagrant$ 
[vagrant@k8s-master: /vagrant$ kubectl get deploy
NAME      DESIRED   CURRENT   UP-TO-DATE   AVAILABLE   AGE
nginx     5          5          5           5           11s
[vagrant@k8s-master: /vagrant$ 
[vagrant@k8s-master: /vagrant$ 
[vagrant@k8s-master: /vagrant$ kubectl get pods -o wide
NAME                  READY   STATUS    RESTARTS   AGE   IP            NODE   NOMINATED NODE
nginx-7969c5cc4f-69xtt 1/1    Running   0          17s   10.1.1.9    k8s-master <none>
nginx-7969c5cc4f-8ssgv 1/1    Running   0          17s   10.1.2.8    k8s-worker1 <none>
nginx-7969c5cc4f-lmvvm2 1/1    Running   0          17s   10.1.2.10   k8s-worker1 <none>
nginx-7969c5cc4f-q85nd 1/1    Running   0          17s   10.1.1.8    k8s-master <none>
nginx-7969c5cc4f-vldff 1/1    Running   0          17s   10.1.2.9    k8s-worker1 <none>
[vagrant@k8s-master: /vagrant$ 
[vagrant@k8s-master: /vagrant$ 
[vagrant@k8s-master: /vagrant$ kubectl get services
NAME      TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)   AGE
kubernetes  ClusterIP  10.96.0.1  <none>       443/TCP   15m
nginx      ClusterIP  10.96.1.1  <none>       80/TCP    22s
vagrant@k8s-master: /vagrant$ 
```

Annotations:

- go to directory
- launch
- view deployment
- view pods
- view service

# Deploying a daemonset

```
vagrant@k8s-master: /vagrant  
[vagrant@k8s-master: /vagrant$ kubectl apply -f busybox.yaml  
daemonset.apps/busybox created  
[vagrant@k8s-master: /vagrant$  
[vagrant@k8s-master: /vagrant$ kubectl get ds  
NAME      DESIRED   CURRENT   READY   UP TO DATE   AVAILABLE   NODE SELECTOR   AGE  
busybox   2          2          2        2           2           <none>       8s  
[vagrant@k8s-master: /vagrant$  
[vagrant@k8s-master: /vagrant$ kubectl get pods -o wide  
NAME            READY   STATUS    RESTARTS   AGE     IP          NODE   NOMINATED NODE  
busybox-fd2cx   1/1     Running   0          19s    10.1.2.11   k8s-worker1  <none>  
busybox-pbfks   1/1     Running   0          19s    10.1.1.10   k8s-master   <none>  
nginx-7969c5cc4f-69xtt 1/1     Running   0          7m     10.1.1.9    k8s-master   <none>  
nginx-7969c5cc4f-8ssgv 1/1     Running   0          7m     10.1.2.8    k8s-worker1  <none>  
nginx-7969c5cc4f-lmvm2 1/1     Running   0          7m     10.1.2.10   k8s-worker1  <none>  
nginx-7969c5cc4f-q85nd  1/1    Running   0          7m     10.1.1.8    k8s-master   <none>  
nginx-7969c5cc4f-vldff  1/1    Running   0          7m     10.1.2.9    k8s-worker1  <none>  
vagrant@k8s-master: /vagrant$ ]
```

The diagram shows three annotations with arrows pointing from labels to specific lines in the terminal output:

- A black oval encircles the first two lines of the terminal output, with an arrow pointing to the right labeled "launch".
- A black oval encircles the line "kubectl get ds", with an arrow pointing to the right labeled "view DS".
- A black oval encircles the line "kubectl get pods -o wide", with an arrow pointing to the right labeled "view pods".

# Testing the app from the daemonset

```
vagrant@k8s-master:/vagrant
[vagrant@k8s-master:/vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1 2>/dev/null
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
  body {
    width: 35em;
    margin: 0 auto;
    font-family: Tahoma, Verdana, Arial, sans-serif;
  }
</style>
</head>
<body>
<h1>Welcome to nginx!</h1>
<p>If you see this page, the nginx web server is successfully installed and
working. Further configuration is required.</p>

<p>For online documentation and support please refer to
<a href="http://nginx.org/">nginx.org</a>.<br/>
Commercial support is available at
<a href="http://nginx.com/">nginx.com</a>.</p>

<p><em>Thank you for using nginx.</em></p>
</body>
</html>
vagrant@k8s-master:/vagrant$ ]
```

# Testing the app from the daemonset

```
vagrant@k8s-master: /vagrant$ [vagrant@k8s-master: /vagrant$] vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.2.8 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.1.9 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.1.8 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.2.9 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.2.10 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.1.9 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.2.10 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.1.8 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.1.9 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.1.9 [vagrant@k8s-master: /vagrant$ kubectl exec -t busybox-pbfks -- wget -O - 10.96.1.1/server_addr 2>/dev/null ] 10.1.2.10 [vagrant@k8s-master: /vagrant$ vagrant@k8s-master: /vagrant$ ]
```

# Using vpptrace

- VPP has internal trace:
  - e.g. “trace add dpdk-input 50”
  - select which type of VPP input graph node to operate on
  - also select number of packets to trace (up to 50)
  - That’s about it!
- Vpptrace.sh script in contiv-vpp has multiple options:
  1. Which VPP input node to operate on
  2. Which K8s node to operate on
  3. Filters to apply (regexp or otherwise)

# VPP debug CLI (vppctl)

The screenshot shows a web browser window displaying the "VPP/Command-line Interface (CLI) Guide" page from the [wiki.fd.io](https://wiki.fd.io/view/VPP/Command-line_Interface_(CLI)_Guide) website. The page title is "VPP/Command-line Interface (CLI) Guide". The left sidebar contains navigation links such as "Main page", "Recent changes", "Random page", "Help", "Tools", "What links here", "Related changes", "Upload file", "Special pages", "Printable version", "Permanent link", and "Page information". The main content area features a "Contents [hide]" section with a hierarchical list of commands:

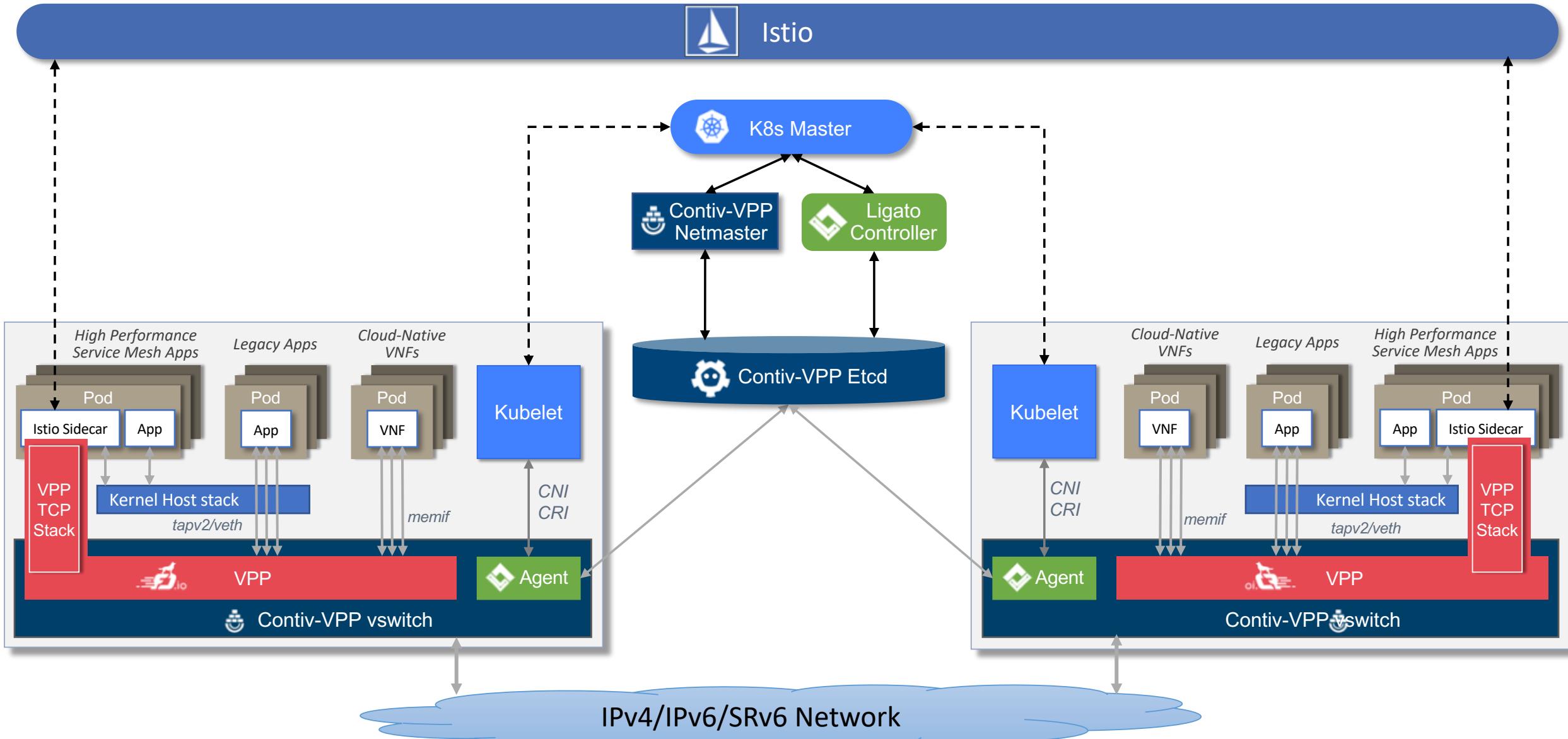
- 1 Introduction
- 2 Debug and Telnet CLI
  - 2.1 CLI features
- 3 Interface Commands
  - 3.1 show interface
  - 3.2 show interface address
  - 3.3 show hardware
  - 3.4 clear interface
  - 3.5 set interface
  - 3.6 show interface
  - 3.7 create vlan subinterface
  - 3.8 set interface ip
  - 3.9 set interface ip addr
  - 3.10 set interface ip table
- 4 Routing table commands
  - 4.1 ip route add/del
  - 4.2 show ip fib / show ip6 fib
  - 4.3 Manipulating the ARP cache
  - 4.4 Proxy ARP
  - 4.5 dhcp proxy
  - 4.6 dhcp proxy option 82 (circuit-ID)
  - 4.7 provisioning martian addresses

The browser interface includes standard navigation buttons (back, forward, search), a tab bar with "Page" and "Discussion" selected, and a header with the URL [https://wiki.fd.io/view/VPP/Command-line\\_Interface\\_\(CLI\)\\_Guide](https://wiki.fd.io/view/VPP/Command-line_Interface_(CLI)_Guide), a user login link, and a search bar.

