

Model it up

Building networks with Cisco Modeling Labs

Matt Leuschner
Solutions Engineer

CISCO Live !

Session ID: BRKOPS-1104

Cisco Webex App

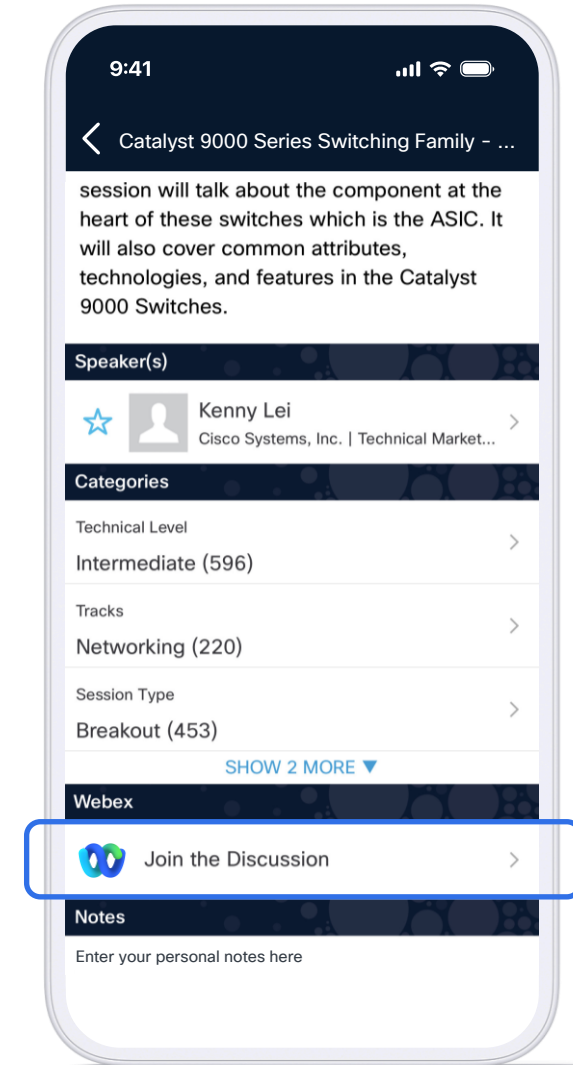
Questions?

Use Cisco Webex App to chat with the speaker after the session

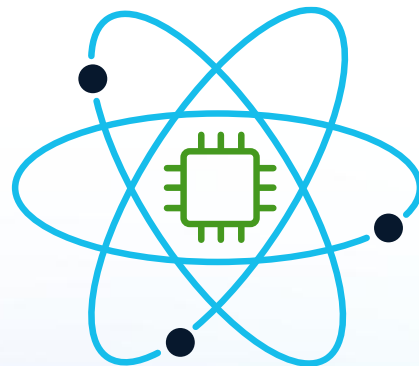
How

- 1 Find this session in the Cisco Live Mobile App
- 2 Click “Join the Discussion”
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- 4 Enter messages/questions in the Webex space

Webex spaces will be moderated by the speaker until 14 November 2025.



<https://cislive.ciscoevents.com/cislivebot/#BRKOPS-1104>



Powered by
Cisco Modeling Labs

Who am I?

Solutions Engineer

6 years at Cisco

23 years of experience in IT

Networking, virtualization, desktop services,
automation/coding

Started my career as a Windows admin out of
high school

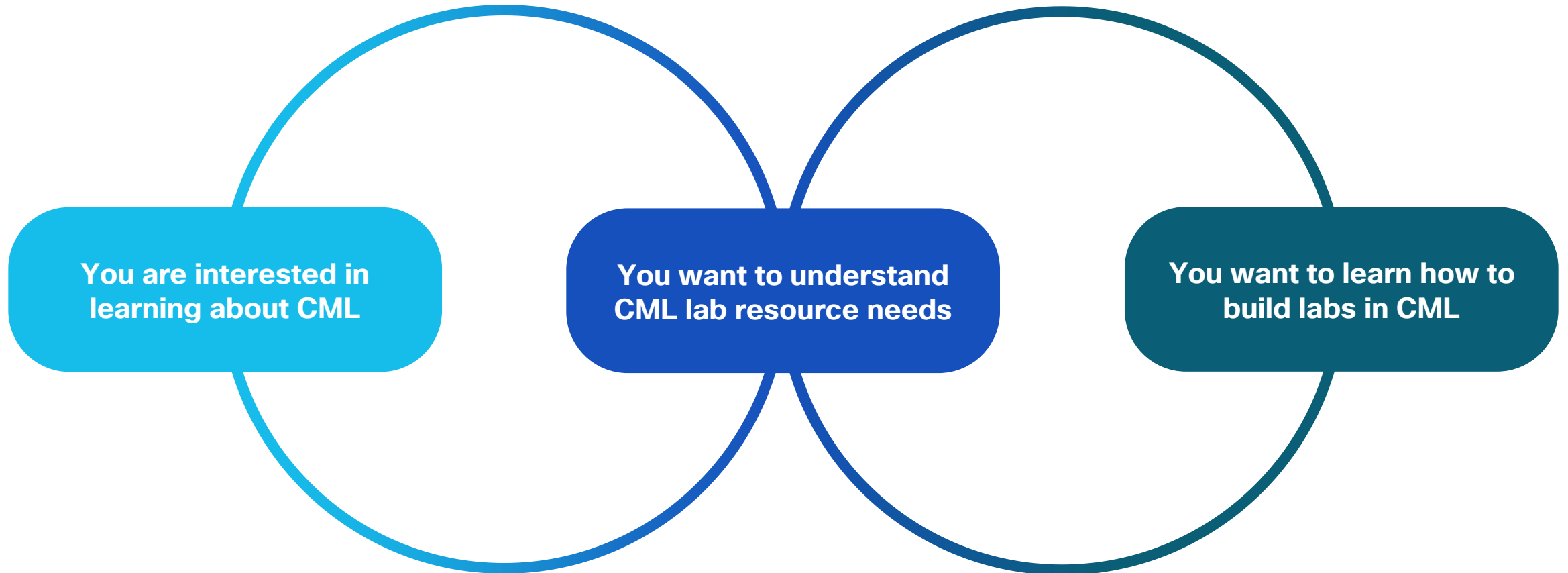
Probably the only speaker with an
unlicensed nuclear accelerator



Agenda

- 01 Get started
- 02 Scaling your resources
- 03 Build networks
- 04 Operate networks

You are attending this session because...

