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The bridge to possible

Kubernetes (K8s) Infrastructure Connectivity

Network Designs for the Modern Data Center

Shangxin Du
Technical Marketing Engineer, Datacenter Switching

BRKDCN-2662

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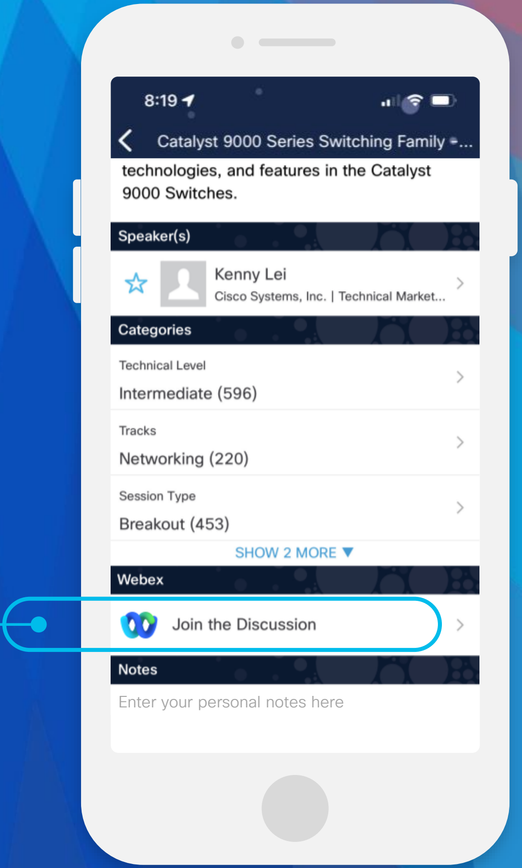

8:19

Catalyst 9000 Series Switching Family •...

technologies, and features in the Catalyst 9000 Switches.

Speaker(s)

☆ Kenny Lei
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Categories

Technical Level
Intermediate (596)

Tracks
Networking (220)

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Agenda

- What is Container Network Interface(CNI) Plugin
- Design the Kubernetes network on IP Fabric
- Design the Kubernetes network on VXLAN EVPN Fabric
- Integration with Nexus Dashboard Fabric Controller(NDFC)

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- **What is Container Network Interface(CNI) Plugin**
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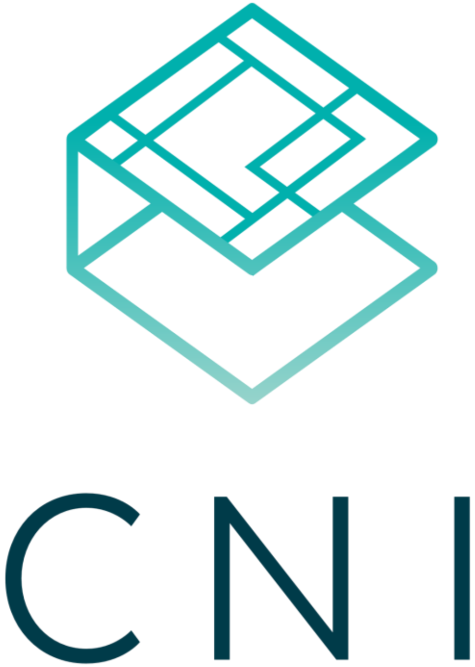
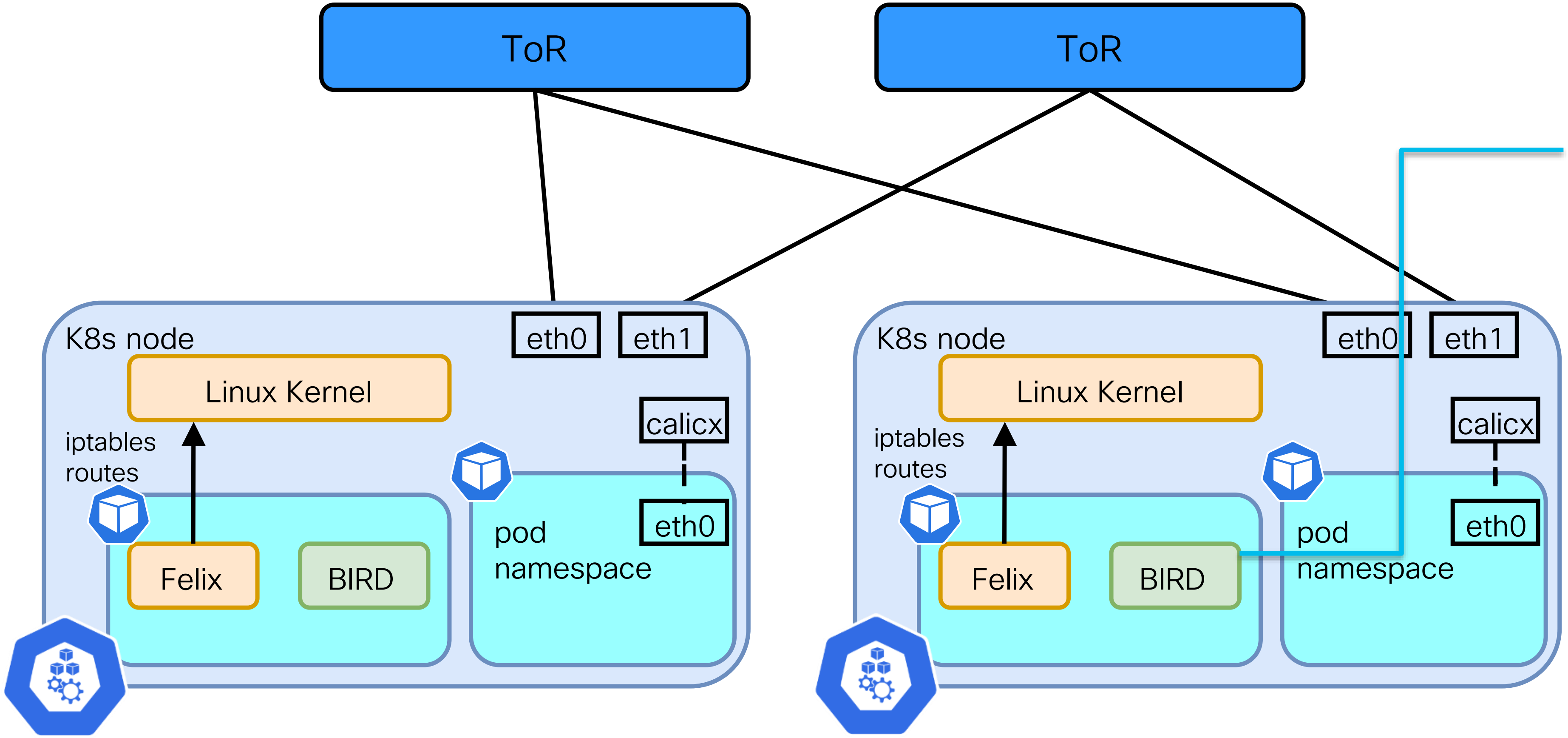
“Outsourcing the issue” - Container Networking Interface



- A generic plugin-based networking solution for application containers on Linux
- The spec defines a container as being a Linux network namespace
- The plugin must connect containers to networks and is responsible for IPAM and DNS configurations.

Project Calico

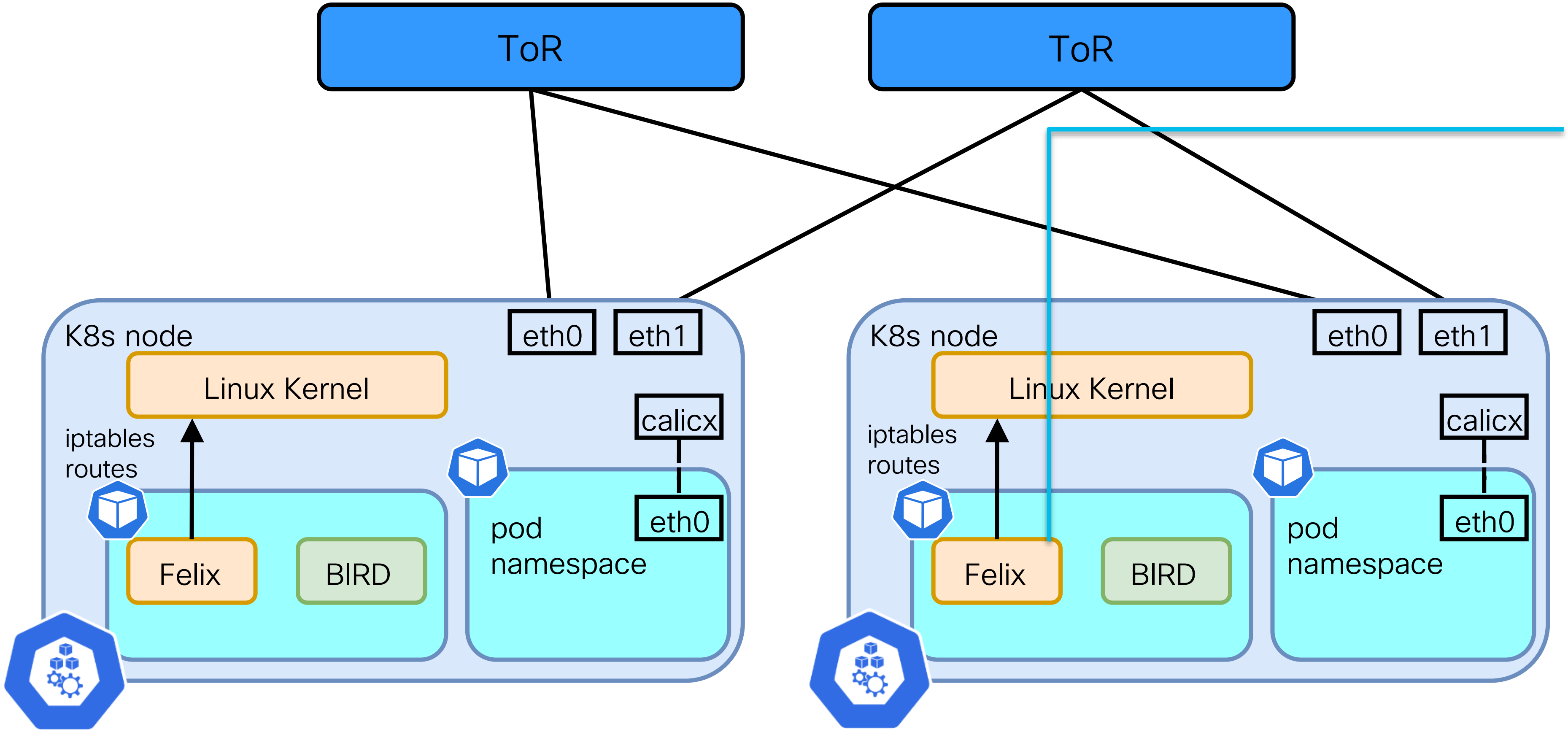
A CNI plugin of Kubernetes



BIRD: It is a routing daemon responsible for peering with other K8s nodes and exchanging routes of pod network and service network for inter-node communication.

Project Calico

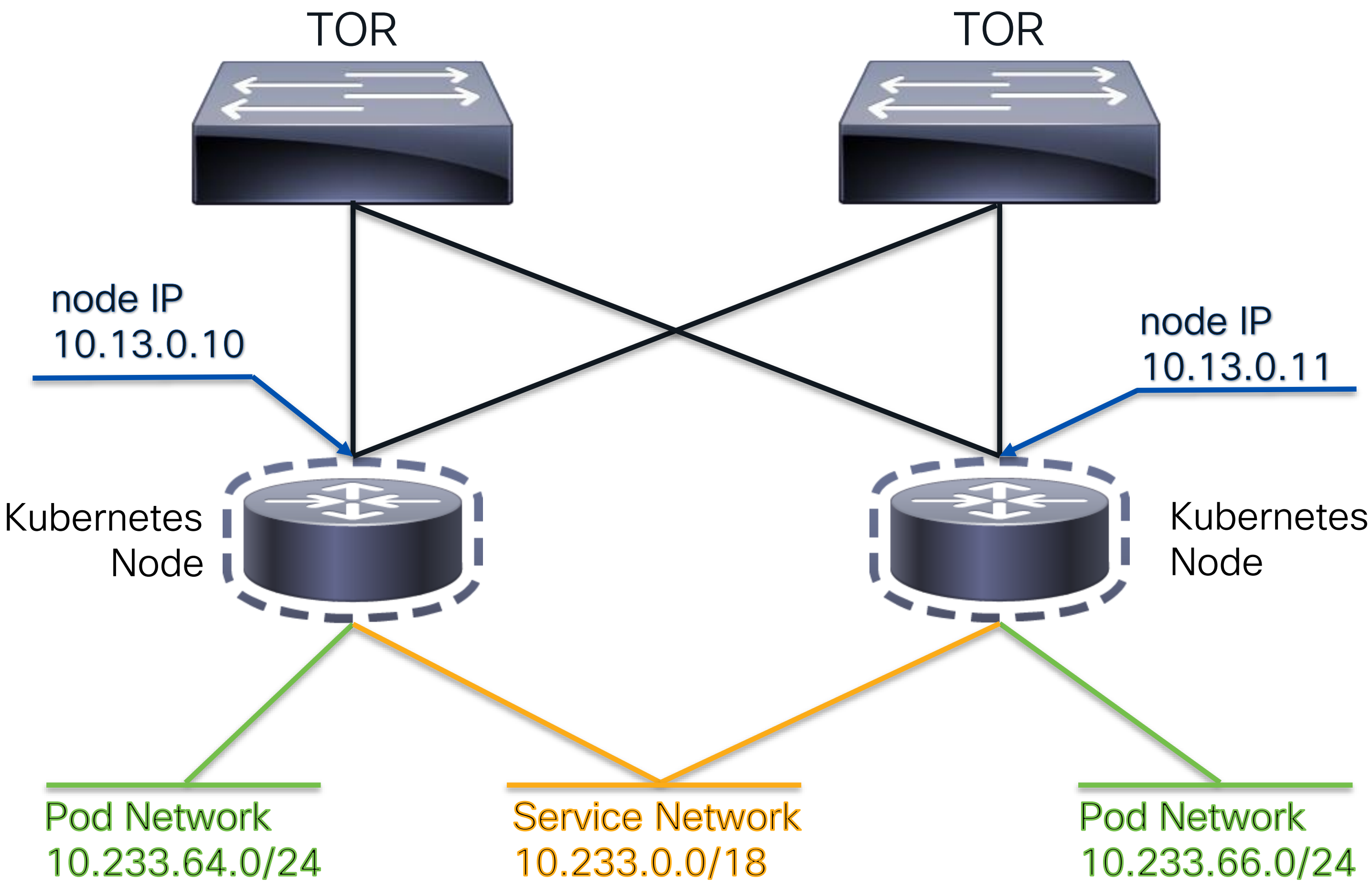
A CNI plugin of Kubernetes



Felix: Running in same pod as BIRD, programs routes and ACLs (iptables) and anything required on Calico node to provide connectivity for the pods scheduled on that node