# Agenda

- Kubernetes Overview
- Contiv-VPP
  - Overview
  - Architecture
  - Hands-On
  - Load-Balancers and Service Meshes
- Ligato
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- The Future

# Putting it All Together...



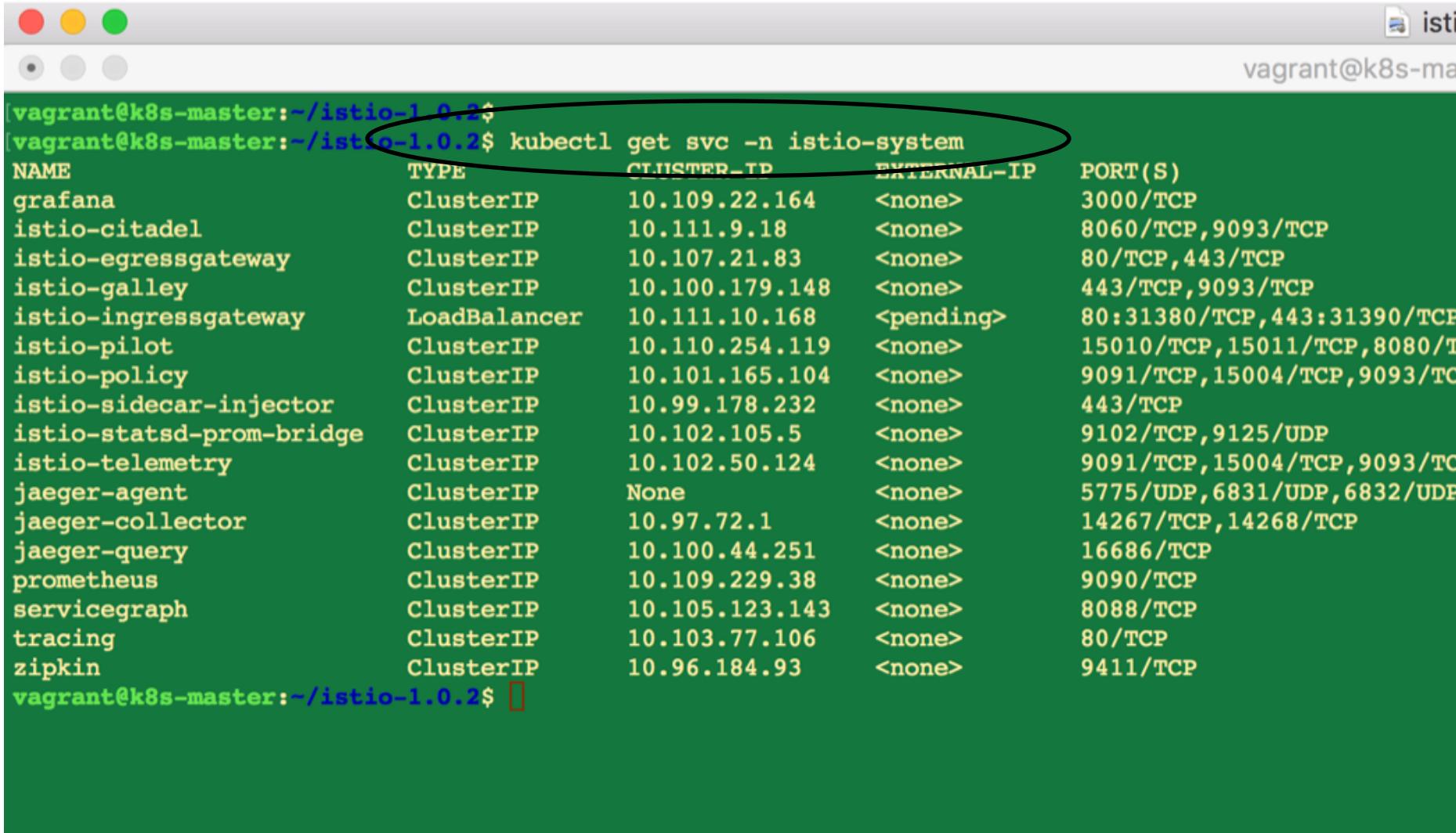
# Download Istio

```
vagrant@k8s-master: ~/istio-1.0.2  
[vagrant@k8s-master: ~]$ curl -L https://git.io/getLatestIstio | sh -  
% Total    % Received % Xferd  Average Speed   Time   Time     Time  Current  
          Dload  Upload Total Spent   Left  Speed  
0       0     0      0      0      0      0 ---:---:---:--- 0  
100  1456  100  1456      0      0  1808      0 ---:---:---:--- 1808  
Downloading istio-1.0.2 from https://github.com/istio/istio/releases/download/1.0.2/istio-1.0.2-  
linux.tar.gz ...  
% Total    % Received % Xferd  Average Speed   Time   Time     Time  Current  
          Dload  Upload Total Spent   Left  Speed  
100    614    0    614      0      0  1154      0 ---:---:---:--- 1154  
100 14.1M  100 14.1M      0      0 2868k      0  0:00:05  0:00:05 ---:--- 3432k  
Downloaded into istio-1.0.2:  
LICENSE README.md bin install istio.VERSION samples tools  
Add /home/vagrant/istio-1.0.2/bin to your path; e.g copy paste in your shell and/or ~/.profile:  
export PATH="$PATH:/home/vagrant/istio-1.0.2/bin"  
[vagrant@k8s-master: ~]$  
[vagrant@k8s-master: ~]$ cd istio-1.0.2  
[vagrant@k8s-master: ~/istio-1.0.2]$  
[vagrant@k8s-master: ~/istio-1.0.2]$ export PATH=$PATH:$PWD/bin  
[vagrant@k8s-master: ~/istio-1.0.2]$  
[vagrant@k8s-master: ~/istio-1.0.2]$
```

# Install Istio

```
vagrant@k8s-master: ~/istio-1.0.2  
[vagrant@k8s-master:~/istio-1.0.2$ kubectl apply -f install/kubernetes/istio-demo-auth.yaml  
namespace/istio-system configured  
configmap/istio-galley-configuration unchanged  
configmap/istio-grafana-custom-resources unchanged  
configmap/istio-statsd-prom-bridge unchanged  
configmap/prometheus unchanged  
configmap/istio-security-custom-resources configured  
configmap/istio configured  
configmap/istio-sidecar-injector unchanged  
serviceaccount/istio-galley-service-account unchanged  
serviceaccount/istio-egressgateway-service-account unchanged  
serviceaccount/istio-ingressgateway-service-account unchanged  
serviceaccount/istio-grafana-post-install-account unchanged  
clusterrole.rbac.authorization.k8s.io/istio-grafana-post-install-istio-system configured  
clusterrolebinding.rbac.authorization.k8s.io/istio-grafana-post-install-role-binding-istio-syste  
m configured  
job.batch/istio-grafana-post-install unchanged  
serviceaccount/istio-mixer-service-account unchanged  
serviceaccount/istio-pilot-service-account unchanged  
serviceaccount/prometheus unchanged  
serviceaccount/istio-cleanup-secrets-service-account unchanged  
clusterrole.rbac.authorization.k8s.io/istio-cleanup-secrets-istio-system configured  
clusterrolebinding.rbac.authorization.k8s.io/istio-cleanup-secrets-istio-system configured  