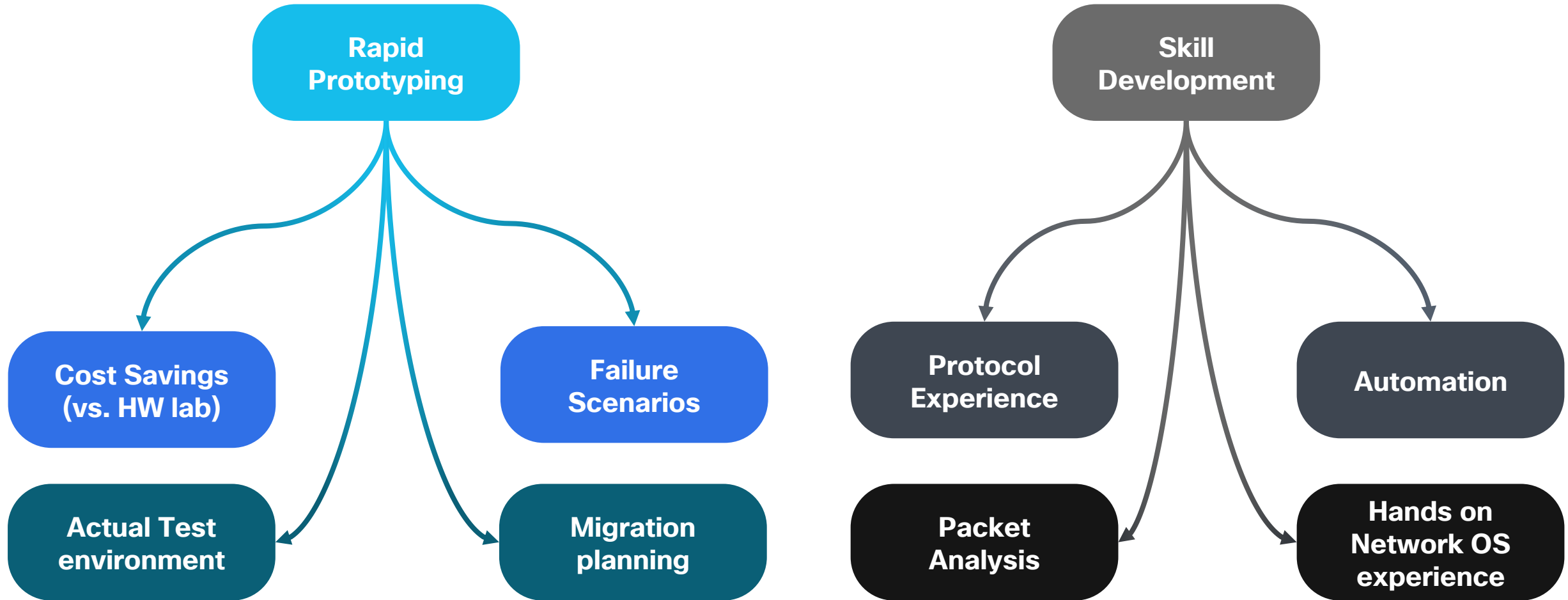


Get started with Cisco Modeling Labs

Why should you be interested in Cisco Modeling Labs?

Hint (it's not just for working on your certifications)

Benefits of network modeling



Choose your licensing and install type

CML Personal Edition 20 node limit

- Non-Commercial Use
- Single User
- Support via CML community forum on Cisco Learning Network

CML Personal Plus Edition 40 node limit

CML Enterprise Edition Up to 320 nodes

- Commercial Use
- Multi-User, LDAP support
- Compute Host Clustering
- TAC Support



Baremetal

or



OVA

Cisco Modeling Labs

Username

ciscolive

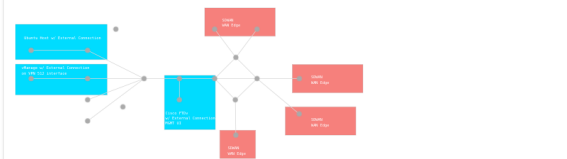
Password

.....