Project Calico

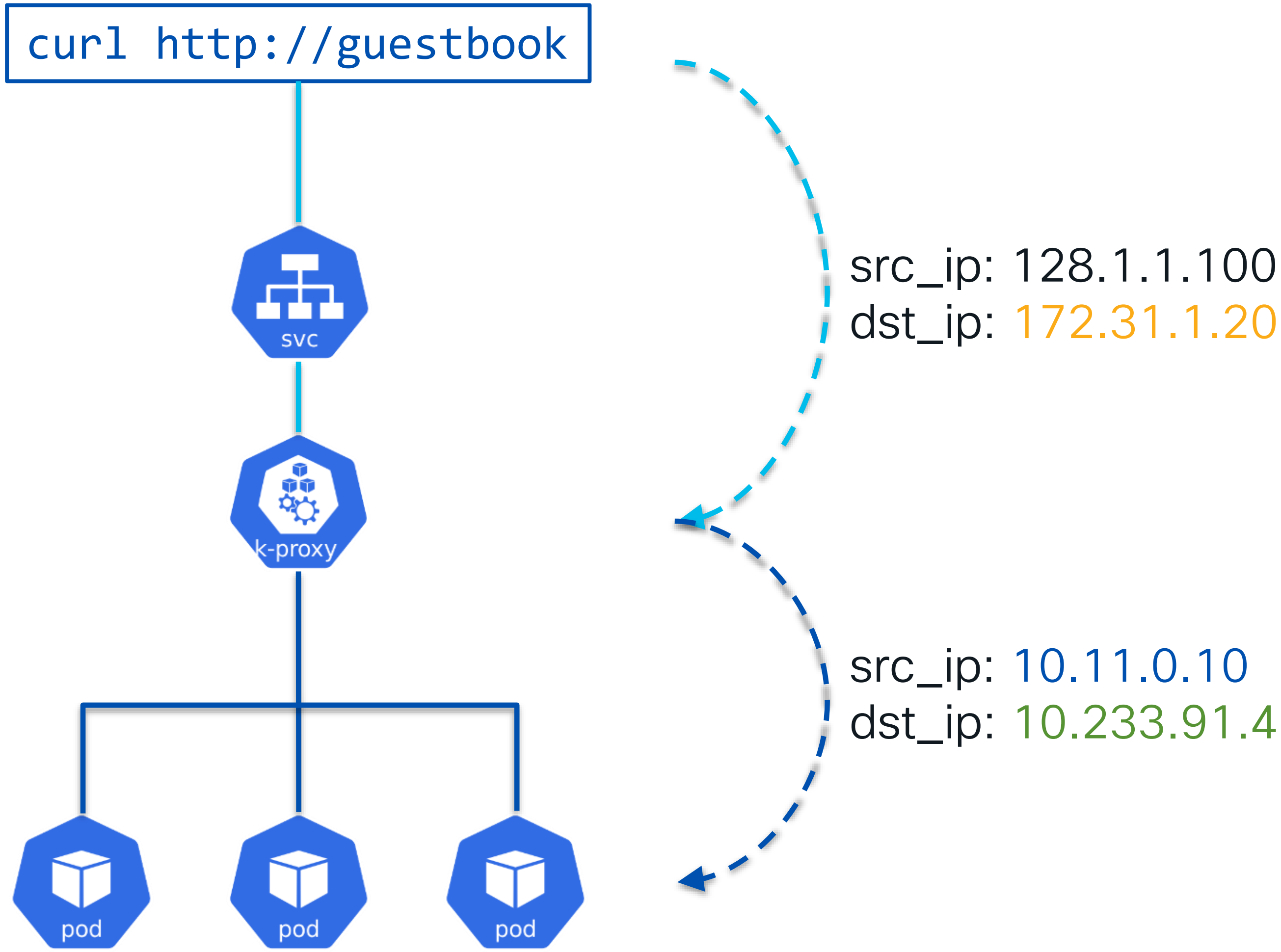
Simplified



- Each Calico node has one node IP
- one or more ranges of IP addresses (CIDRs) for Pod Networks
- a shared network for the whole Kubernetes cluster which is called the Service Network.

Kubernetes Service

A life of packet



```
curl http://guestbook
```

src_ip: 128.1.1.100
dst_ip: 172.31.1.20

src_ip: 10.11.0.10
dst_ip: 10.233.91.4

- The HTTP request is sent to service ip
- One of the Kubernetes nodes will first receive the request
- Source IP is rewritten to node ip and destination ip is rewritten to one of the pod ips

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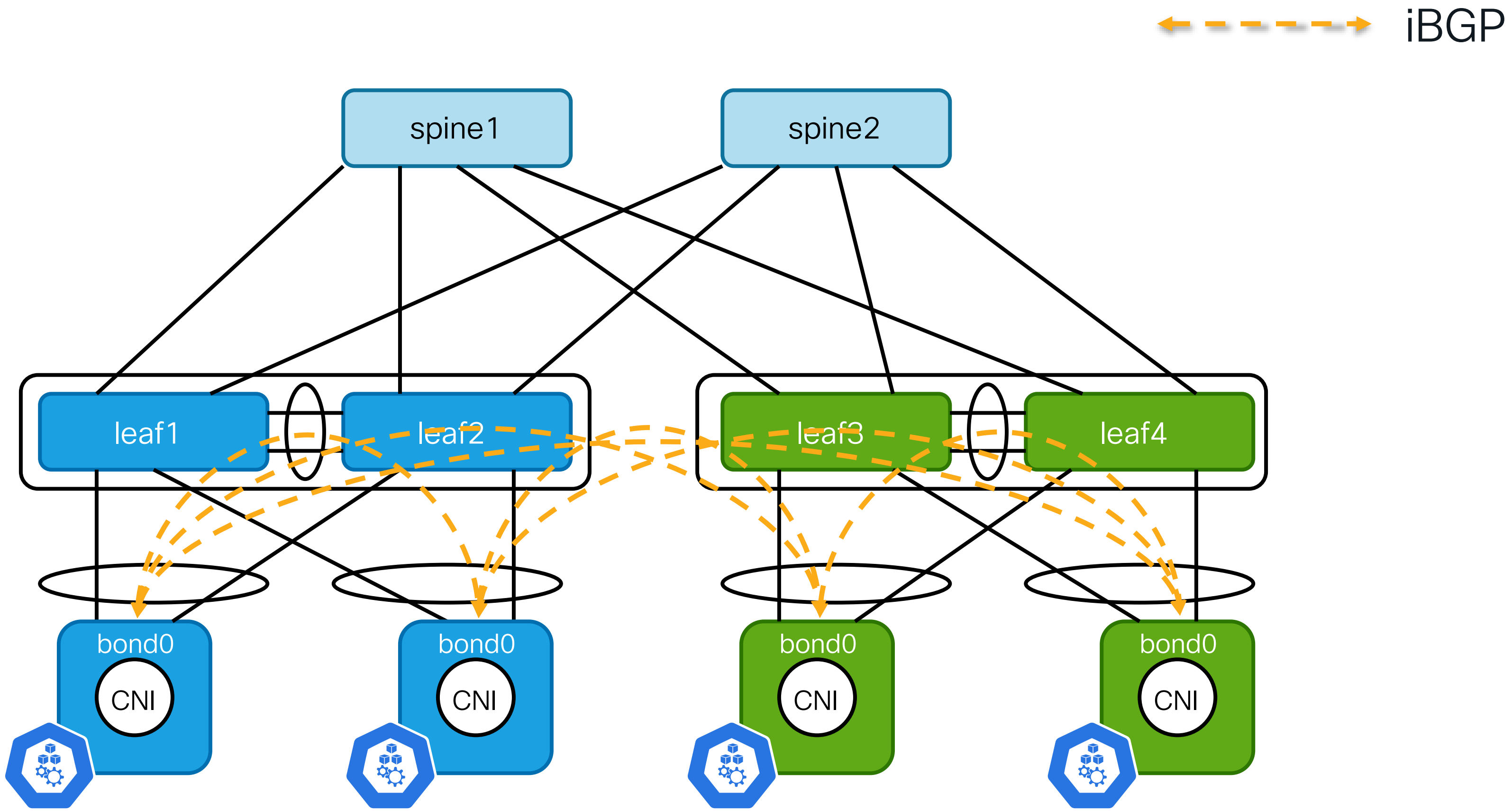
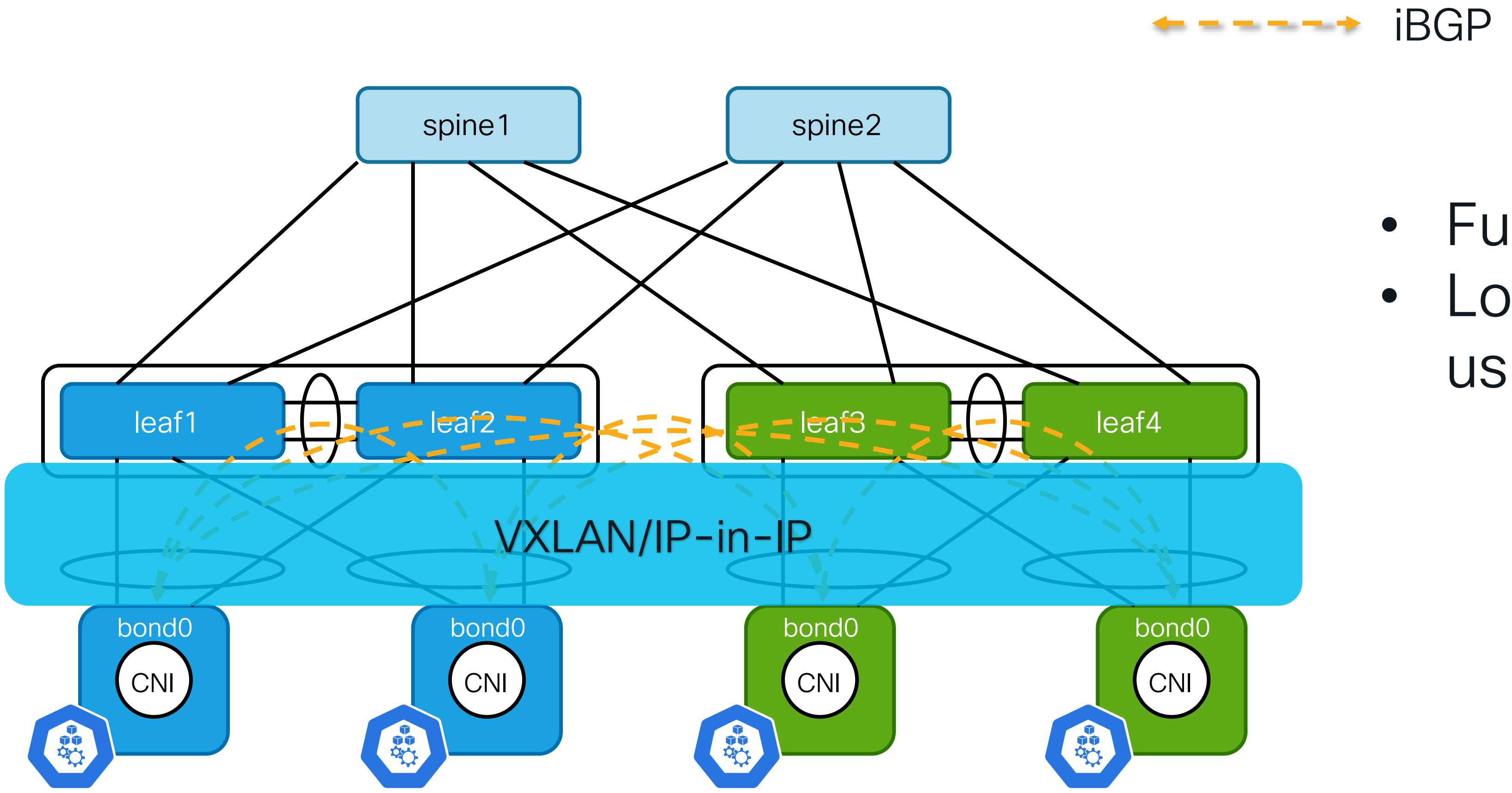
Network Architecture