job.batch/istio-cleanup-secrets unchanged
```

# Check Istio Services



vagrant@k8s-master:~/istio-1.0.2\$ kubectl get svc -n istio-system

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)
grafana	ClusterIP	10.109.22.164	<none>	3000/TCP
istio-citadel	ClusterIP	10.111.9.18	<none>	8060/TCP,9093/TCP
istio-egressgateway	ClusterIP	10.107.21.83	<none>	80/TCP,443/TCP
istio-galley	ClusterIP	10.100.179.148	<none>	443/TCP,9093/TCP
istio-ingressgateway	LoadBalancer	10.111.10.168	<pending>	80:31380/TCP,443:31390/TCP
istio-pilot	ClusterIP	10.110.254.119	<none>	15010/TCP,15011/TCP,8080/TCP
istio-policy	ClusterIP	10.101.165.104	<none>	9091/TCP,15004/TCP,9093/TCP
istio-sidecar-injector	ClusterIP	10.99.178.232	<none>	443/TCP
istio-statsd-prom-bridge	ClusterIP	10.102.105.5	<none>	9102/TCP,9125/UDP
istio-telemetry	ClusterIP	10.102.50.124	<none>	9091/TCP,15004/TCP,9093/TCP
jaeger-agent	ClusterIP	None	<none>	5775/UDP,6831/UDP,6832/UDP
jaeger-collector	ClusterIP	10.97.72.1	<none>	14267/TCP,14268/TCP
jaeger-query	ClusterIP	10.100.44.251	<none>	16686/TCP
prometheus	ClusterIP	10.109.229.38	<none>	9090/TCP
servicegraph	ClusterIP	10.105.123.143	<none>	8088/TCP
tracing	ClusterIP	10.103.77.106	<none>	80/TCP
zipkin	ClusterIP	10.96.184.93	<none>	9411/TCP

vagrant@k8s-master:~/istio-1.0.2\$

# Check Istio Pods

```
vagrant@k8s-master: ~/istio-1.0.2$ kubectl get pods -n istio-system
NAME                         READY   STATUS    RESTARTS   AGE
grafana-85dbf49c94-2nn9j      1/1     Running   0          3m
istio-citadel-545f49c58b-b9xxq 1/1     Running   0          3m
istio-cleanup-secrets-fq8gn   0/1     Completed  0          3m
istio-egressgateway-7d59954f4-81vfg 1/1     Running   0          3m
istio-galley-5b6449c48f-gvc5x    1/1     Running   0          3m
istio-grafana-post-install-52gs4 0/1     Completed  3          3m
istio-ingressgateway-8455c8c6f7-pb48v 1/1     Running   0          3m
istio-pilot-58ff4d6647-hbzmm     2/2     Running   0          3m
istio-policy-59685fd869-s8mcm    2/2     Running   0          3m
istio-security-post-install-6wd4c 0/1     Completed  0          3m
istio-sidecar-injector-75b9866679-9mzw9 1/1     Running   0          3m
istio-statsd-prom-bridge-549d687fd9-49557 1/1     Running   0          3m
istio-telemetry-6ccf9ddb96-s882f    2/2     Running   0          3m
istio-tracing-7596597bd7-mrsmt    1/1     Running   0          3m
prometheus-6ffc56584f-mh8h2       1/1     Running   0          3m
servicegraph-5d64b457b4-kvh7m     1/1     Running   0          3m
vagrant@k8s-master:~/istio-1.0.2$
```

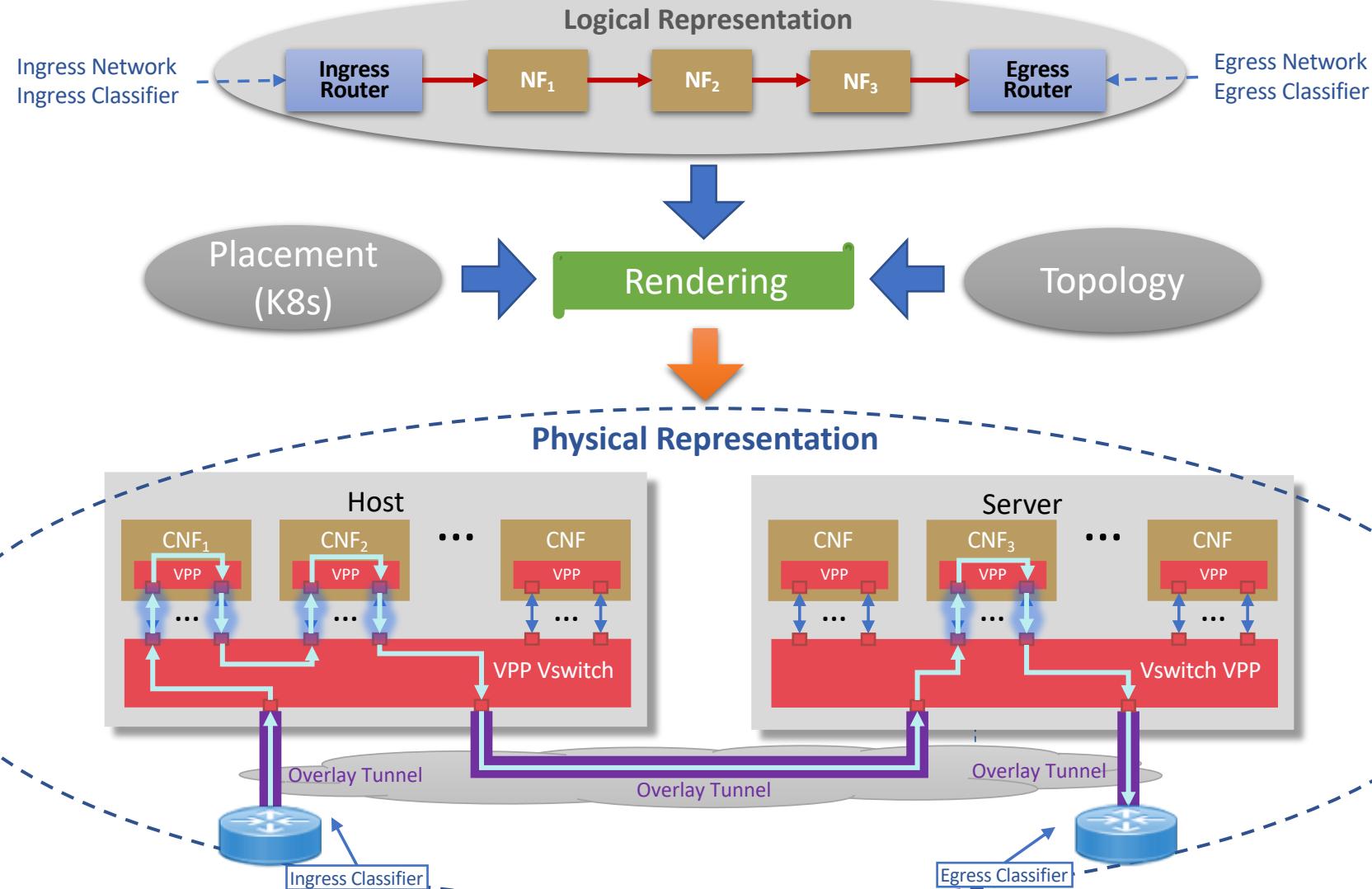
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# What Container Networking Lacks for NFV Use-Cases

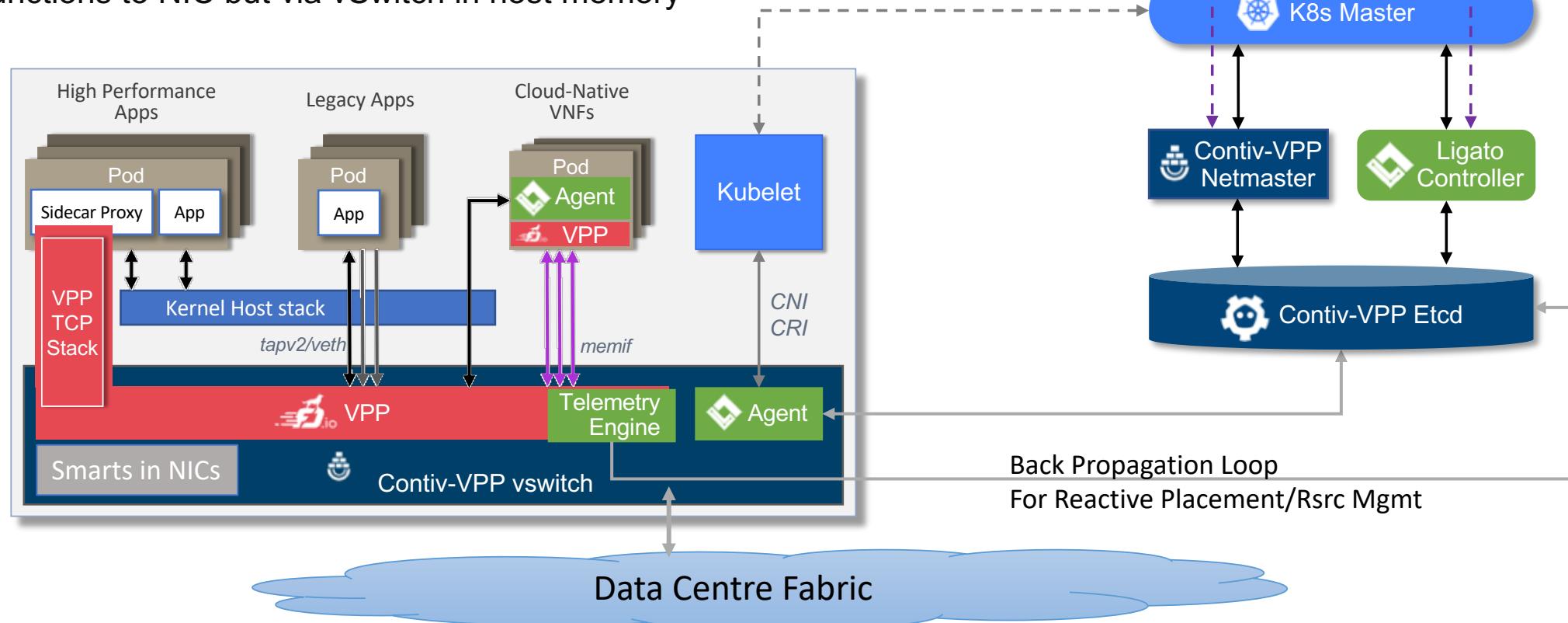
- Networking
  - HTTP or NAT-based load balancing isn't suitable for NFV use-cases
  - No support for multiple interfaces or IP addresses per pod
  - No support for high-speed wiring of NFs
- Policy
  - No support for QoS, network-aware placement etc.