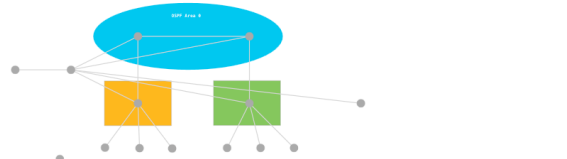
 LOGIN

Version: 2.9.0+build.3

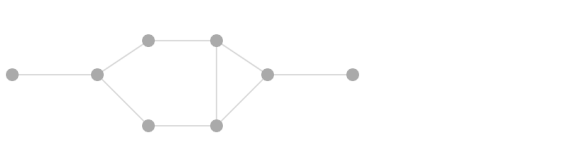
SDWAN Lab



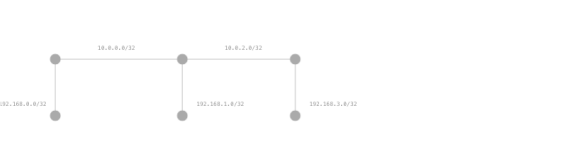
Cisco Catalyst Center Demo



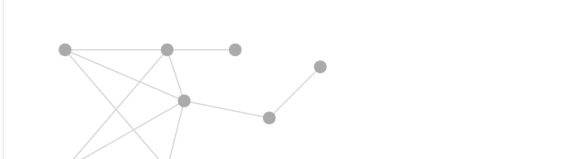
Lab at Wed 19:00 PM



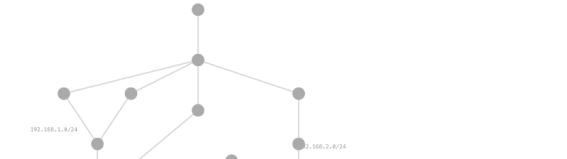
Lab at Fri 18:40 PM



Sam-TestLab-VXLAN1



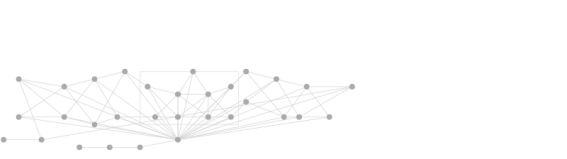
K3s + Cilium



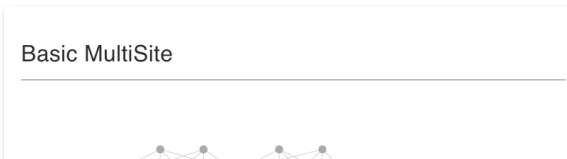
eBPF



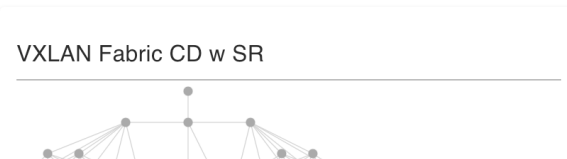
dci1-ipv4



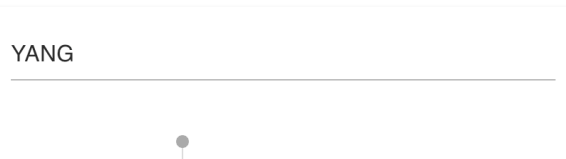
Basic MultiSite



VXLAN Fabric CD w SR

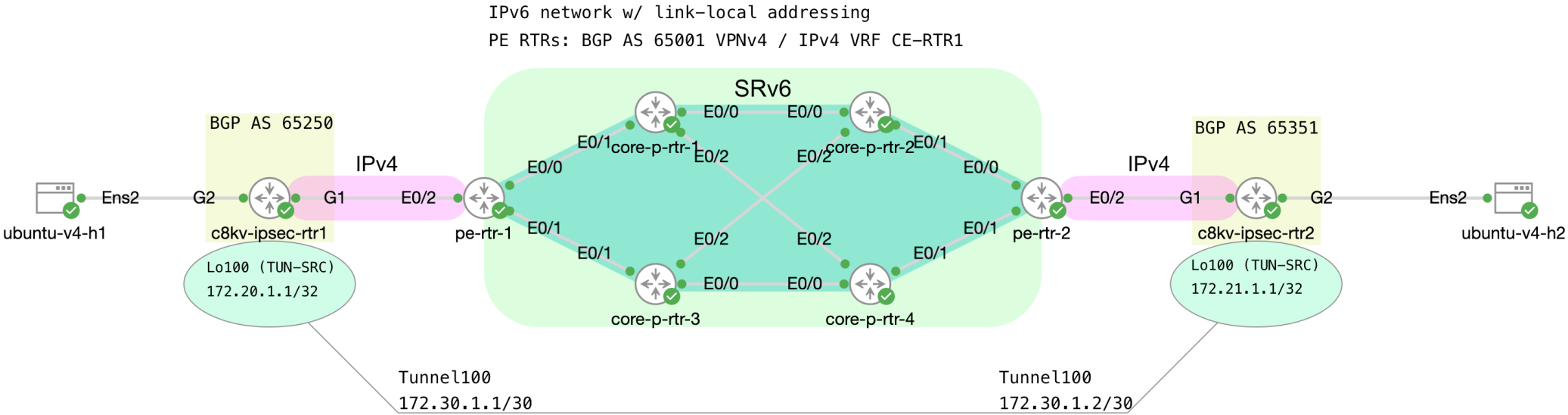


YANG



IPv6 Lab - Initial





Filter

Match case

ADD

IMPORT

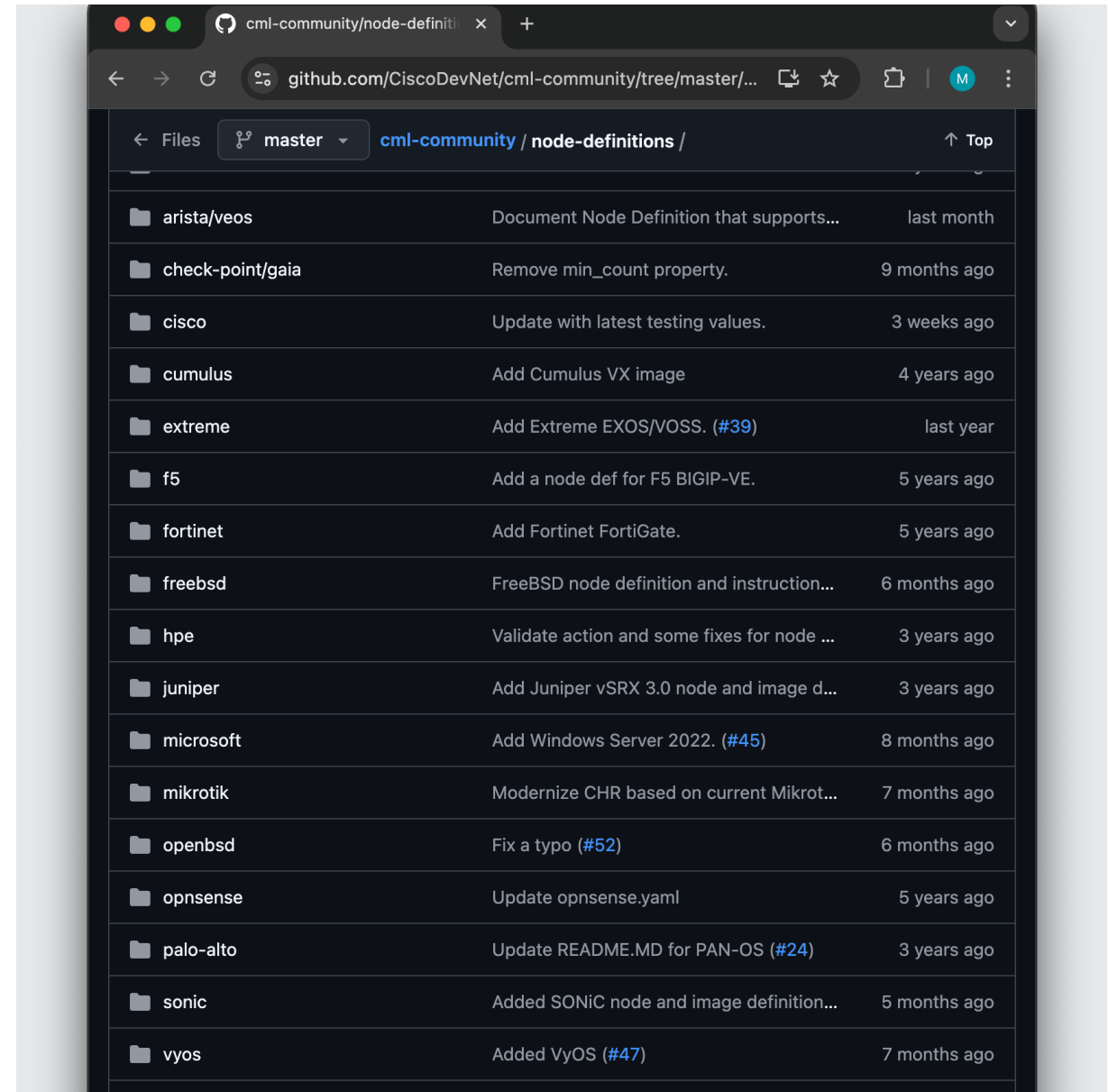
<div>External Connector</div> <div>Connect to devices outside of the simulation</div>	<div>ASAv</div> <div>Cisco Adaptive Security Virtual Appliance</div>	<div>FTDv</div> <div>Cisco Firepower Threat Defense Virtual</div>	<div>Chrome</div> <div>Google Chrome stable (Docker)</div>	<div>Firefox</div> <div>Firefox (Docker)</div>	<div>Splunk</div> <div>Splunk Enterprise (Docker)</div>
<div>Catalyst SD-WAN Edge</div> <div>Catalyst SD-WAN Edge</div>	<div>CAT8000V</div> <div>Catalyst 8000V Edge Software</div>	<div>CSR1000v</div> <div>Cloud Services Router 1000V</div>	<div>FRR</div> <div>Free Range Routing (Docker)</div>	<div>IOL</div> <div>IOL XE Router</div>	<div>IOL (4s)</div> <div>IOL XE Router with 4 serial interfaces</div>
<div>IOSv</div> <div>Cisco IOSv Virtual Router Platform</div>	<div>IOS XRv</div> <div>Cisco IOS XRv Router platform</div>	<div>IOS XRv 9000</div> <div>Cisco IOS XRv 9000 Router platform</div>	<div>IOS XRv 9000 EFI</div> <div>Cisco IOS XRv 9000 Router platform</div>	<div>Alpine</div> <div>Alpine Linux</div>	<div>Catalyst SD-WAN Controller</div> <div>Cisco Catalyst SD-WAN Controller</div>
<div>Catalyst SD-WAN Manager</div> <div>Cisco Catalyst SD-WAN Manager</div>	<div>Catalyst SD-WAN Validator</div> <div>Cisco Catalyst SD-WAN Validator</div>	<div>Catalyst SD-WAN vEdge</div> <div>Catalyst SD-WAN vEdge</div>	<div>CoreOS</div> <div>CoreOS Container Linux</div>	<div>Desktop</div> <div>Alpine Linux with X11 Desktop</div>	<div>Dnsmasq</div> <div>Dnsmasq server (Docker)</div>
<div>FMCv</div> <div>Cisco Firepower Management Center Virtual Appliance</div>	<div>Net-Tools</div> <div>Networking tools node (Docker)</div>	<div>Nginx</div> <div>Nginx web server (Docker)</div>	<div>Radius</div> <div>FreeRadius server (Docker)</div>	<div>Server</div> <div>Tiny Core Linux</div>	<div>Syslog</div> <div>Syslog NG server (Docker)</div>
<div>TacPlus</div> <div>Tacacs plus (Docker)</div>	<div>ThousandEyes Agent</div> <div>ThousandEyes Enterprise Agent (Docker)</div>	<div>TRex</div> <div>Alpine Linux</div>	<div>Ubuntu</div> <div>Ubuntu Cloud Init Platform</div>	<div>Ubuntu</div> <div>Ubuntu Cloud Init Platform</div>	<div>WAN Emulator</div> <div>WAN Emulator</div>
<div>BETA CAT9000v Q200</div> <div>Catalyst 9000v Q200</div>	<div>BETA CAT9000v UADP</div> <div>Catalyst 9000v UADP</div>	<div>IOL-L2</div> <div>IOL XE Switch</div>	<div>IOSvL2</div> <div>Cisco IOSv-L2 Virtual Switch Platform</div>	<div>NX-OS</div> <div>Cisco NX-OSv "Titanium" Switch</div>	<div>NX-OS 9000</div> <div>Cisco Nexus 9000v Switch</div>