Full mesh



Network Architecture

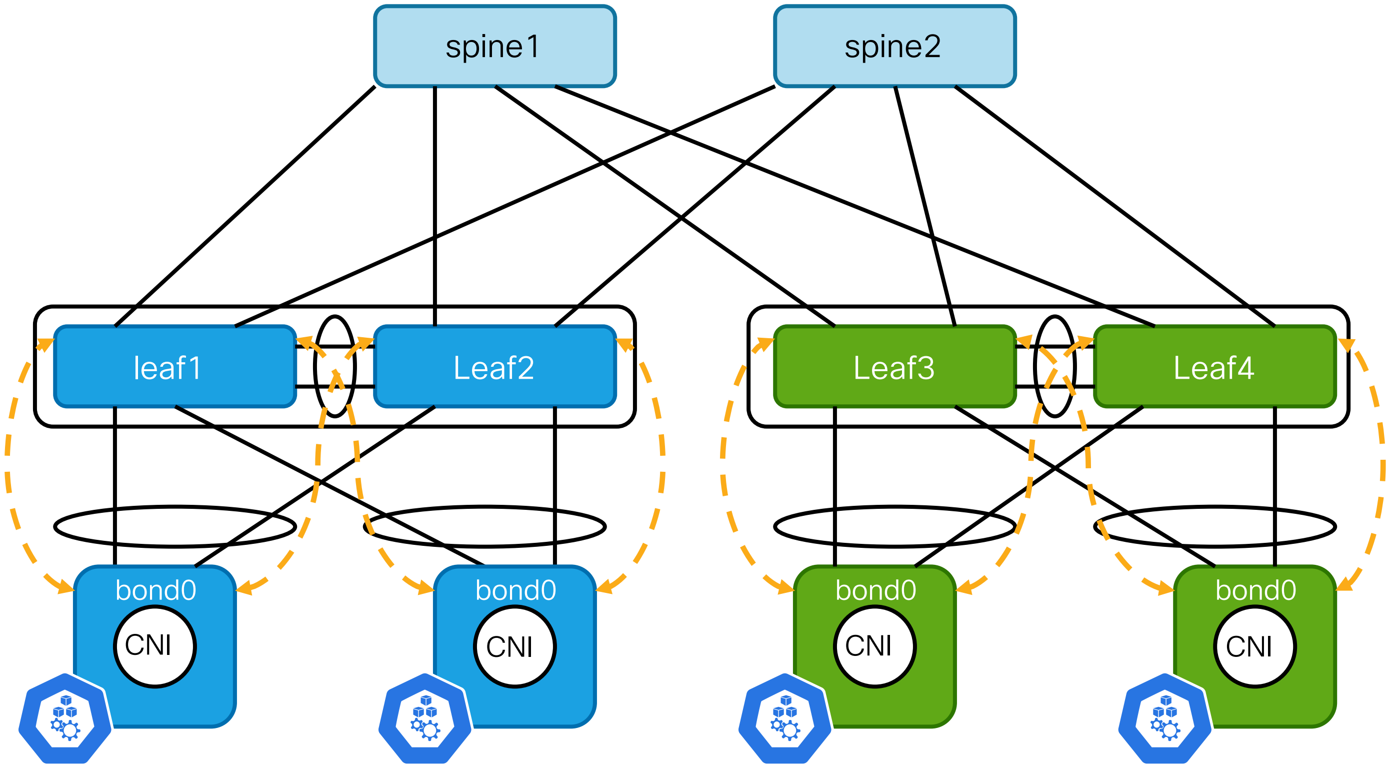
Full mesh data plane



- Full mesh does not scale!
- Losing visibility when using software overlay

Network Architecture

Peer with Switch



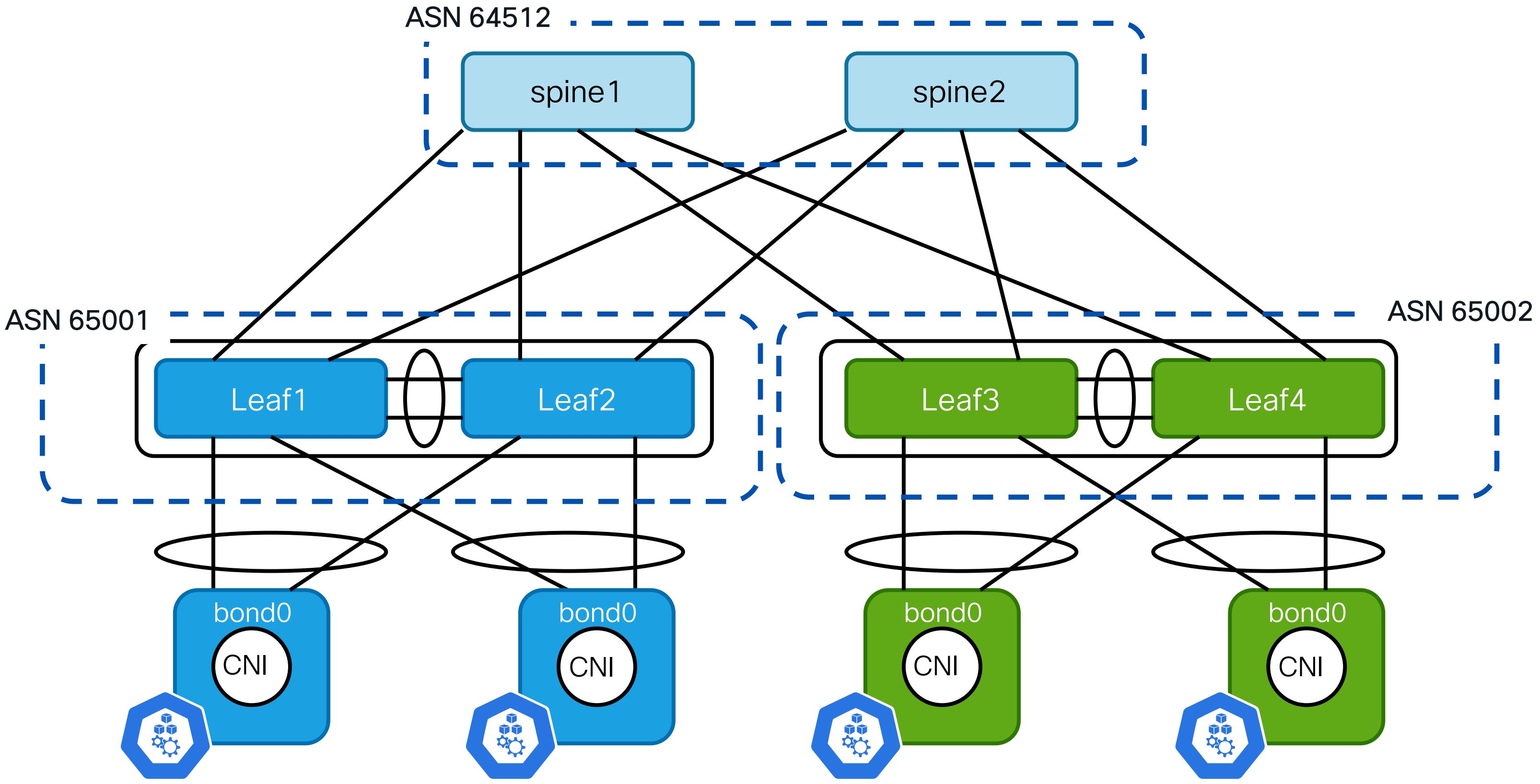
⇠ ⇢ iBGP

- Scalable approach, the leaf switches become Route-Reflector
- Data is transported with the original header

```
apiVersion: projectcalico.org/v3
kind: IPPool
metadata:
  name: default-pool
spec:
  blockSize: 24
  cidr: 10.233.64.0/20
  ipipMode: Never
  nodeSelector: all()
  vxlanMode: Never
```

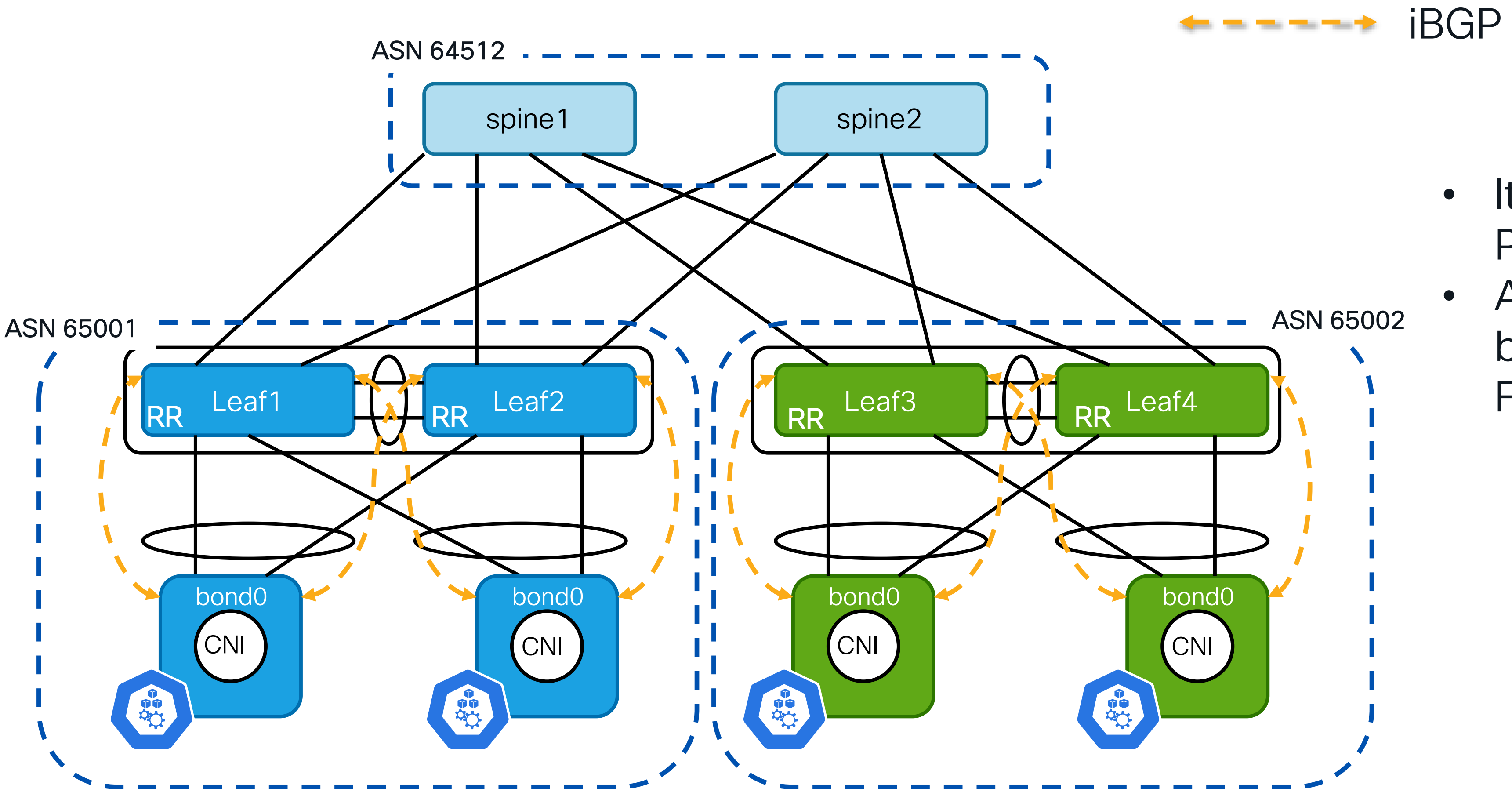
Network Architecture

Deploy Over IP Fabric



Network Architecture

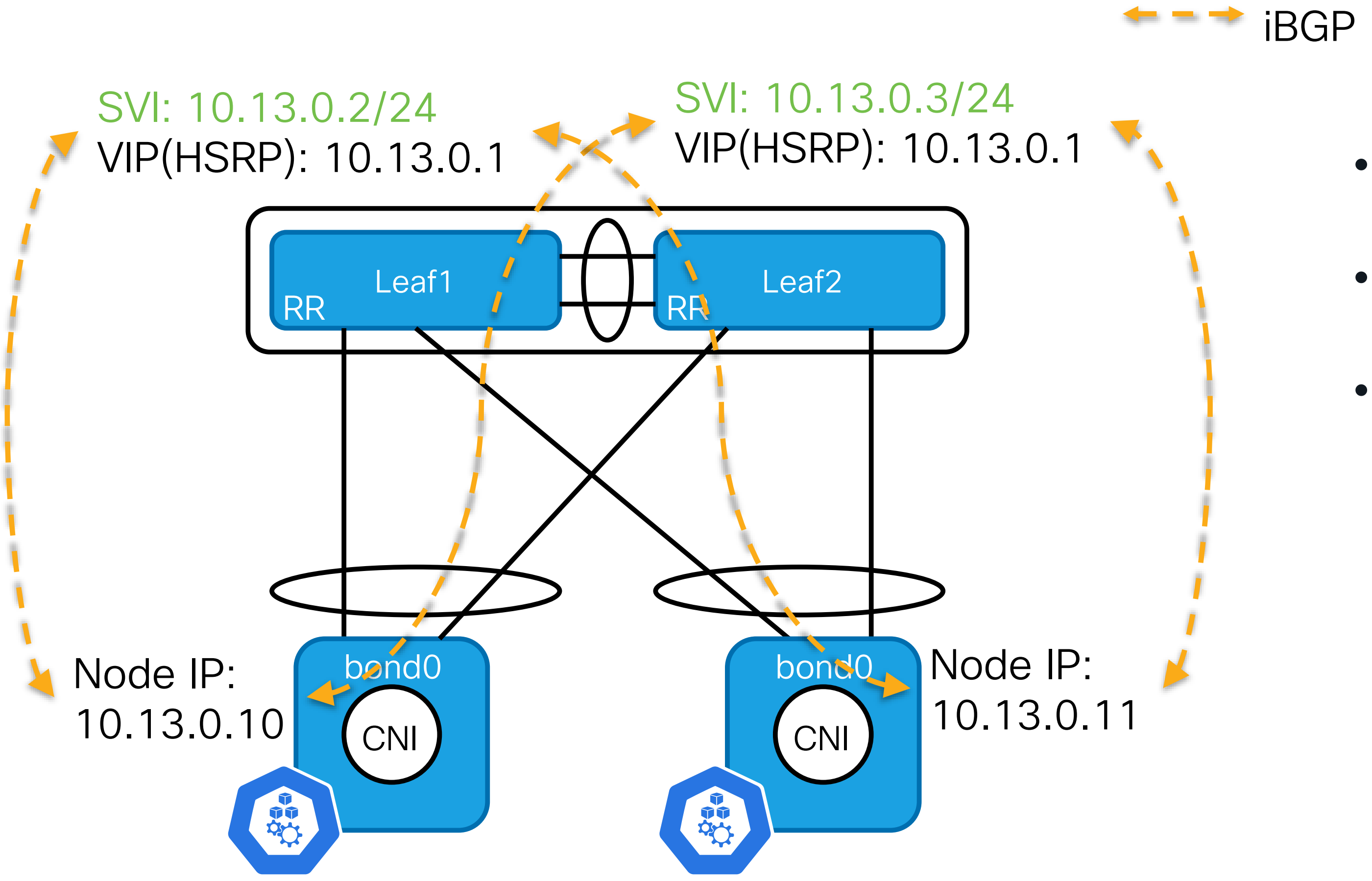
Deploy Over IP Fabric



- It is usually referred to as AS-Per-Rack design.
- AS-Per-Rack is recommended by Calico, but exclusively for IP Fabric(RFC 7938)