- Isolation
  - Applications run in user-space – kernel networking is unsuited to NFV
- Performance
  - Polling mode drivers (e.g. DPDK) required for maximum throughput

# Service Function Chaining with Ligato



# Ligato – Cloud-native NFs (CNFs)

- Kubernetes does not provide a way to stitch micro-services together today
- Ligato enables you to wire the data plane together into a service topology
- Network functions can now become part of the service topology
- Dedicated Telemetry Engine in VPP to enable closed-loop control
- Offload functions to NIC but via vSwitch in host memory

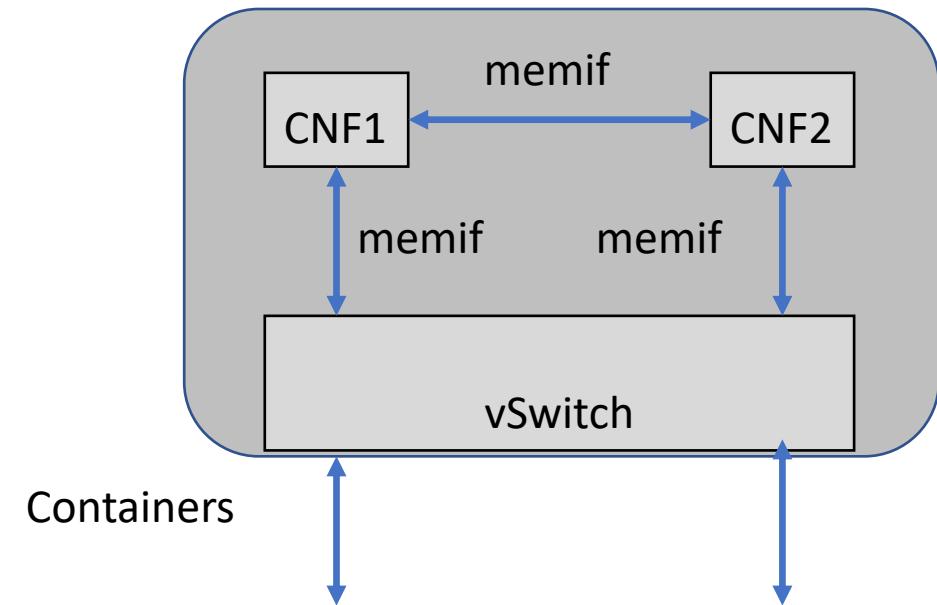
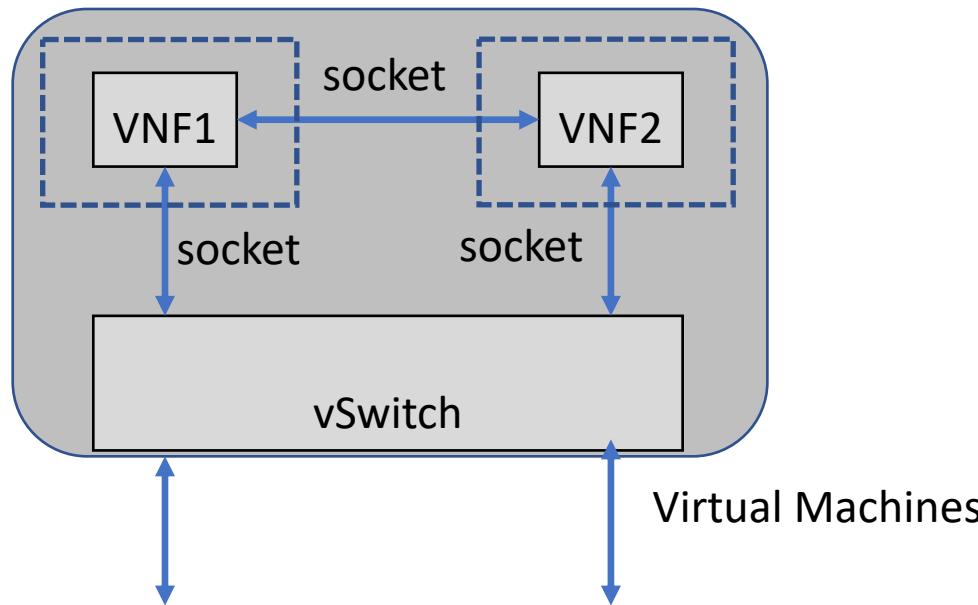


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  - Hands-On
- The Future

# Accelerating NFV Using Containers

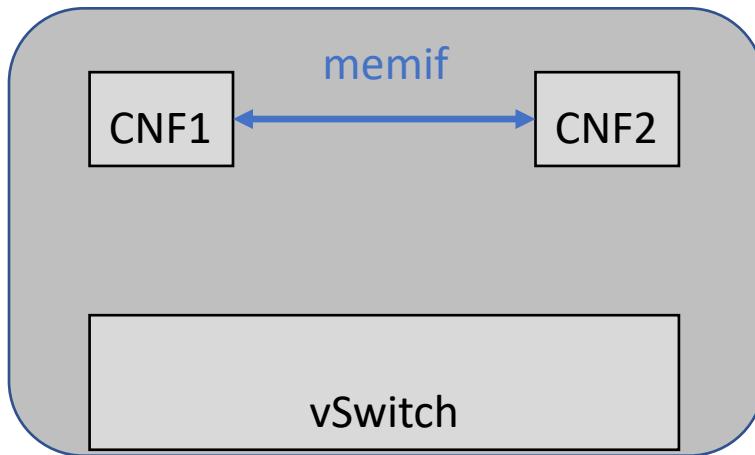