Add 3rd party nodes

More node definitions at the CML Community GitHub
<https://github.com/cisco/devnet/cml-community>

Just supply the necessary qcow2 image!



Scaling your Resources



**You don't need to run CML on a
massive server to learn networking**

Your Speaker, at some random point in time

This is running our lab today

CML Server
8 Core
16GB RAM

Ubuntu External
Host

A physical host attached
to the CML topology

bridge0 (native vlan192)
bridge292 (trunk vlan292)

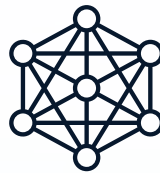
bridge292 (access vlan292)

Home/LAN (access vlan192)

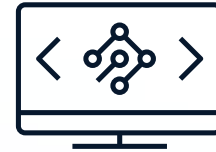
Scoping the size of your CML Host



Node Type and Count



**Size of
Network Topology**

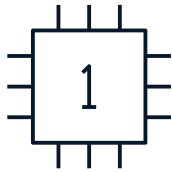


**Use of Managers
(FMCv / SDWAN)**

Resource considerations

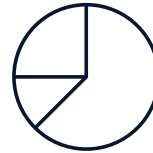
Feature rich node types:

Nexus 9kv, Catalyst 8kv/9kv,
IOS-XRv9k, SDWAN, FTD/FMC



CPU

Highest at node launch



Disk

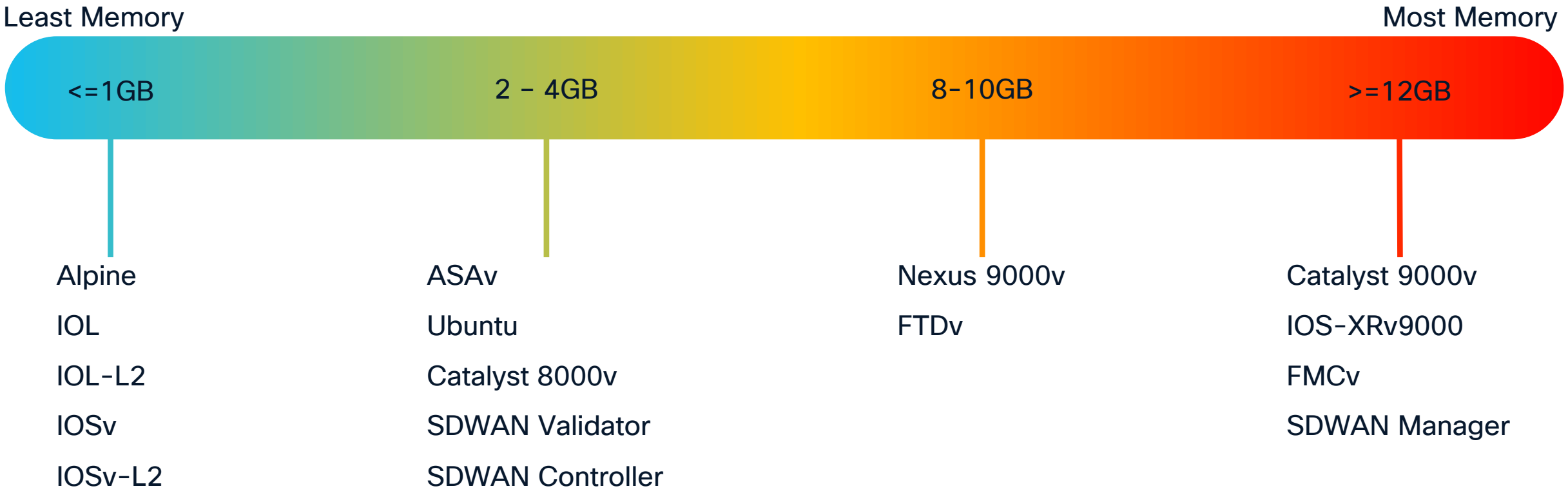
Increases as you build labs

010110
110010
001011

Memory

Feature nodes = More RAM

Approximate memory utilization by node type



Hardware Recommendations

By topology types

Learning / Small Topologies

- 4 core x86_64 processor
- 8 – 16GB RAM
- Mini PC or VMware Workstation
- Recommend IOL/IOL-L2