Network Architecture

Deploy Over IP Fabric



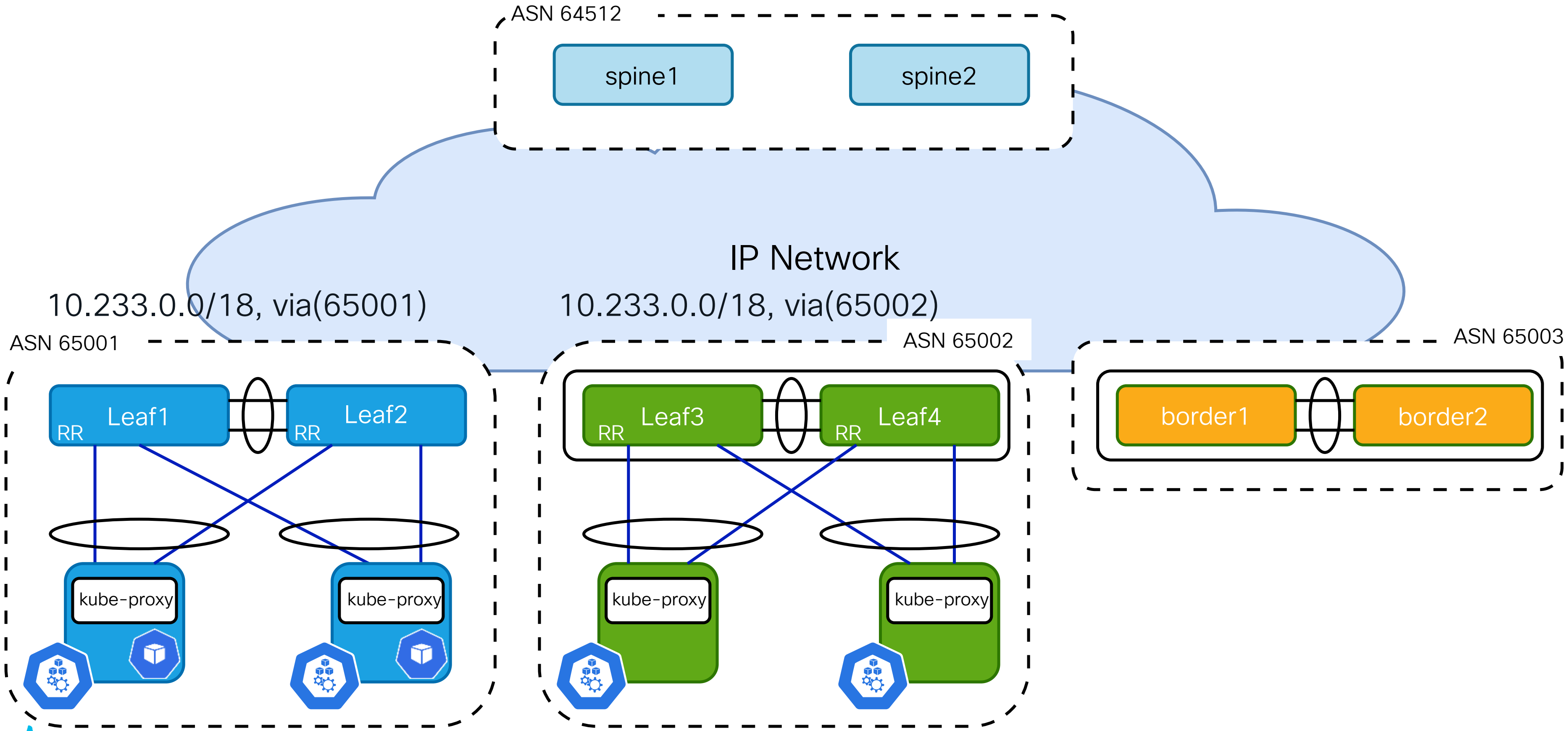
- HSRP/VRRP is used for gateway redundancy
- Kubernetes nodes peer with the primary IP address of SVI
- The node subnets are advertised into BGP to provide nodes reachability

Deploy over IP Fabric

Service Traffic

Service Subnet:
10.233.0.0/18

```
10.233.0.0/18, ubest/mbest: 4/0
    *via 10.4.0.37, [20/0], 2d10h, bgp-64512, external, tag 65001
    *via 10.4.0.45, [20/0], 2d10h, bgp-64512, external, tag 65001
```



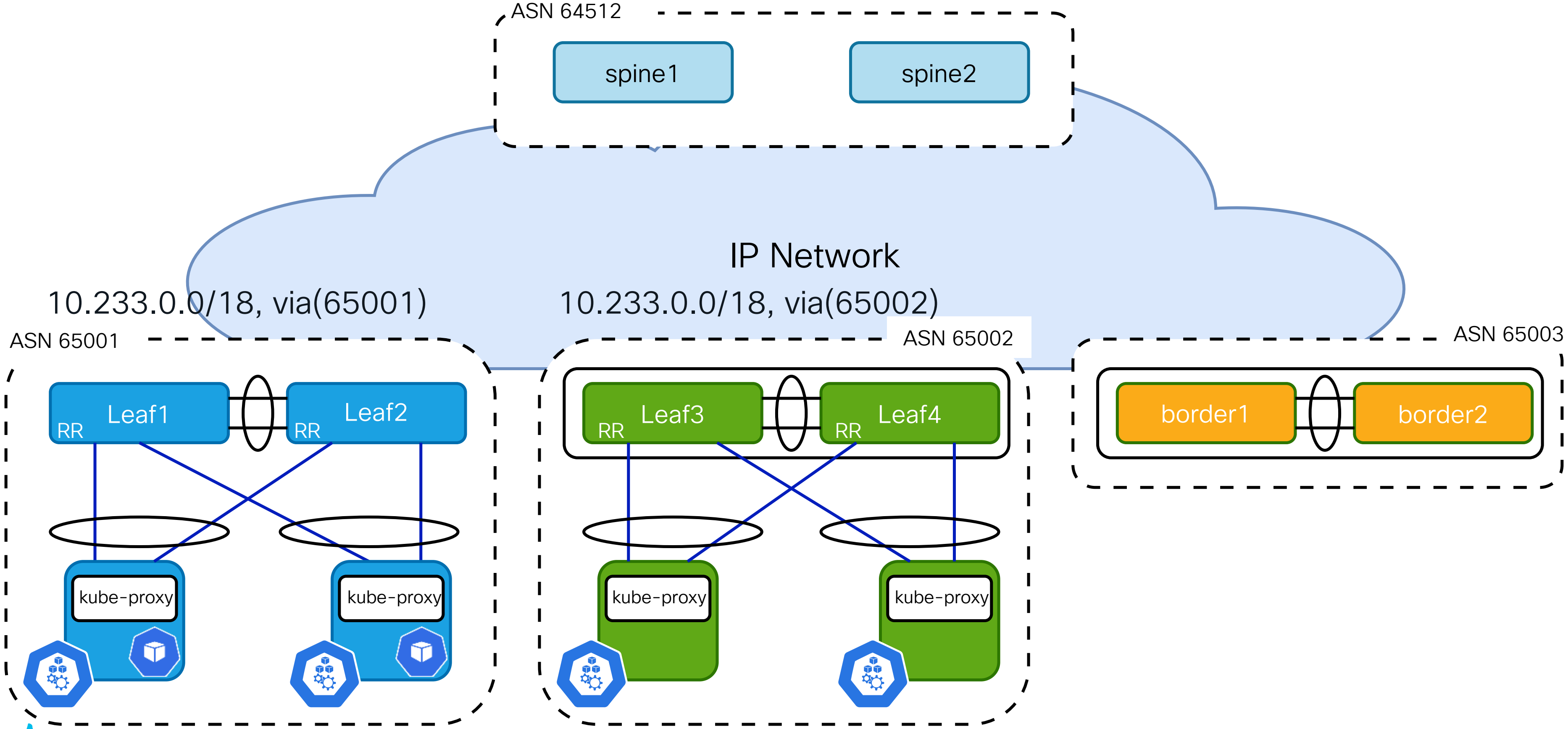
Deploy over IP Fabric

Service Traffic

```
router bgp 64512
  bestpath as-path multipath-relax
```

Service Subnet:
10.233.0.0/18

```
10.233.0.0/18, ubest/mbest: 4/0
    *via 10.4.0.21, [20/0], 2d10h, bgp-64512, external, tag 65002
    *via 10.4.0.29, [20/0], 2d10h, bgp-64512, external, tag 65002
    *via 10.4.0.37, [20/0], 2d10h, bgp-64512, external, tag 65001
    *via 10.4.0.45, [20/0], 2d10h, bgp-64512, external, tag 65001
```



Deploy over IP Fabric

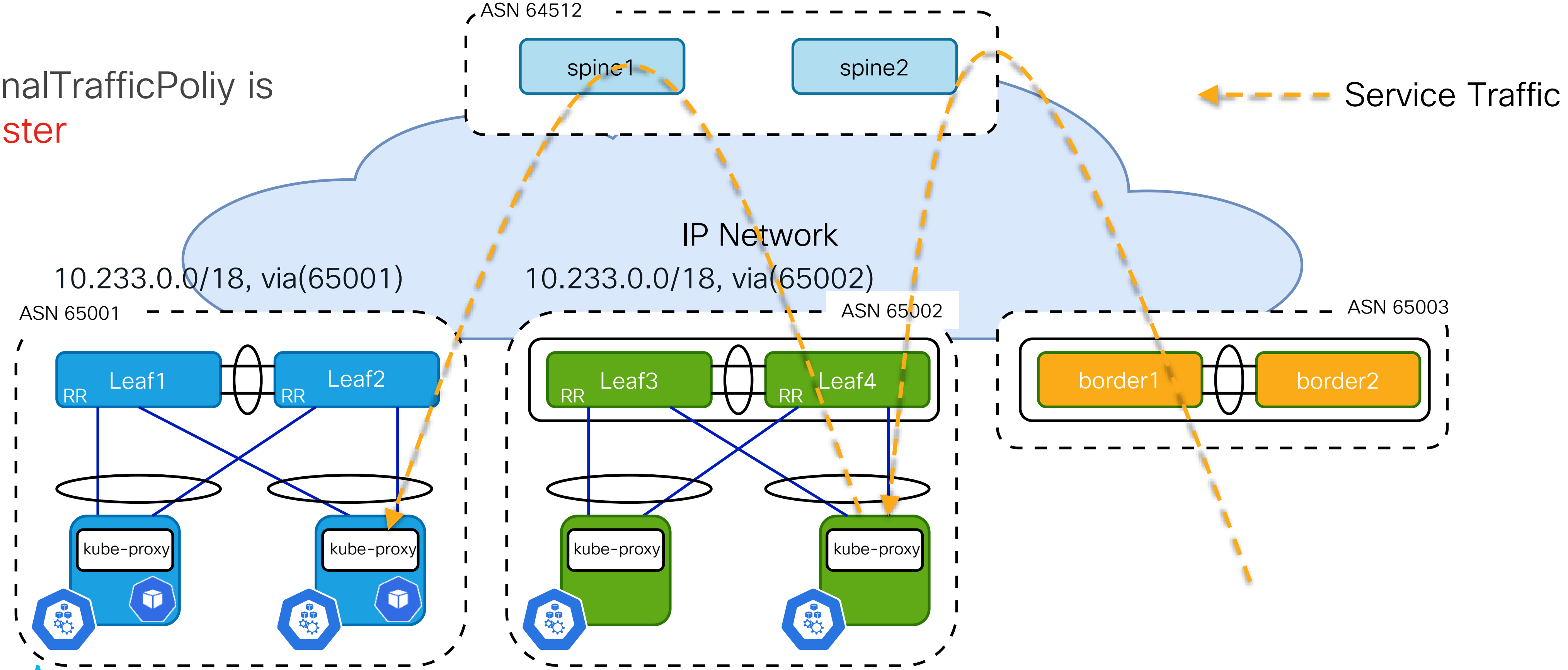
Sub-optimal service traffic

```
router bgp 64512
  bestpath as-path multipath-relax
```

Service Subnet:
10.233.0.0/18

```
10.233.0.0/18, ubest/mbest: 4/0
    *via 10.4.0.21, [20/0], 2d10h, bgp-64512, external, tag 65002
    *via 10.4.0.29, [20/0], 2d10h, bgp-64512, external, tag 65002
    *via 10.4.0.37, [20/0], 2d10h, bgp-64512, external, tag 65001
    *via 10.4.0.45, [20/0], 2d10h, bgp-64512, external, tag 65001
```