- In VM case have to copy via the kernel
- With containers we use a shared memory interface (memif)
  - Key is to chain between NFs on the same server
  - Containers are “cheap” so can have dedicated chain per tenant service



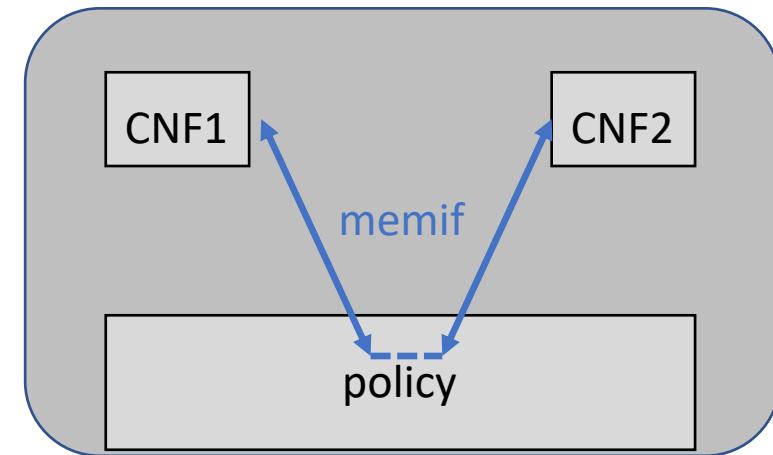
# Intra-Server Rendering

Point to Point – 2 options based on policy

Direct East/West Memif



Memif via vSwitch



# Creating memif xConnect

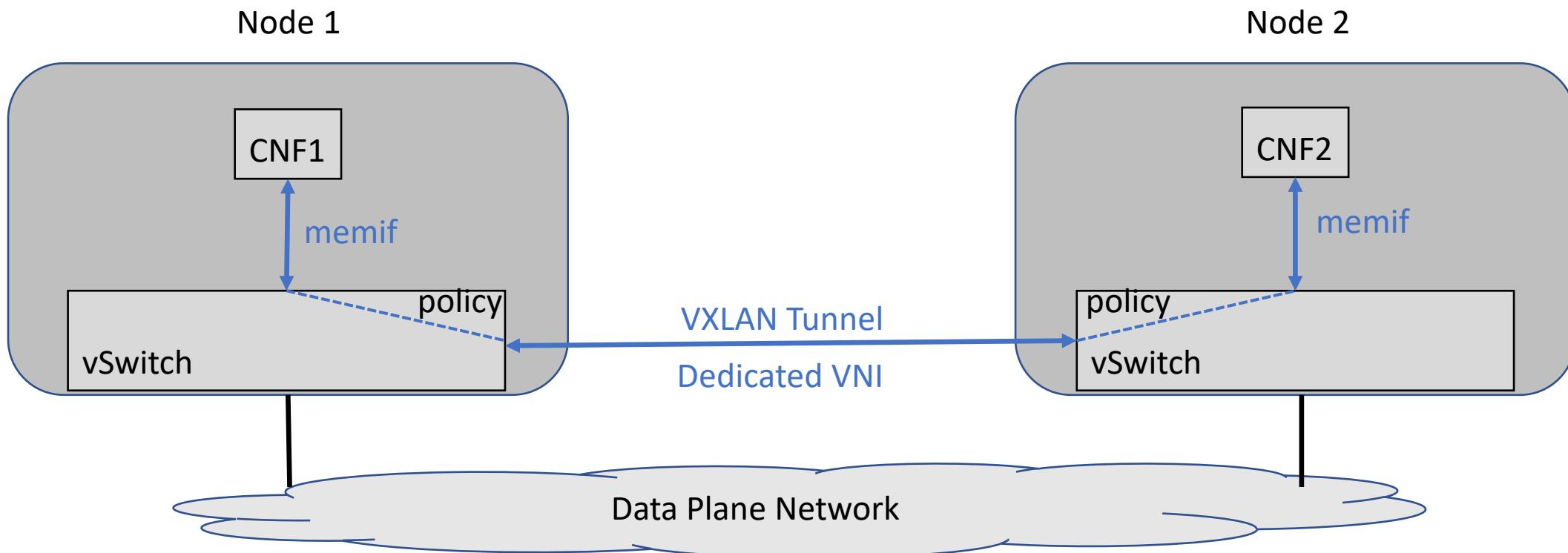
```
xrvr@i2ss-c2201:~$ sudo vppctl
[vpp#]
[vpp#] create interface memif id 1 master
[vpp#] create interface memif id 2 master
[vpp#]
[vpp#]
[vpp#] set interface 12 xconnect memif0/1 memif0/2
[vpp#] set interface 12 xconnect memif0/2 memif0/1
[vpp#]
```

Create memifs

Create xConnect

# VXLAN Rendering

## Point to Point



# Creating VXLAN xConnect

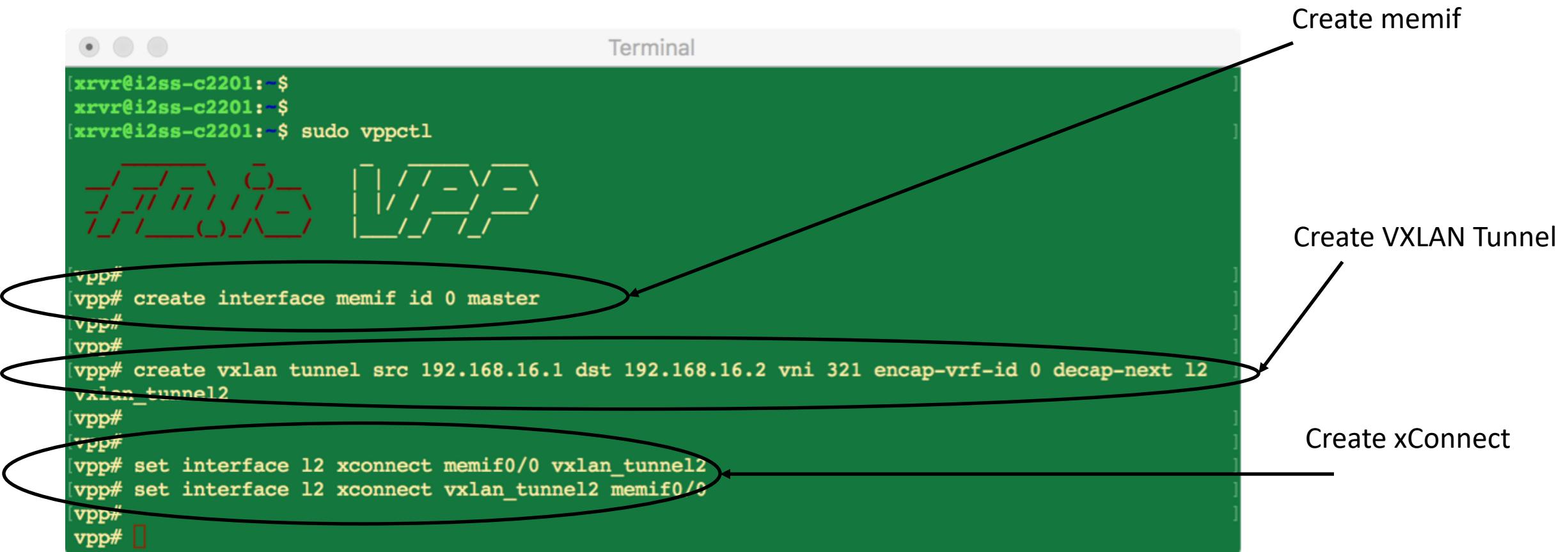