Mix / Medium topologies

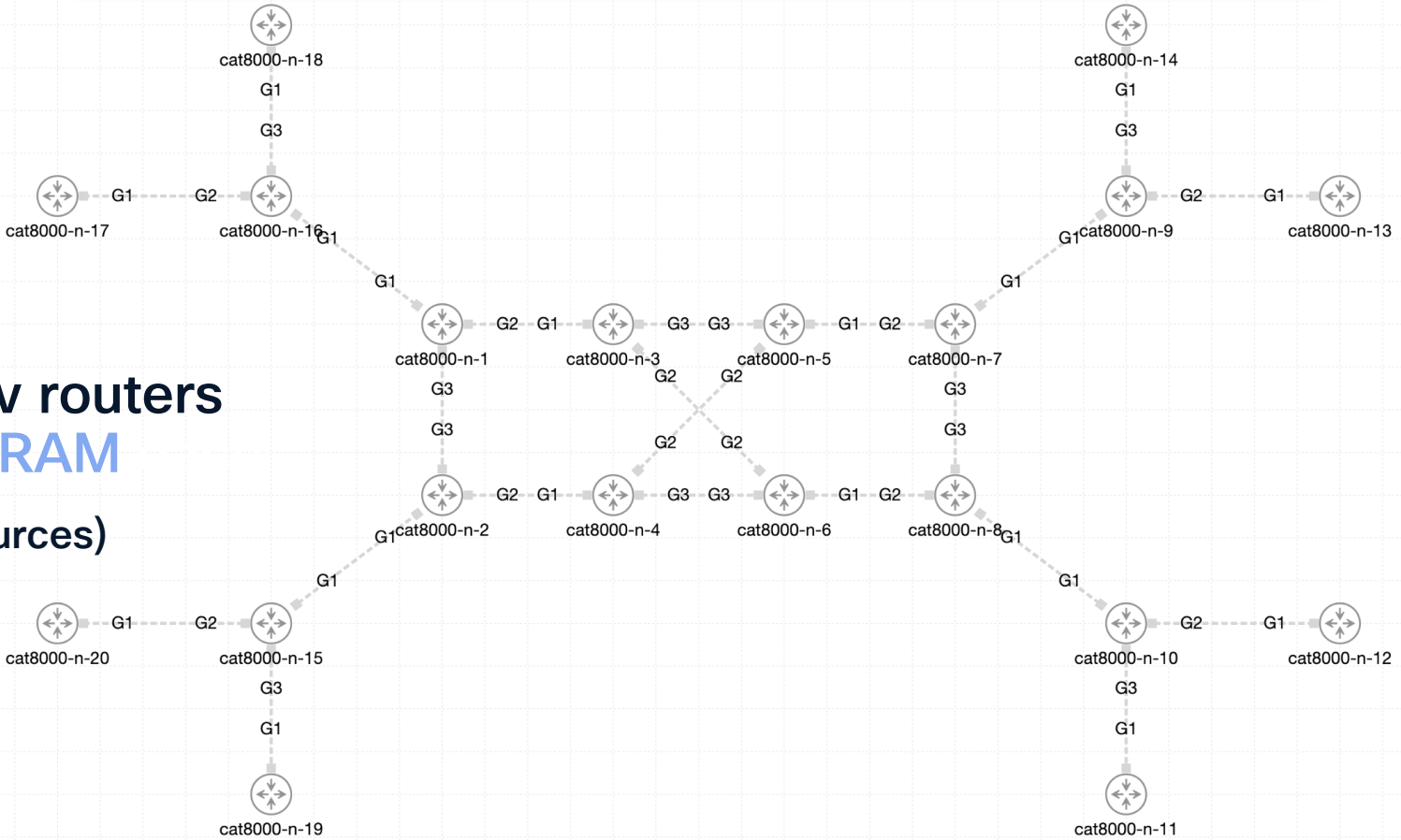
- 12 core x86_64 processor
- 32 – 64GB RAM
- Mix of Catalyst 8000v, ASA/FTDv, Nexus 9000v IOL/IOL-L2

Feature Rich / Large topology

- 24+ core x86_64 processor
- 128GB+ RAM
- Clustered Hardware
- SDWAN / IOS-XRv9000 / Catalyst 9000v / FMCv

**If you have limited hardware
resources...**

...how can you do more?



Launching –
20 – Cat 8000v routers
1 vCPU 4GB RAM
(with too little resources)

System:

8 CPUs16 GB RAM

cml-mininode	CPU / Load Avg			Memory [GB]			Disk [GB]			VM Stats		Running / Total	
	1 min	5 min	15 min	Total	Used	Free	Total	Used	Free	Allocated CPUs	Allocated Memory	Nodes	Orphans
	0.16	0.77	0.93	15.49	1.09	14.07	224.29	72.15	152.14	0	0.00 GB	0 / 62	0 / 0