K8s externalTrafficPoliy is set to Cluster



Deploy over IP Fabric

Avoid Second Hop of Service Traffic

```
router bgp 64512
  bestpath as-path multipath-relax
```

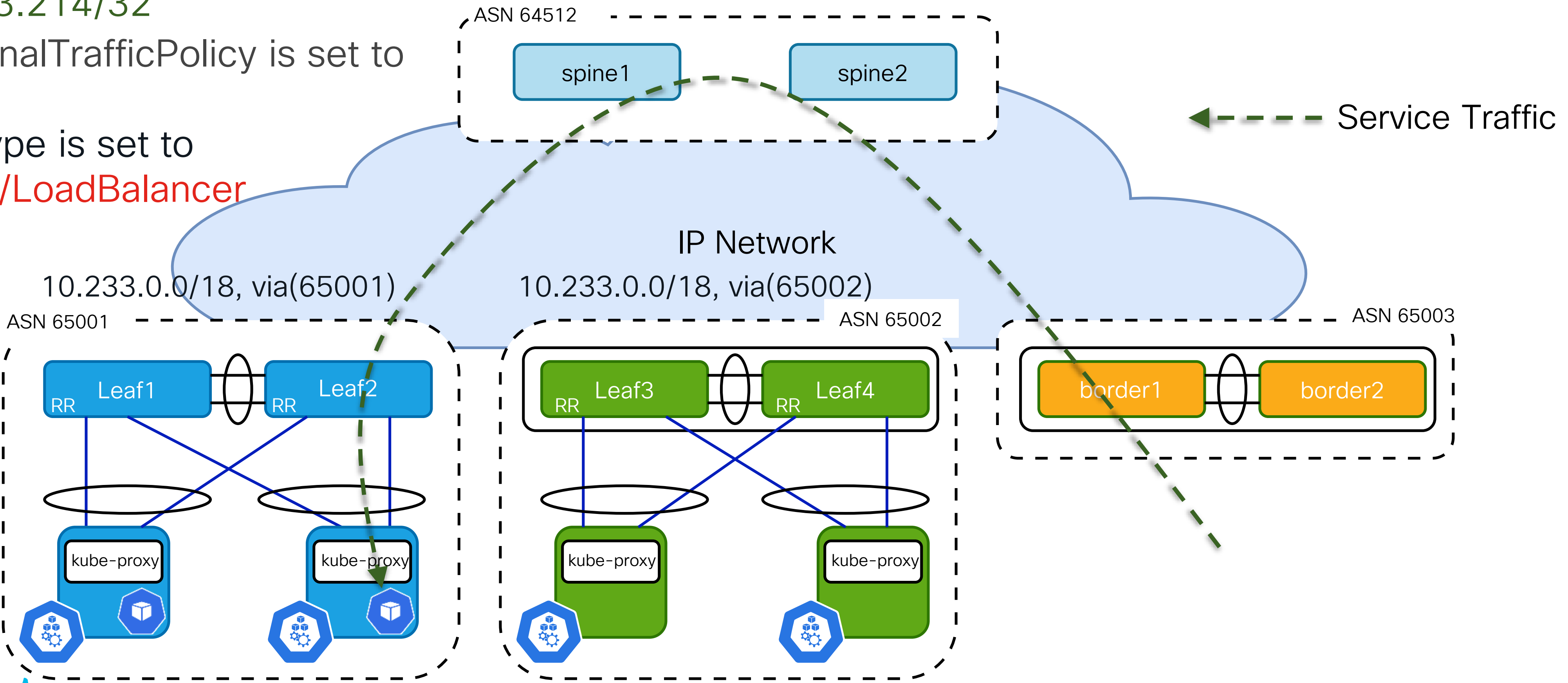
```
10.233.63.214/32, ubest/mbest: 2/0
    *via 10.4.0.37, [20/0], 2d10h, bgp-64512, external, tag 65001
    *via 10.4.0.45, [20/0], 2d10h, bgp-64512, external, tag 65001
```

Service Subnet:
10.233.0.0/18

Service ip:
10.233.63.214/32

K8s externalTrafficPolicy is set to
Local

Sevice Type is set to
NodePort/LoadBalancer



Exposing Services

A note on "externalTrafficPolicy"

- Denotes if this Service desires to route external traffic to node-local or cluster-wide endpoints.
- externalTrafficPolicy == Cluster
  - Pros: overall good load-balance between pods
  - Cons: potential second hop which will bring additional latency
- externalTrafficPolicy == Local
  - Pros: avoid the second hop, source IP is preserved
  - Cons: potentially imbalanced workload spreading
    - Pods can be spread evenly with topologySpreadConstraints

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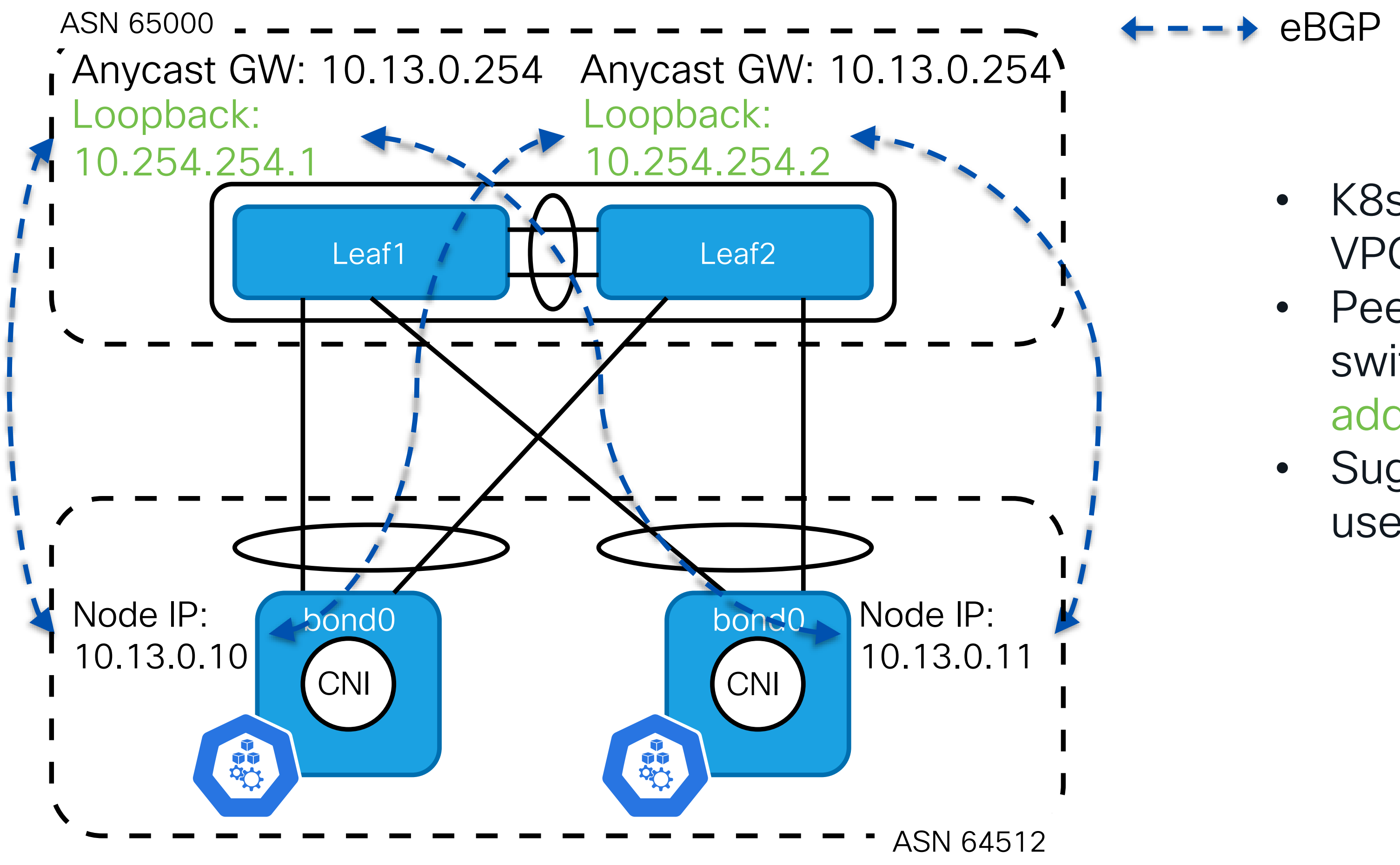
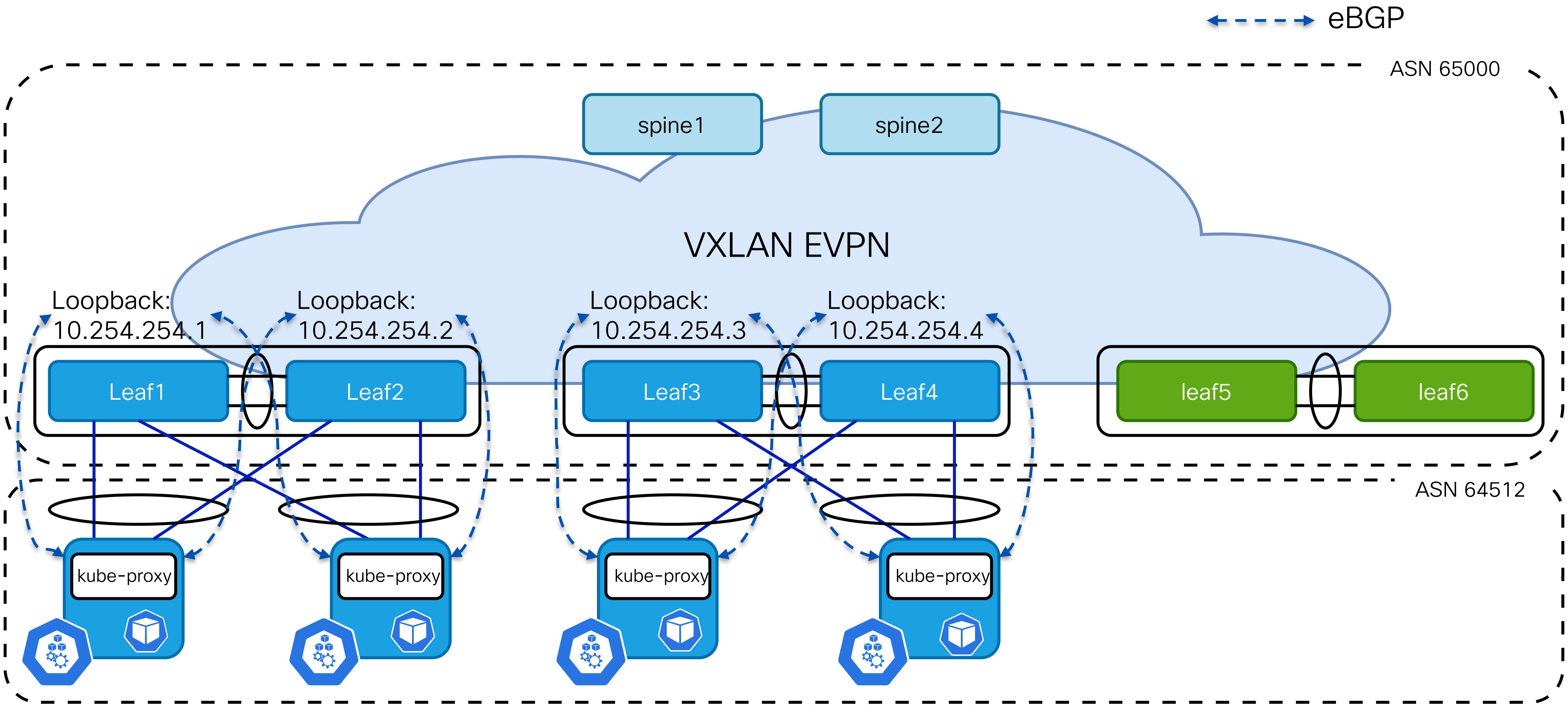
Connecting K8s nodes to Leaf Switches