Terminal

```
[xrvr@i2ss-c2201:~$  
xrvr@i2ss-c2201:~$  
[xrvr@i2ss-c2201:~$ sudo vppctl  
  
[vpp#  
[vpp# create interface memif id 0 master  
[vpp#  
[vpp#  
[vpp# create vxlan tunnel src 192.168.16.1 dst 192.168.16.2 vni 321 encap-vrf-id 0 decap-next 12  
vxlan_tunnel2  
[vpp#  
[vpp#  
[vpp# set interface 12 xconnect memif0/0 vxlan_tunnel2  
[vpp# set interface 12 xconnect vxlan_tunnel2 memif0/0  
[vpp#  
vpp# ]
```

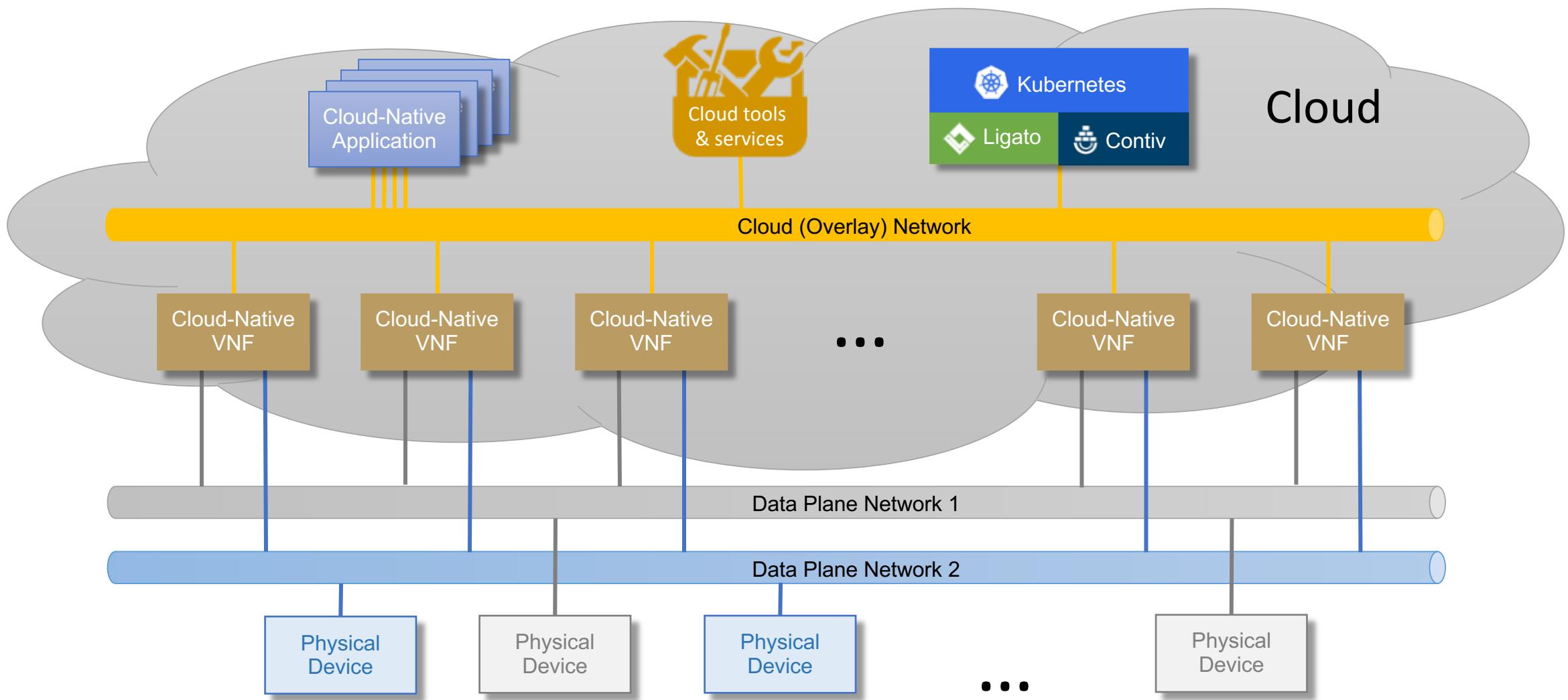
Create memif

Create VXLAN Tunnel

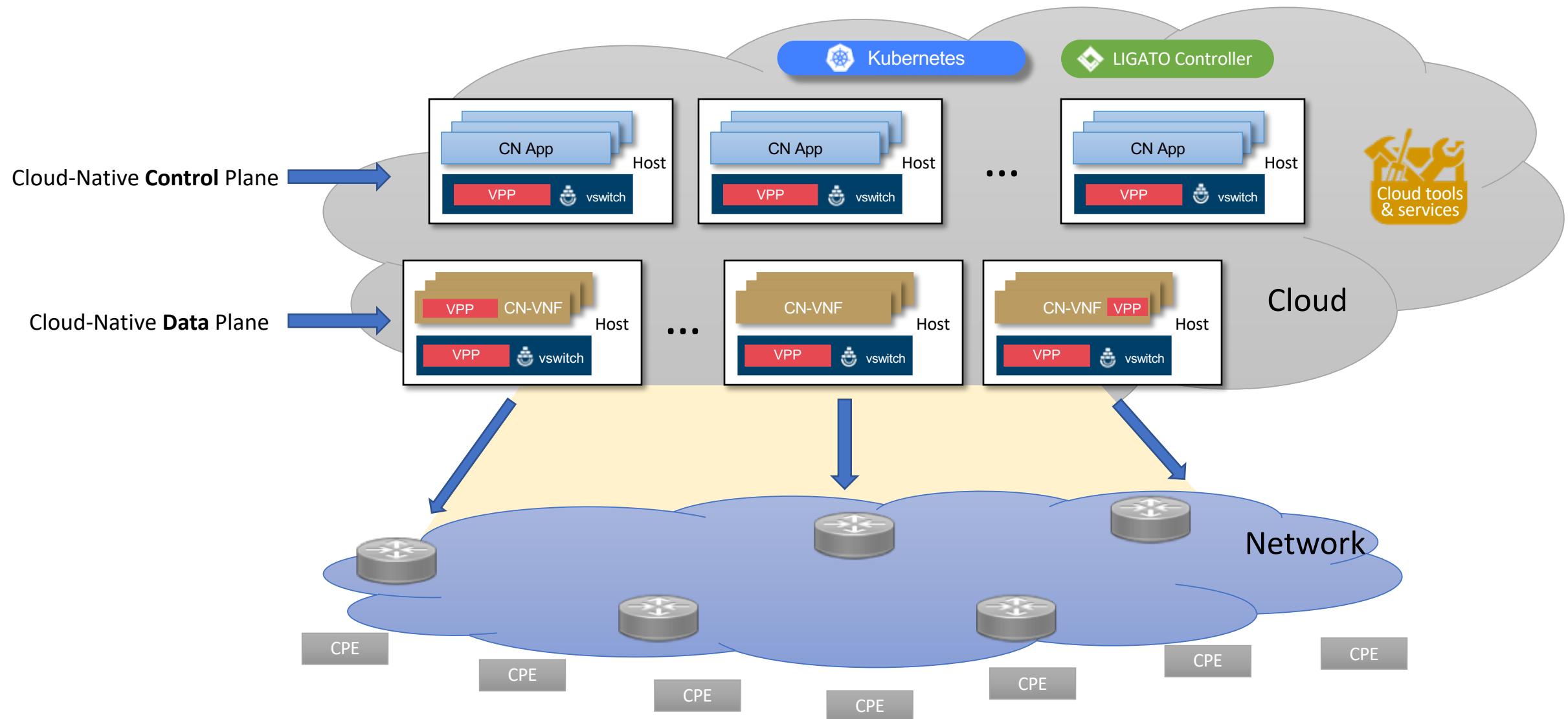
Create xConnect



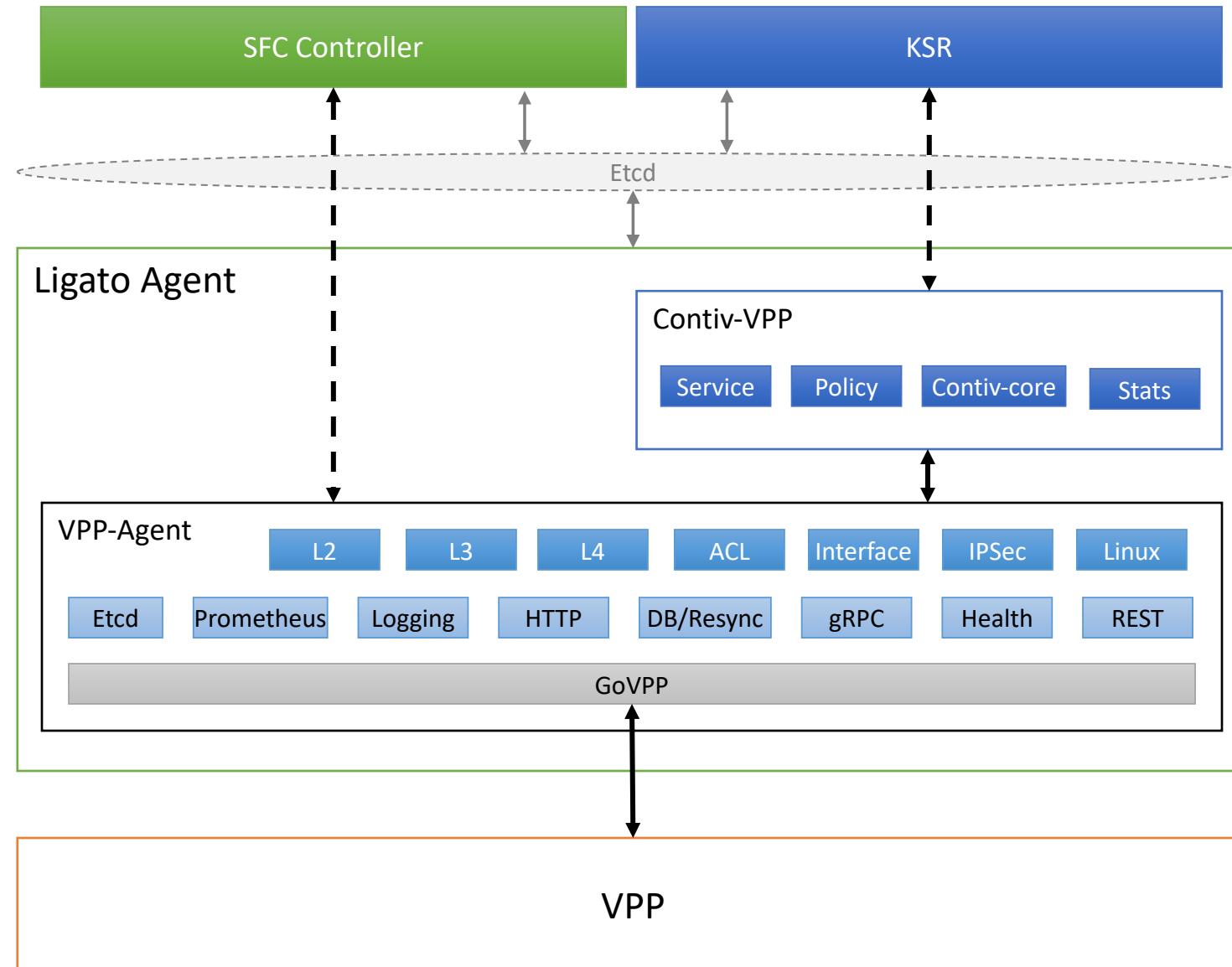
# A VNF Cloud



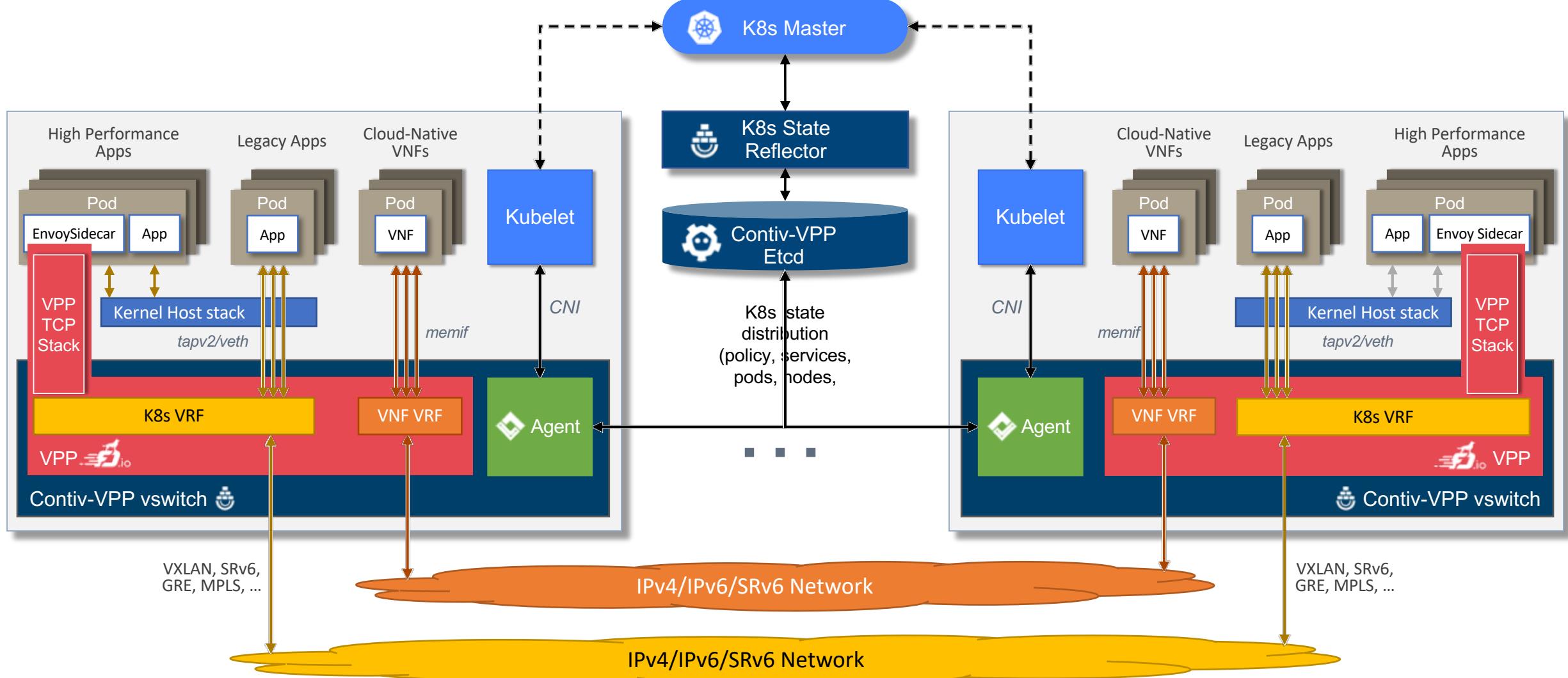
# A VNF Cloud: Data and Control Planes



# Ligato and Kubernetes Control and Data Planes



# VNFs & K8s Networking



# Ligato on Github

 Ligato  