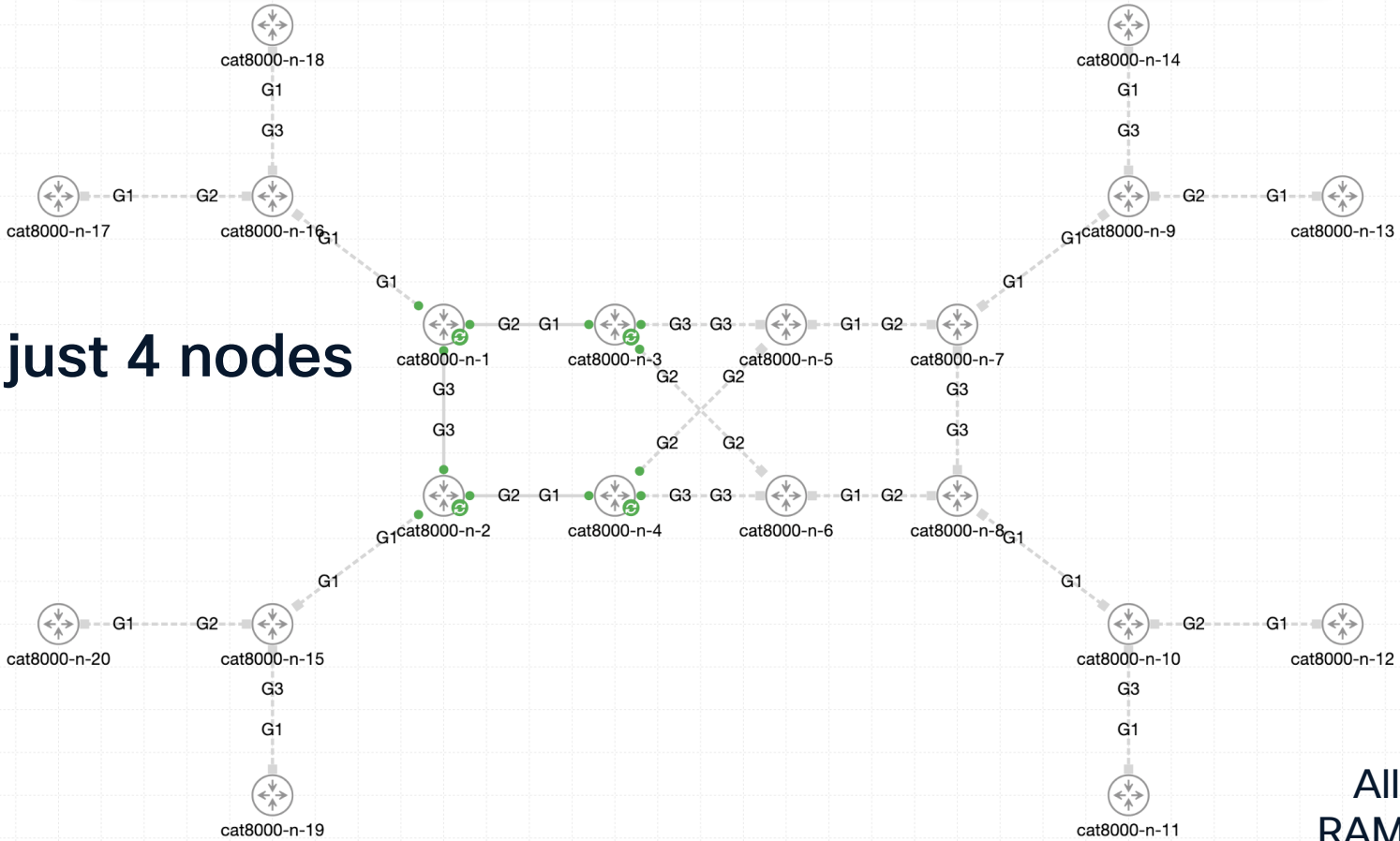
CPU0.00%

MEMORY7.02%

DISK32.17%

0

OK



Starting just 4 nodes

CPU still good

Memory High

Allocated more RAM than available

cml-mininode	CPU / Load Avg			Memory [GB]			Disk [GB]			VM Stats		Running / Total	
	1 min	5 min	15 min	Total	Used	Free	Total	Used	Free	Allocated CPUs	Allocated Memory	Nodes	Orphans
	3.36	1.66	1.22	15.49	15.08	0.12	224.29	72.17	152.13	4	16.01 GB	4 / 66	0 / 0

CPU

45.91%

MEMORY

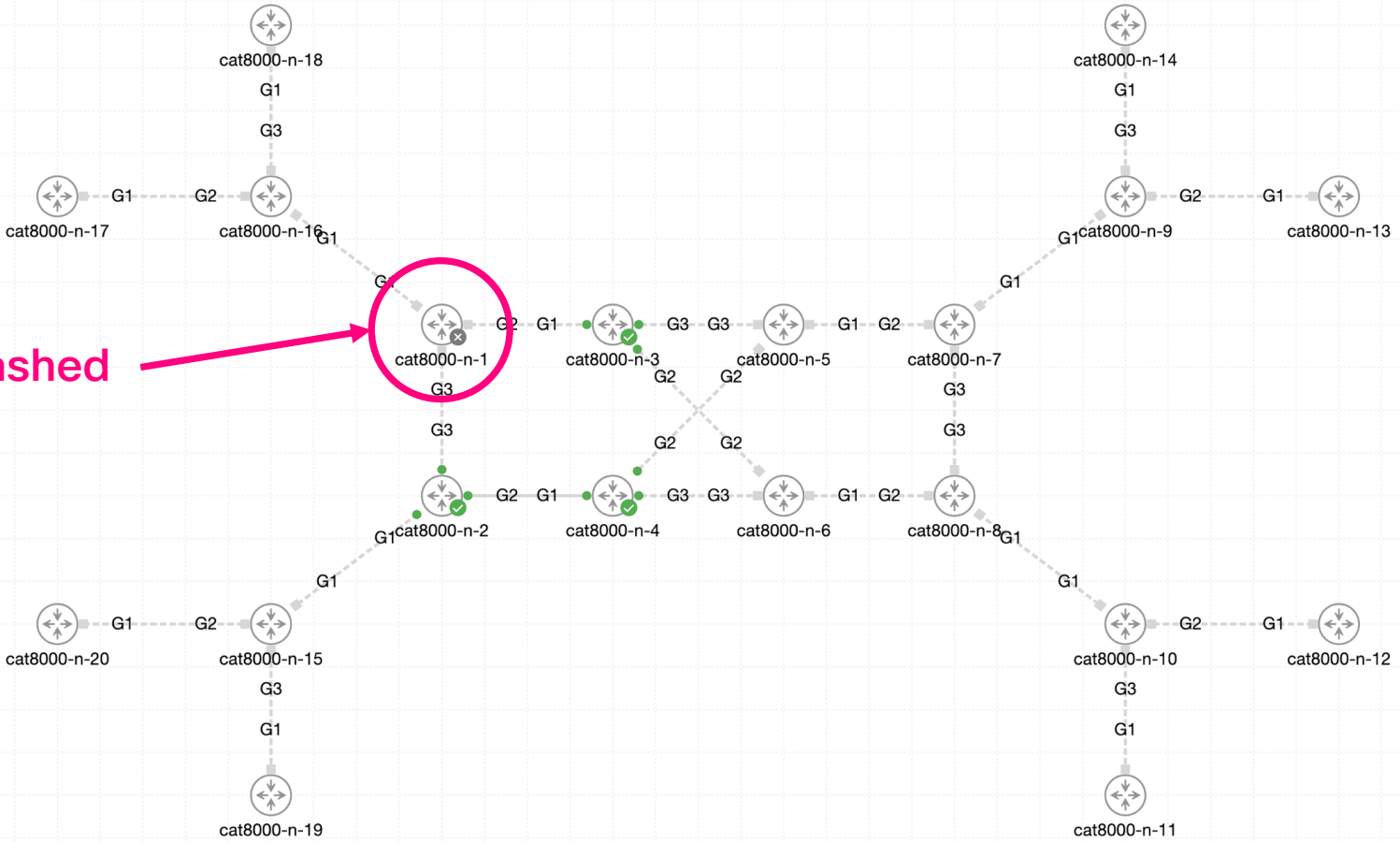
97.39%

DISK

32.17%

34

OK



Node 1 - Crashed

CPU dropped to 9.5%

Memory High

High Memory Load on Compute



cml-mininode

CPU / Load Avg		
1 min	5 min	15 min
<div><div></div></div> 9.43% (8 CPUs)		
2.36	1.77	1.29