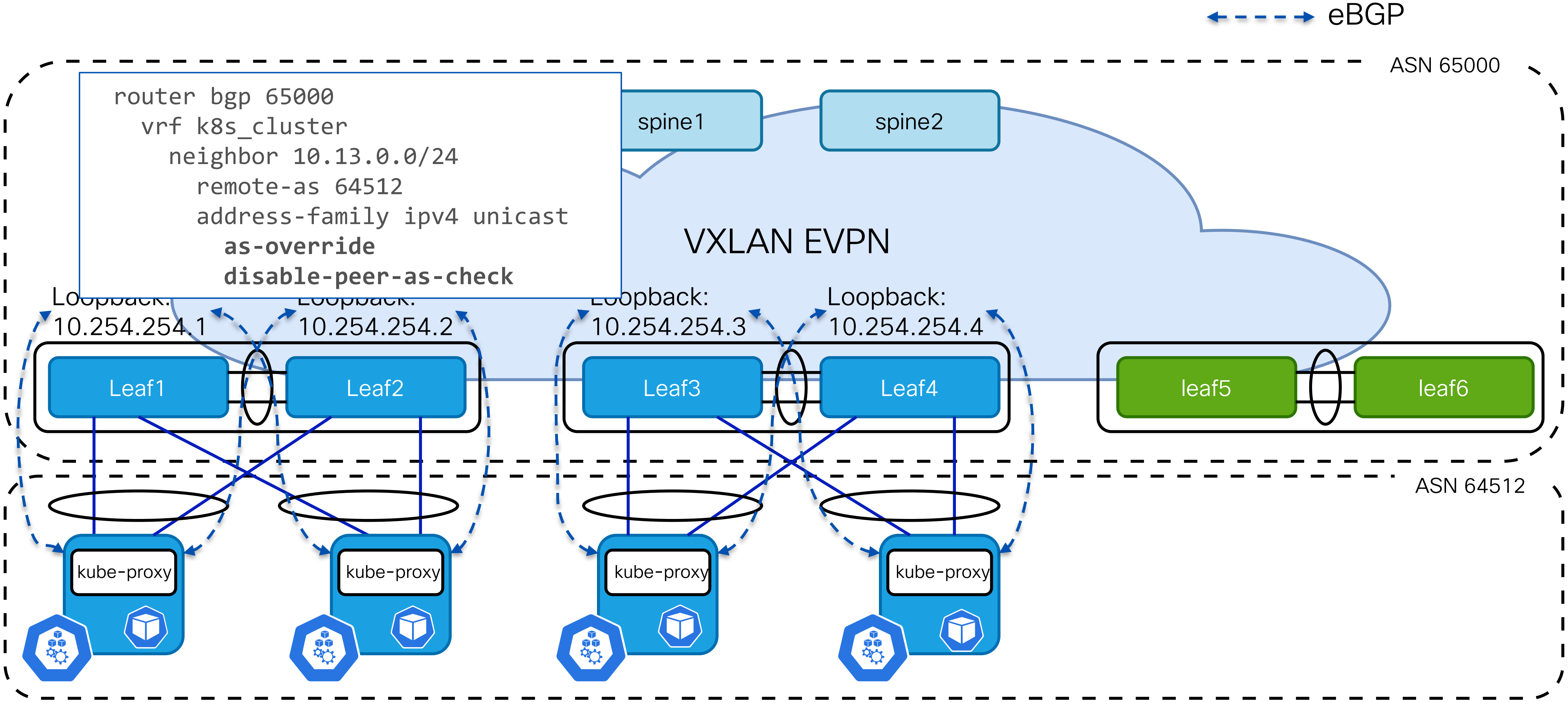
- K8s nodes connect to Leaf switches using VPC or Active-Standby
- Peering eBGP between K8s nodes and leaf switches using node IP and localized loopback addresses on each leaf switches
- Suggest peering iBGP between vPC pair in the user VRF

AS-Per-Cluster design



AS-Per-Cluster design

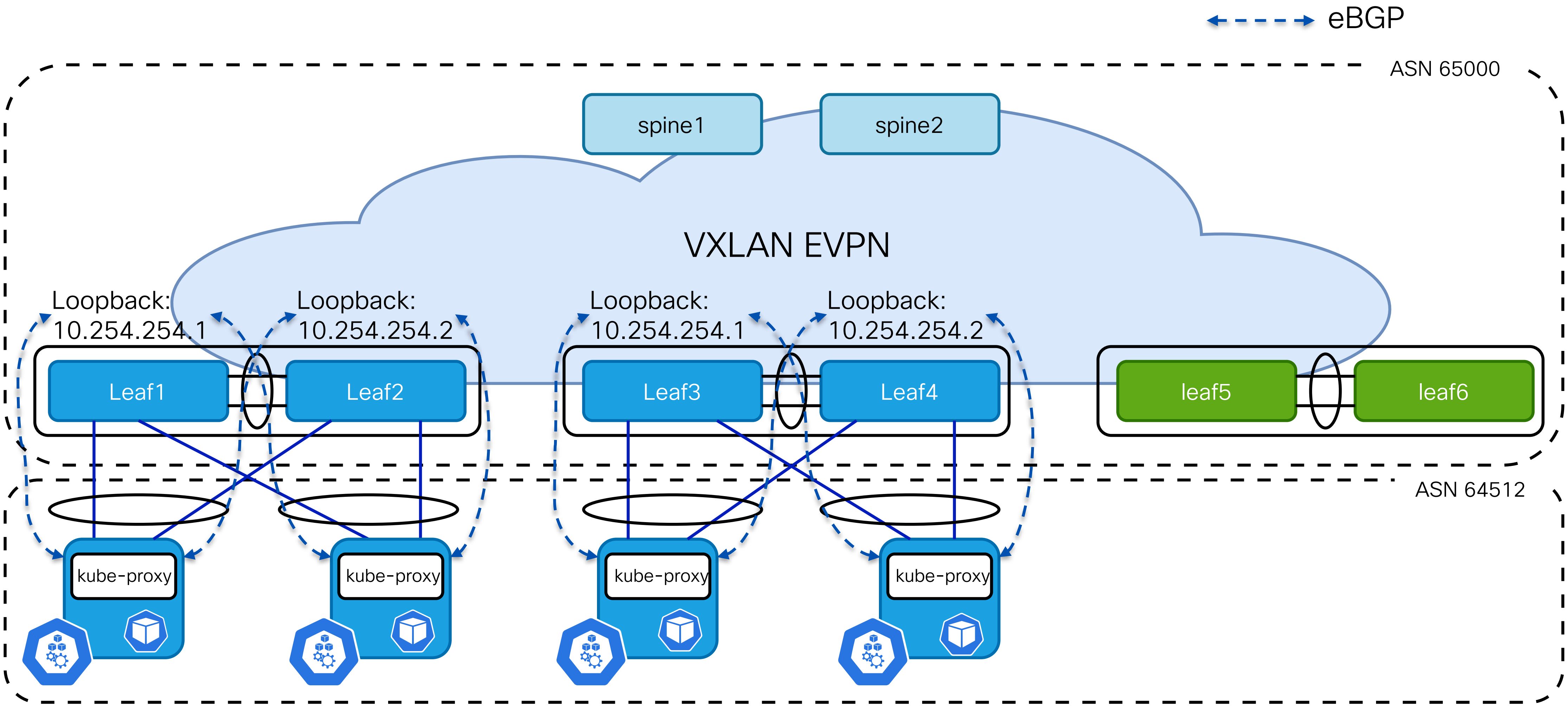
BGP tunning



```
router bgp 65000
  vrf k8s_cluster
    neighbor 10.13.0.0/24
      remote-as 64512
      address-family ipv4 unicast
        as-override
        disable-peer-as-check
```

AS-Per-Cluster design

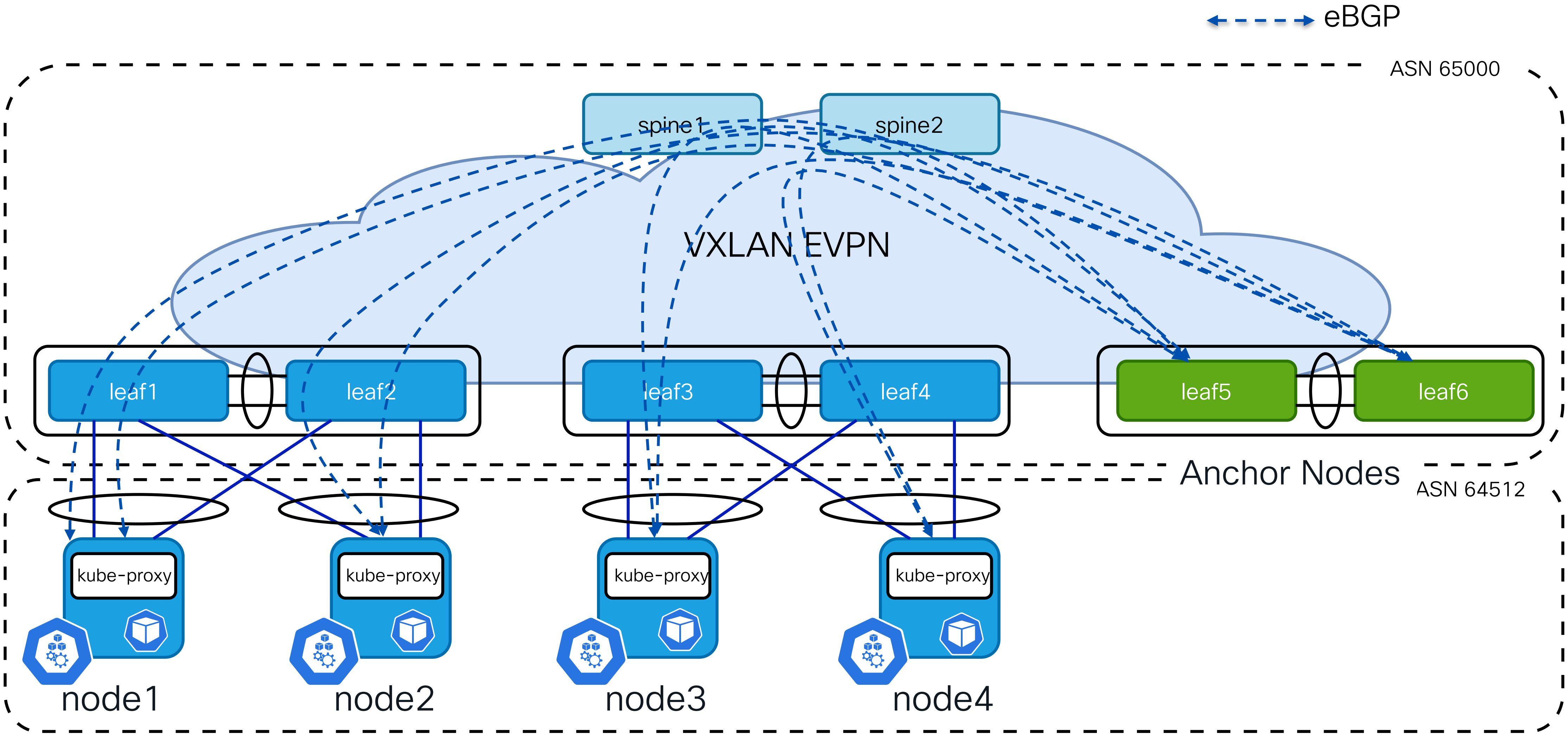
Use same loopback addresses



AS-Per-Cluster design

- Using single AS number per cluster reduces the complexity of bootstrap K8s node
- Loopback addresses are local to leaf switches
  - It does not need to be advertised to EVPN address family
    - But you will need iBGP peering between vPC peer switches
  - The same loopbacks can be used on all pairs of leaf switches
- Minimum BGP configuration can be tuned on Calico
  - `disable-peer-as-check` and `as-override` are needed on leaf switches

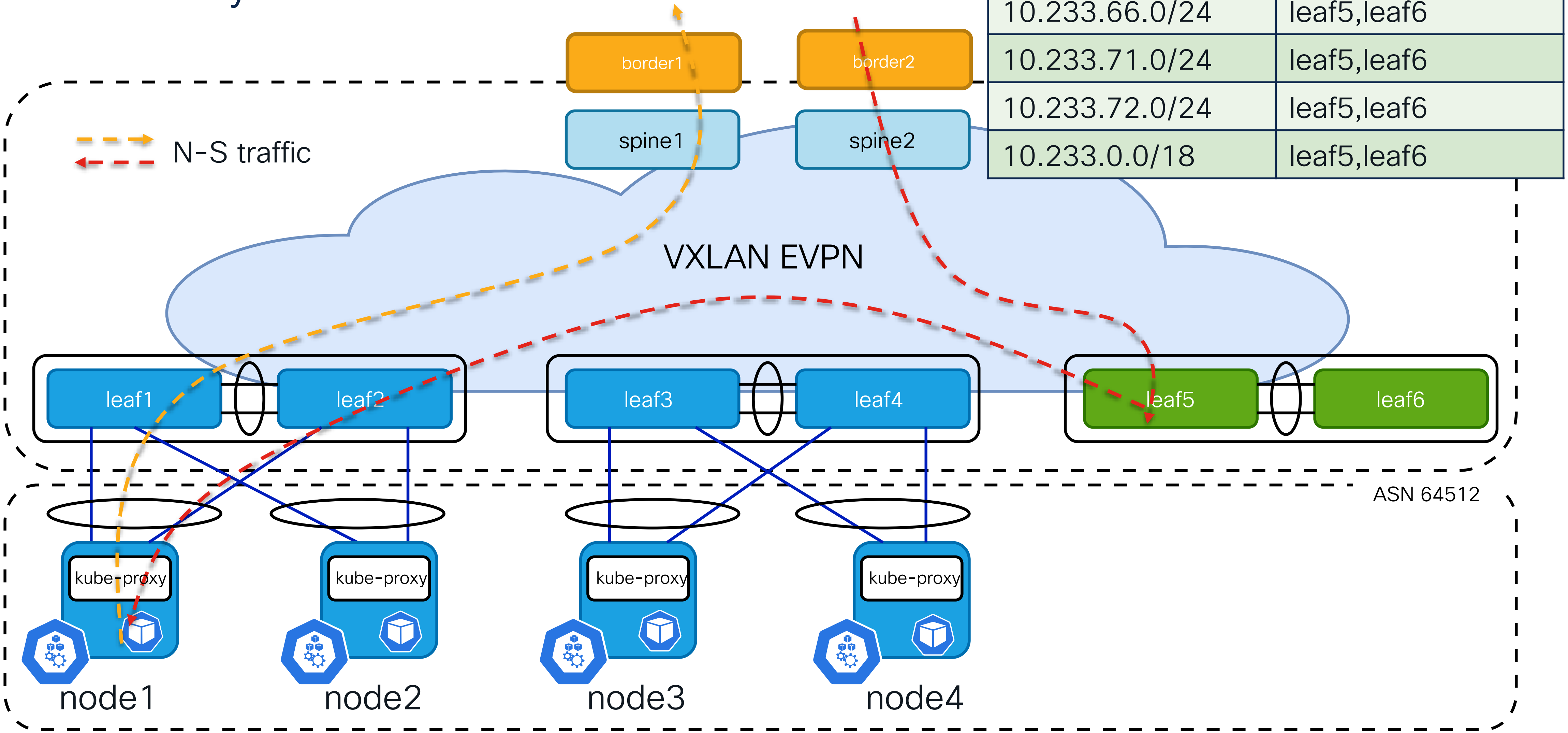
Centralized Routing Peering



Centralized Routing Peering

Problem: Asymmetric traffic

prefix	nexthop
10.233.64.0/24	leaf5,leaf6
10.233.66.0/24	leaf5,leaf6
10.233.71.0/24	leaf5,leaf6
10.233.72.0/24	leaf5,leaf6
10.233.0.0/18	leaf5,leaf6