<https://ligato.github.io>

Repositories 8 People 18 Teams 1 Projects 1 Settings

Pinned repositories

cn-infra vpp-agent sfc-controller

Customize pinned repositories

Search repositories... Type: All Language: All New

**vpp-agent**  
cn-infra based VNF agent for VPP (FD.io)  
cloud-native vpp vnf fdio cn-infra  
Go ★ 18 23 Apache-2.0 Updated 8 hours ago

**cn-infra**  
A platform for developing cloud-native VNFs  
microservices cloud-native vnf cn-infra  
Go ★ 13 17 Apache-2.0 Updated a day ago

**sfc-controller**  
Service Function Chain (SFC) Controller for stitching virtual and physical networking  
Go ★ 4 4 Apache-2.0 Updated 4 days ago

Top languages Go CSS Makefile

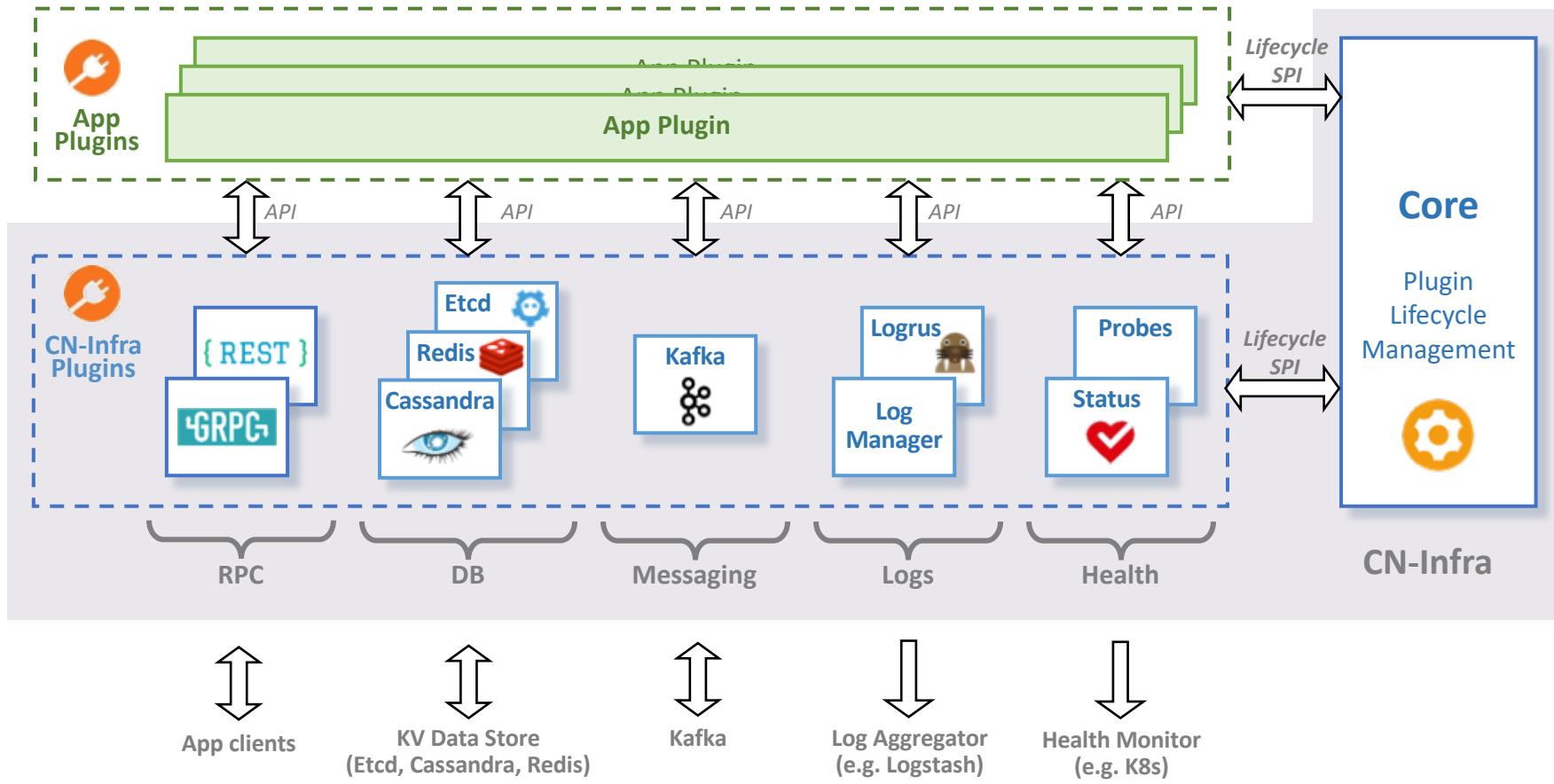
Most used topics Manage cloud-native cn-infra vnf

People 18 >

Cisco Confidential