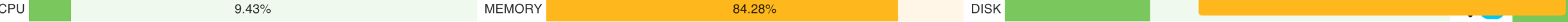
Memory [GB]		
Total	Used	Free
<div><div></div></div> 84.28%		
15.49	13.05	2.13

Disk [GB]			VM Stats	
Total	Used	Free	Allocated CPUs	Running / Total
<div><div></div></div> 32.65%				
224.29	73.23	151.06	3	

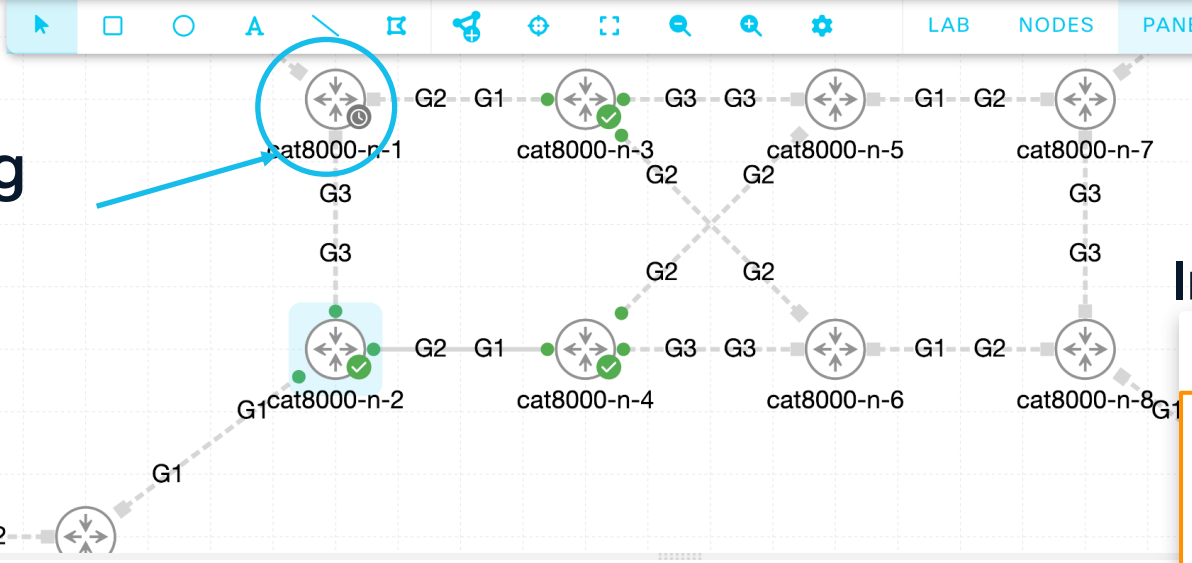
!

Warning: High System Load (memory) on cml-mininode: launch sequencing will be paused until system load stabilizes.

x



Restarting - waiting for compute



Insufficient HW resources

>_ CAT8000-N-2

Memory usage on node 2 is 65%

```
cat8000-n-2#show platform software status control-processor brief
Load Average
Slot Status 1-Min 5-Min 15-Min
RP0 Healthy 0.06 0.44 0.37

Memory (kB)
Slot Status Total Used (Pct) Free (Pct) Committed (Pct)
RP0 Healthy 3960284 2571764 (65%) 1388520 (35%) 3612968 (91%)

CPU Utilization
Slot CPU User System Nice Idle IRQ SIRQ IOWait
RP0 0 3.87 3.48 0.00 92.45 0.00 0.00 0.18

cat8000-n-2#
```

HW Memory Still High

	CPU / Load Avg			Memory [GB]			Disk [GB]		
	1 min	5 min	15 min	Total	Used	Free	Total	Used	Free
	1.40	1.19	1.16	15.49	12.02	3.17	224.29	73.24	151.06
cml-mininode									
CPU	12.56%			MEMORY	77.60%			DISK	32.65%

Lab Notifications

11:59:24 cat8000-n-1: Failed to choose a suitable compute host (Insufficient HW resources)

11:58:20 cat8000-n-1: Failed to choose a suitable compute host (Insufficient HW resources)

11:57:16 cat8000-n-1: Failed to choose a suitable compute host (Insufficient HW resources)

11:56:12 cat8000-n-1: Failed to choose a suitable compute host (Insufficient HW resources)

11:55:08 cat8000-n-1: Failed to choose a suitable compute host (Insufficient HW resources)

11:54:04 cat8000-n-1: Failed to choose a suitable compute host (Insufficient HW resources)