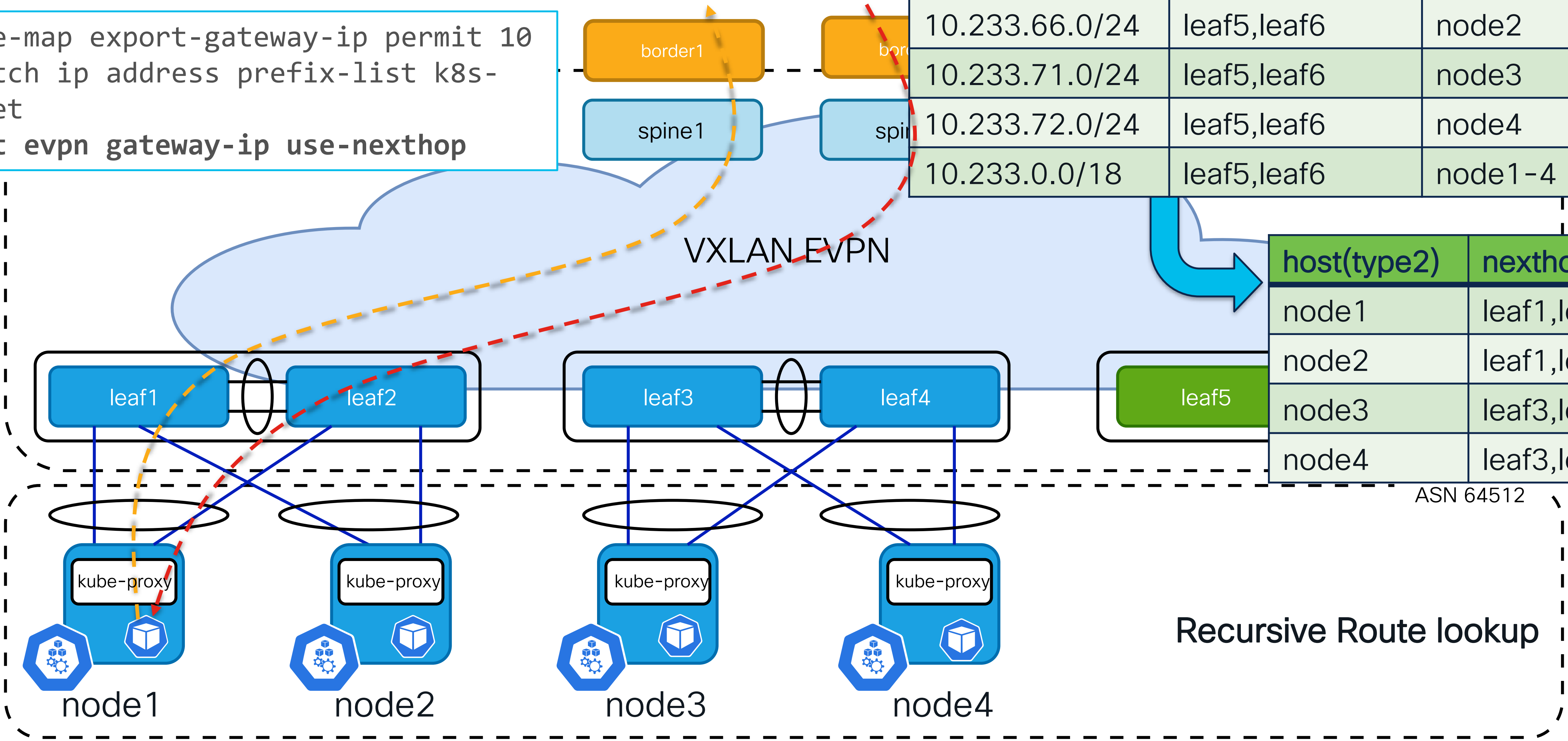
Centralized Routing Peering

Solution

```
route-map export-gateway-ip permit 10
  match ip address prefix-list k8s-
subnet
  set evpn gateway-ip use-nexthop
```

prefix	nexthop	gateway
10.233.64.0/24	leaf5,leaf6	node1
10.233.66.0/24	leaf5,leaf6	node2
10.233.71.0/24	leaf5,leaf6	node3
10.233.72.0/24	leaf5,leaf6	node4
10.233.0.0/18	leaf5,leaf6	node1-4

host(type2)	nexthop
node1	leaf1,leaf2
node2	leaf1,leaf2
node3	leaf3,leaf4
node4	leaf3,leaf4

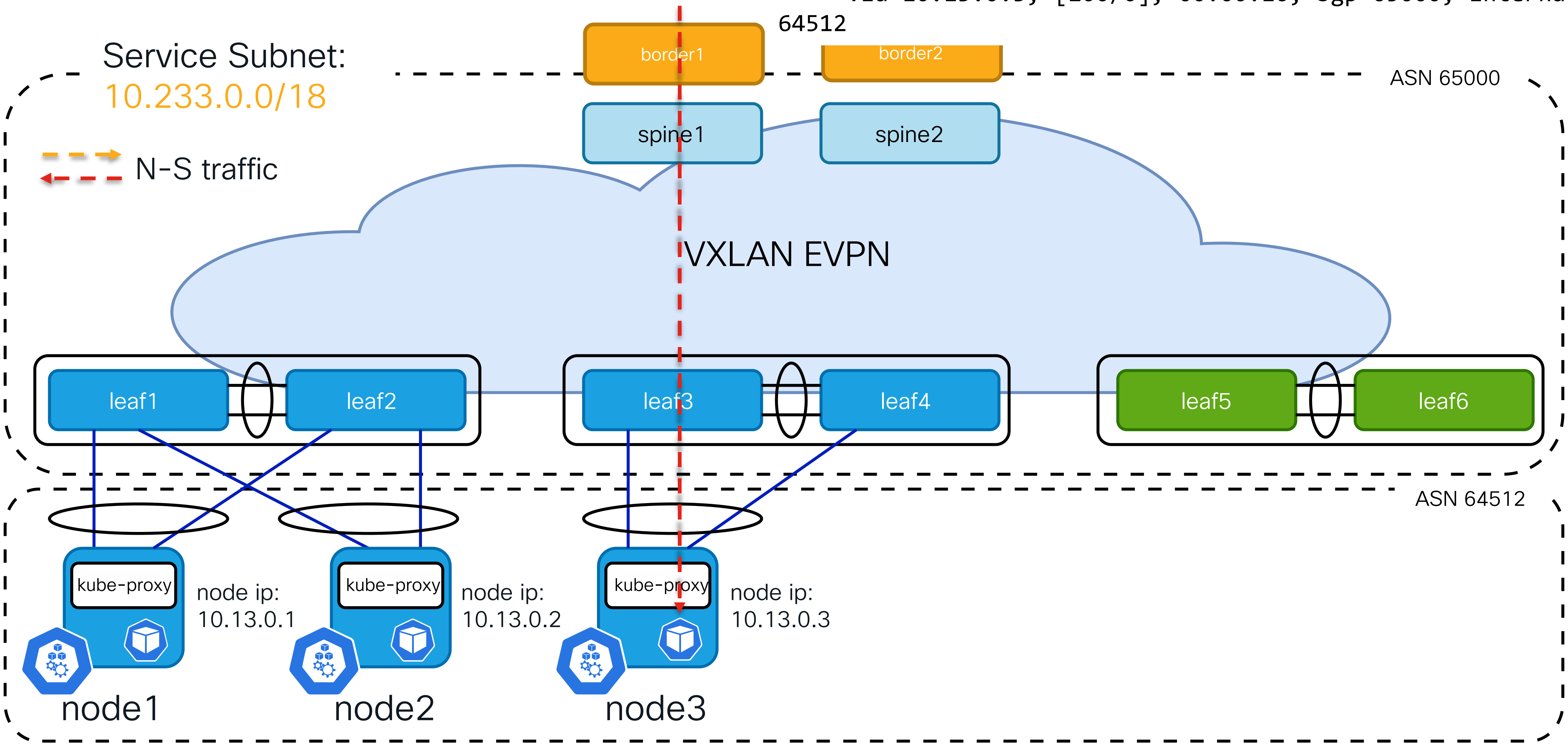


Recursive Route lookup

Centralized Routing Peering

Service Traffic

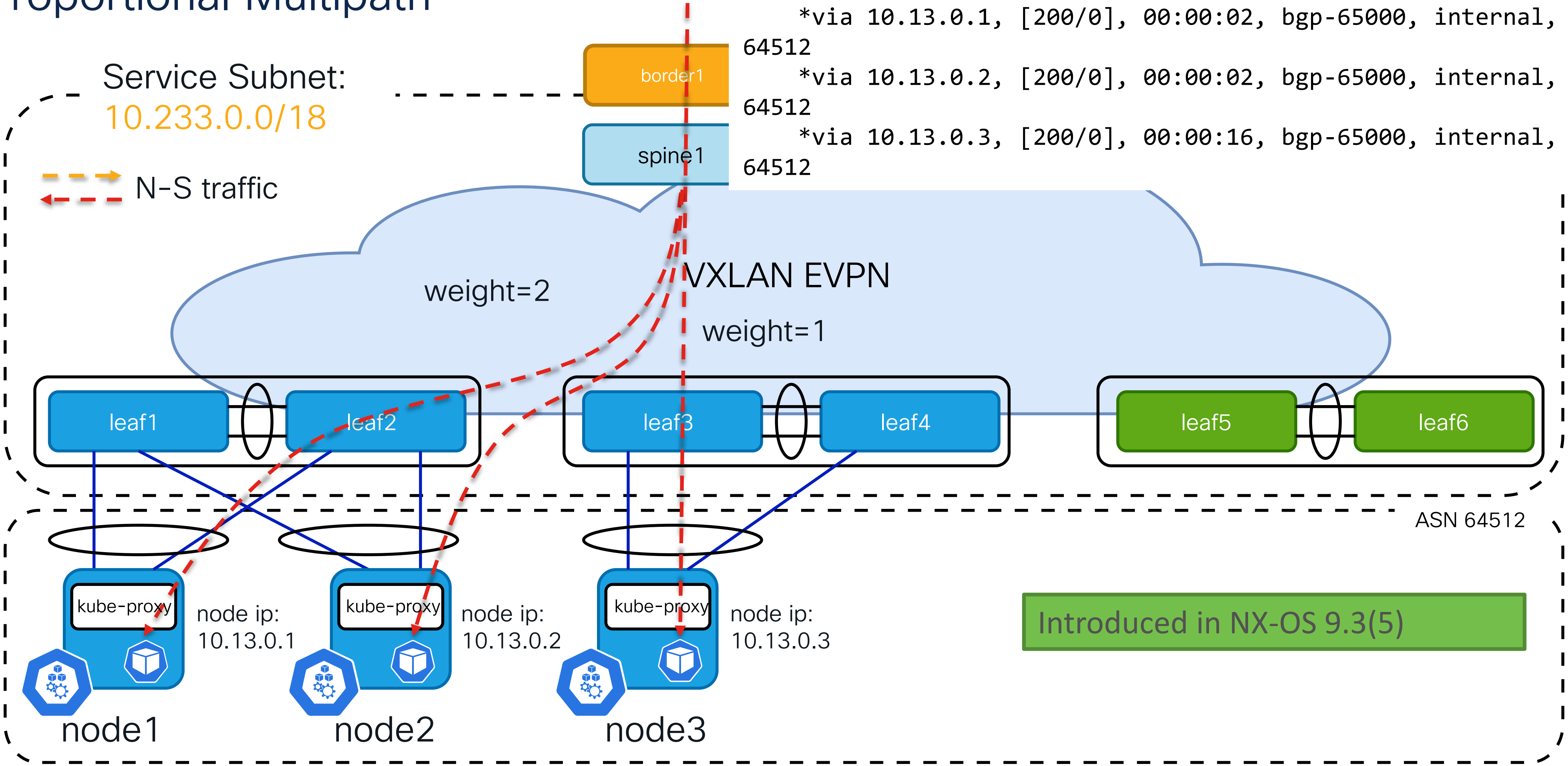
```
10.233.0.0/18, ubest/mbest: 4/0
    *via 10.13.0.3, [200/0], 00:00:16, bgp-65000, internal, tag
64512
```



Centralized Routing Peering

Proportional Multipath

```
10.233.0.0/18, ubest/mbest: 4/0
    *via 10.13.0.1, [200/0], 00:00:02, bgp-65000, internal, tag
64512
    *via 10.13.0.2, [200/0], 00:00:02, bgp-65000, internal, tag
64512
    *via 10.13.0.3, [200/0], 00:00:16, bgp-65000, internal, tag
64512
```



Introduced in NX-OS 9.3(5)