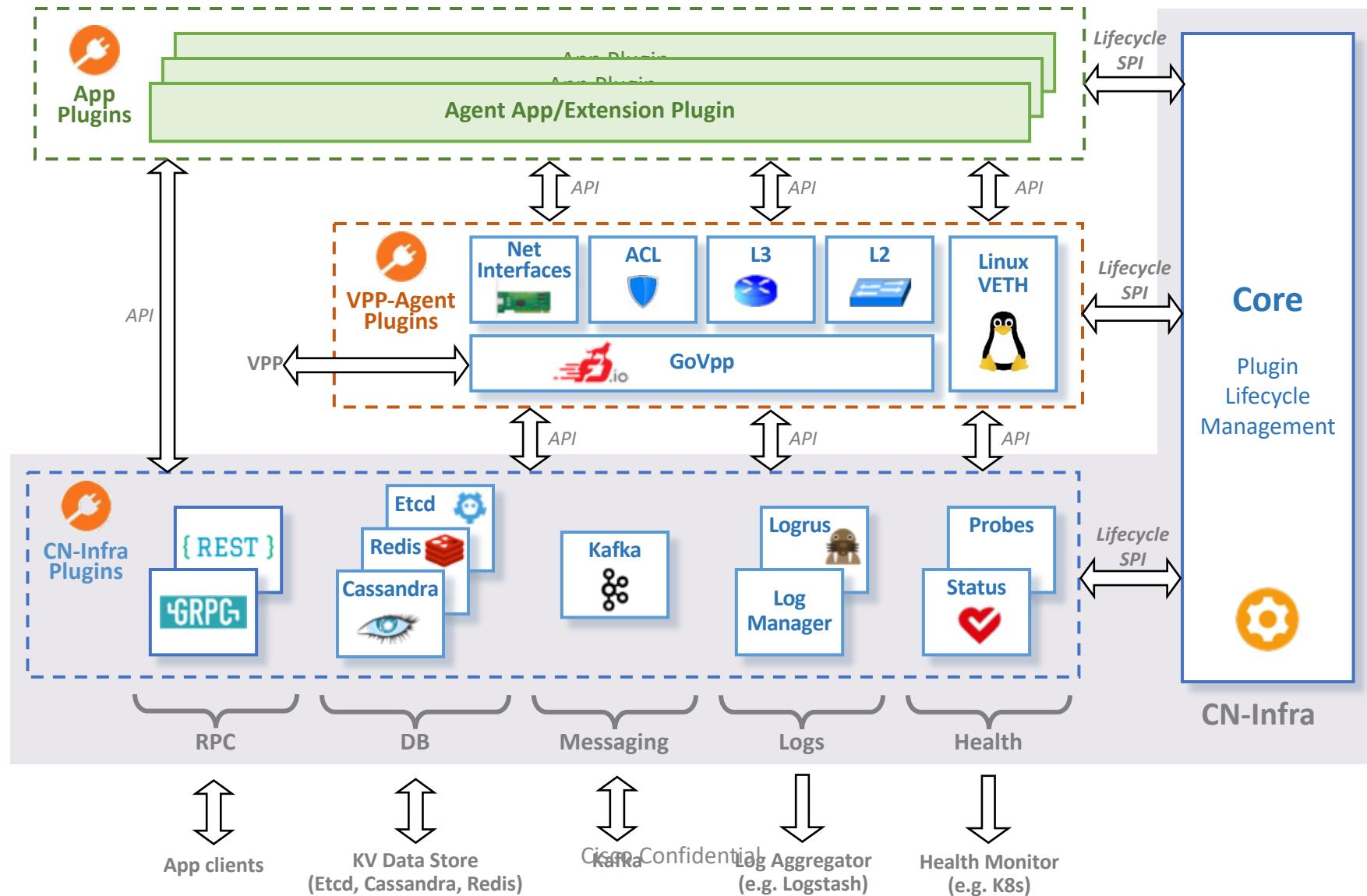
# Ligato CN-Infra: a CNF Development Platform

[www.github.com/ligato/cn-infra](https://www.github.com/ligato/cn-infra)



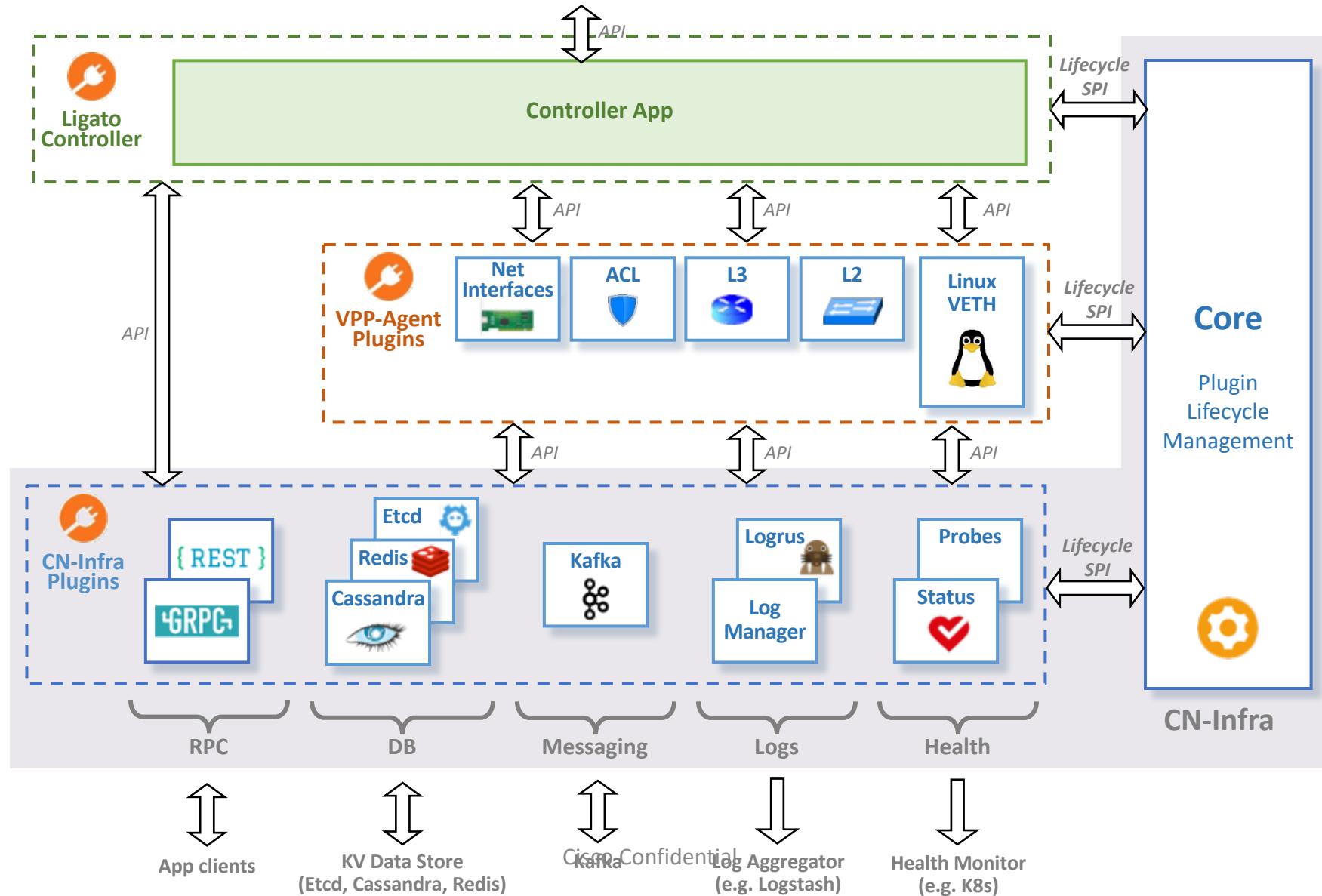
# Ligato VPP Agent: a CNF Management Agent

[www.github.com/ligato/vpp-agent](https://www.github.com/ligato/vpp-agent)



# Ligato SFC Controller: a CNF Deployment Platform

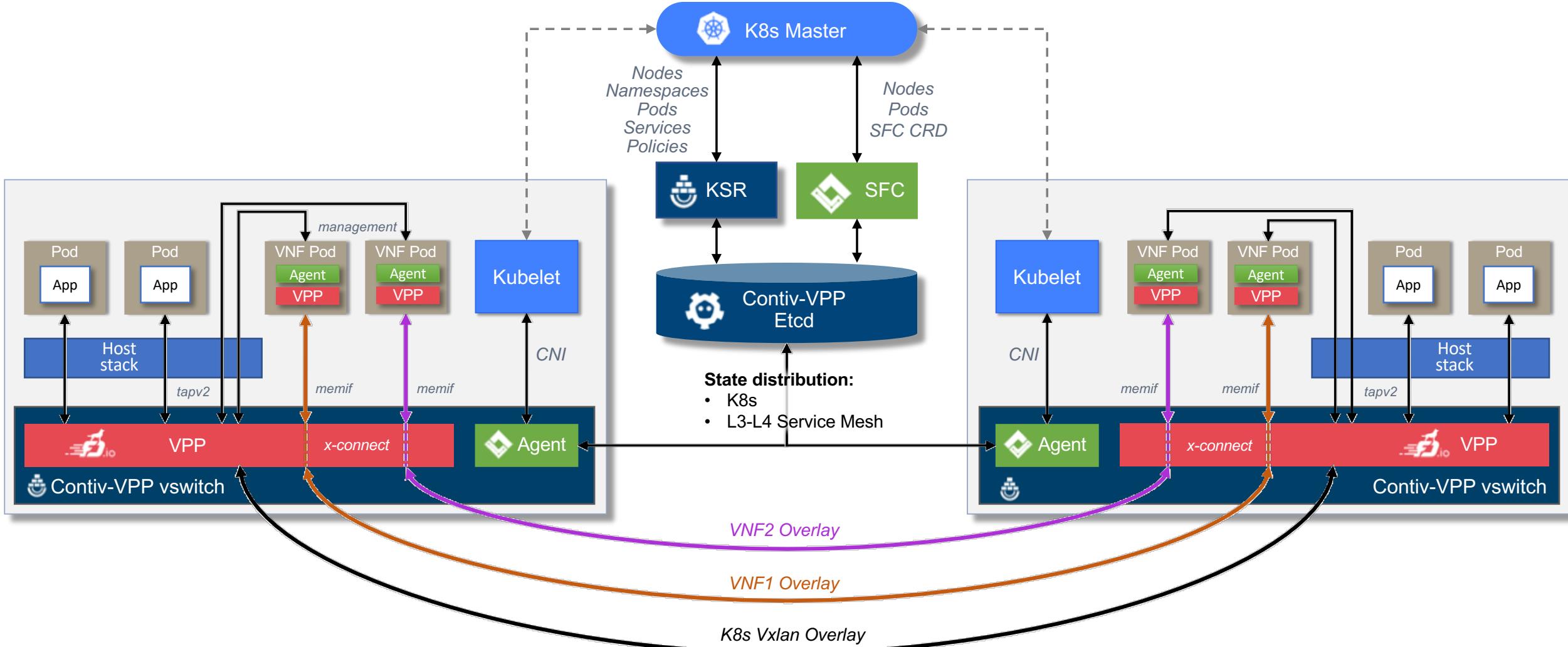
[www.github.com/ligato/sfc-controller](https://www.github.com/ligato/sfc-controller)



# Agenda

- Kubernetes Overview
- Contiv-VPP
  - Overview
  - Architecture
  - Hands-On
  - Load-Balancers and Service Meshes
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  - Overview
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- The Future

# ONS Demo



# Agenda

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