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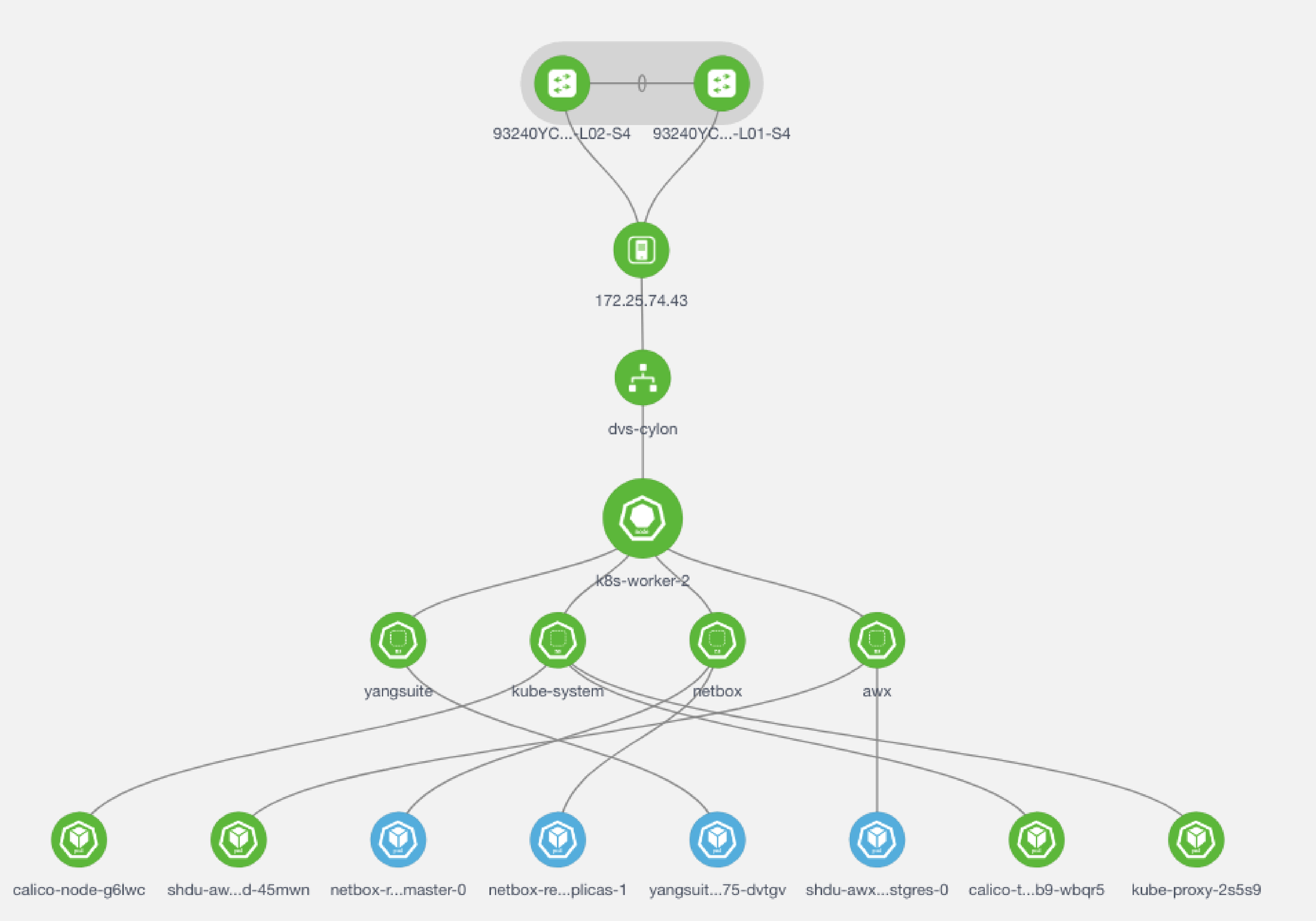
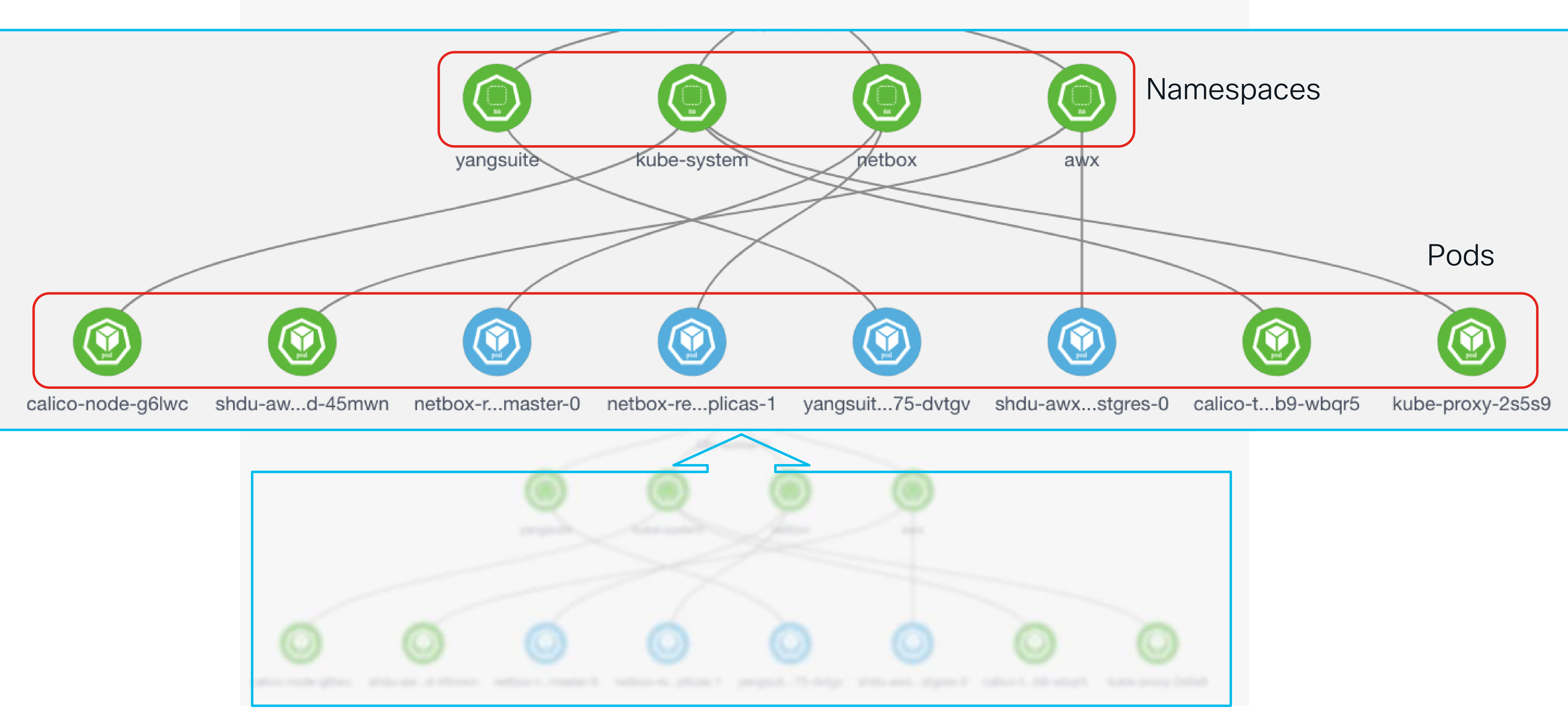
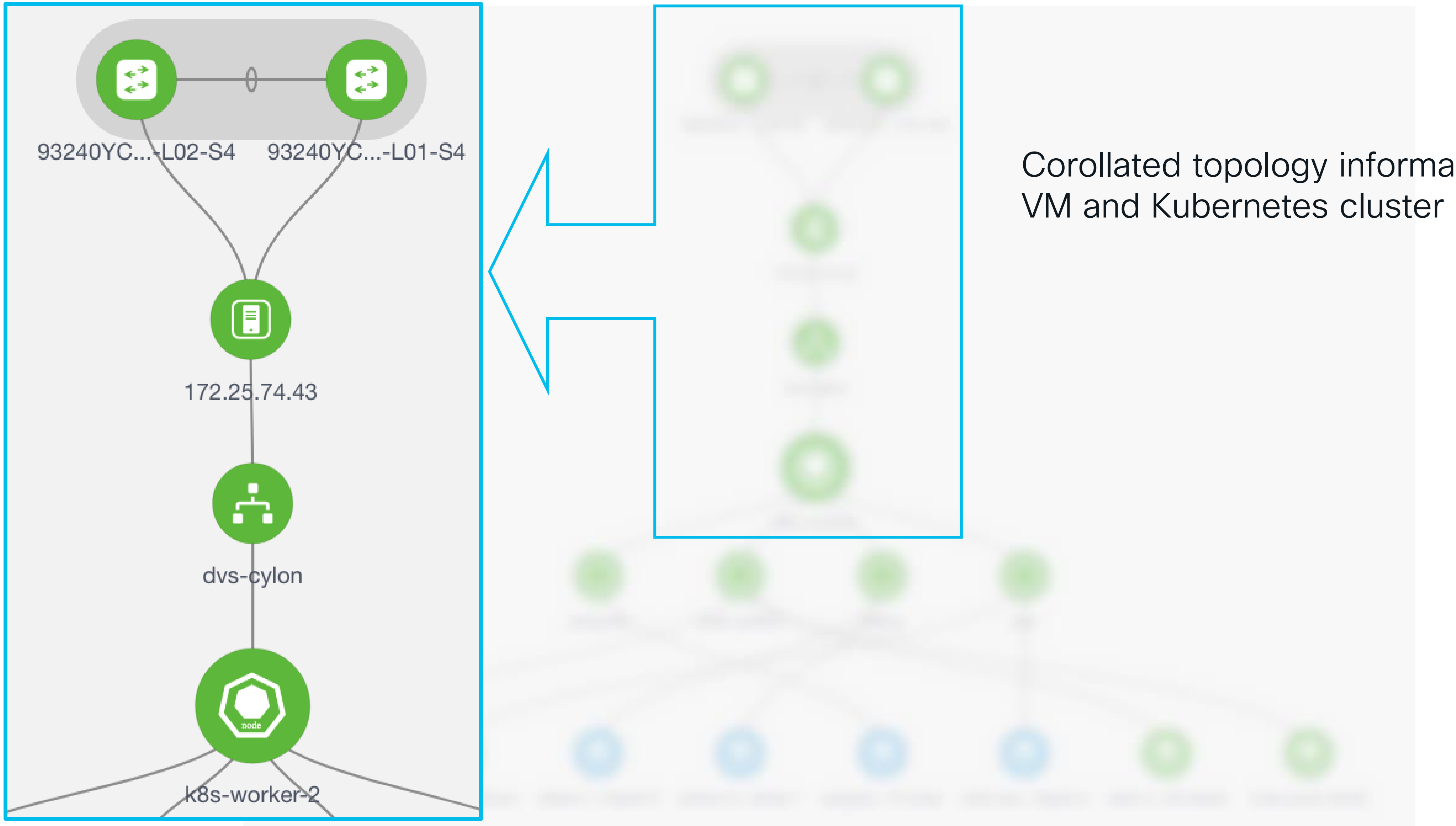
Kubernetes Visualization with NDFC



Kubernetes Visualization with NDFC



Kubernetes Visualization with NDFC



Corollated topology information with VM and Kubernetes cluster

Summary

- Greenfield Calico network does not require L2 extension
- The best practice is peering BGP neighborship with local switches
- Centralized Route Peering can simplify the configuration of Calico
  - But does require additional consideration to optimize traffic
- All the necessary features are shipped today on NX-OS

Reference

- Cisco NX-OS Calico Network Design White Paper
  - https://www.cisco.com/c/en/us/td/docs/dcn/whitepapers/cisco-nx-os-calico-network-design.html
- Configuring Proportional Multipath for VNF
  - https://www.cisco.com/c/en/us/td/docs/switches/datacenter/nexus9000/sw/93x/vxlan/configuration/guide/b-cisco-nexus-9000-series-nx-os-vxlan-configuration-guide-93x/b-cisco-nexus-9000-series-nx-os-vxlan-configuration-guide-93x_appendix_011010.html

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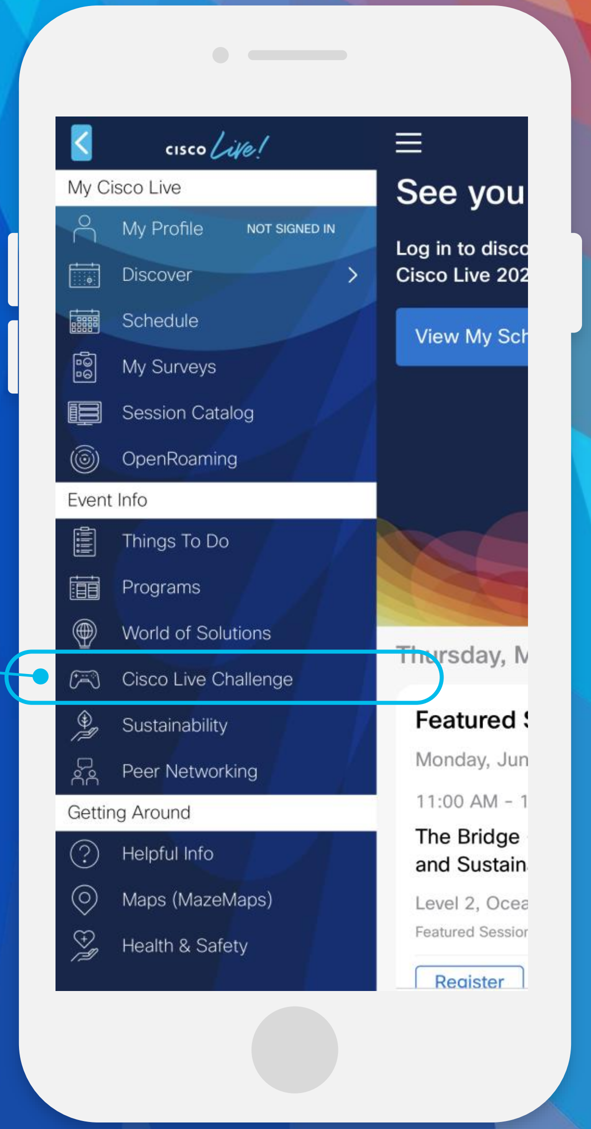

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