CLEAR

Optimize your design with IOL / IOL-L2 images



Lower resources than Cat8000v / Cat9000v



Still running IOS-XE, but not as a full VM

010110
110010
001011

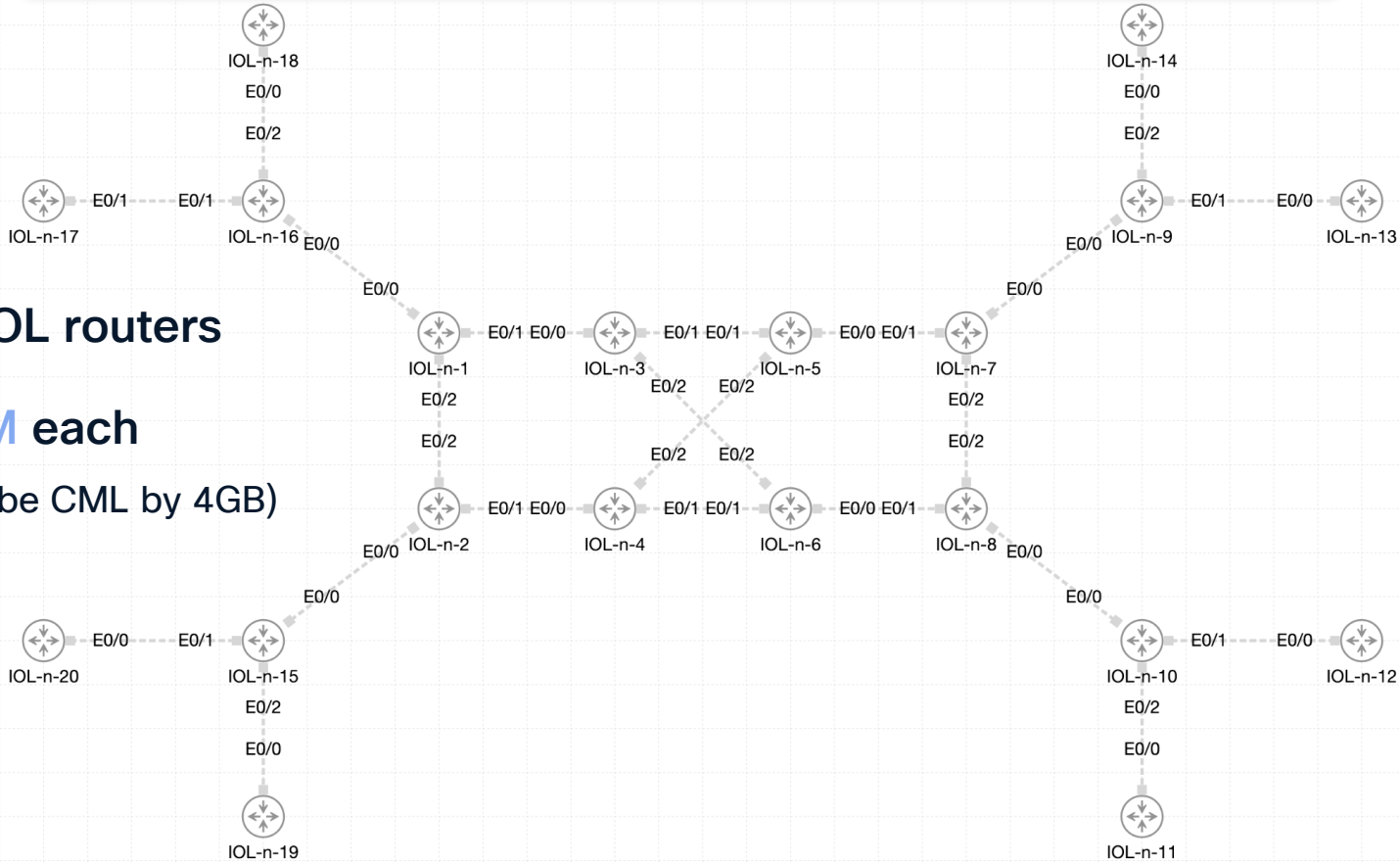
Similar data and control plane functions

IOL (L3 router)

- BGP, OSPF, IS-IS, EIGRP
- IPv4/IPv6
- Tunnels
- L3VPN/L2VPN
- MPLS, SR-MPLS, SRv6

IOL-L2 (L2 switch w/ L3)

- VXLAN
- Switchports/trunks
- HSRP
- Port Security
- DHCP



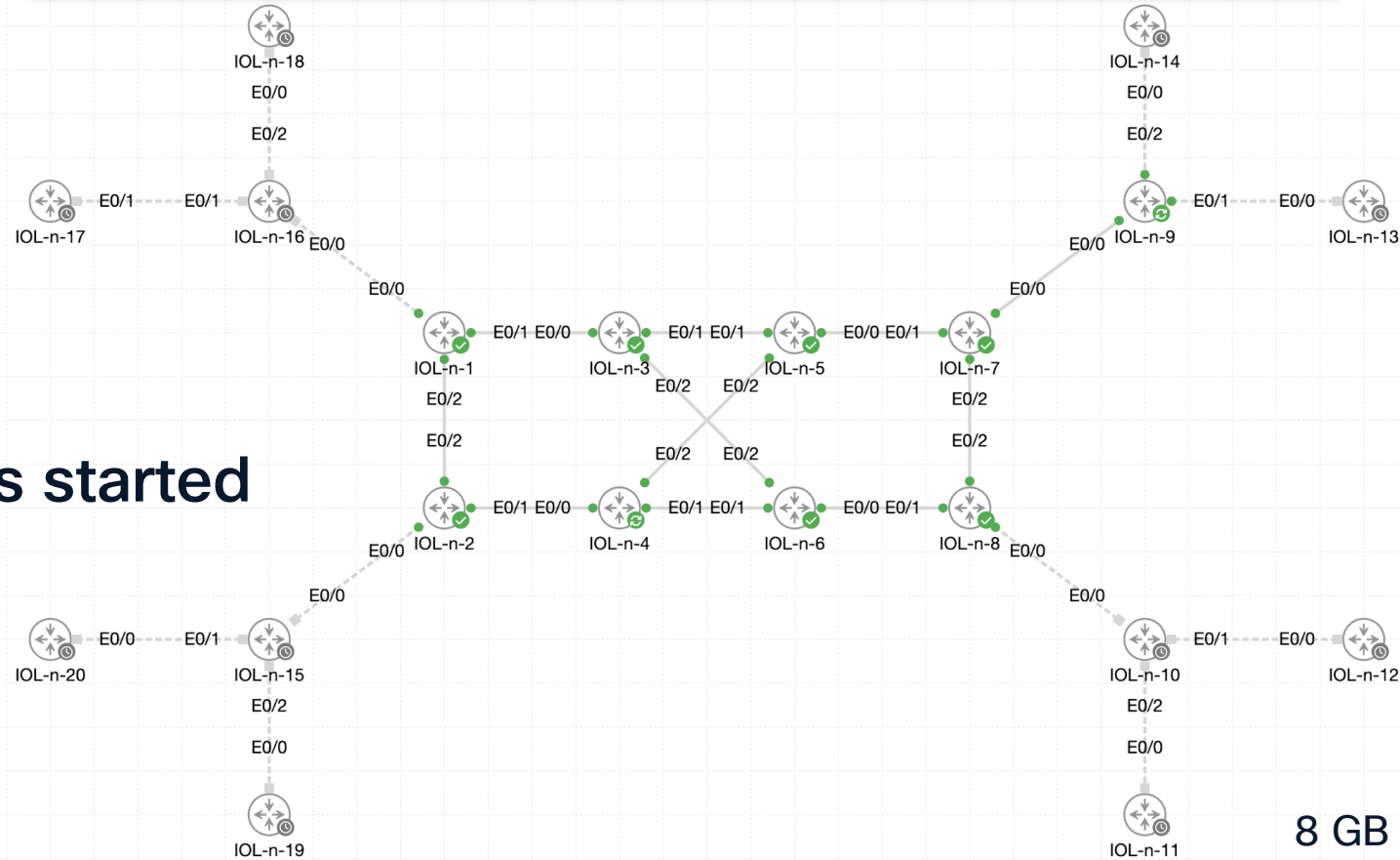
Launching - 20x IOL routers

1 vCPU 1GB RAM each

(This would oversubscribe CML by 4GB)

System: 8 CPUs 16 GB RAM

	CPU / Load Avg			Memory [GB]			Disk [GB]			VM Stats		Running / Total	
	1 min	5 min	15 min	Total	Used	Free	Total	Used	Free	Allocated CPUs	Allocated Memory	Nodes	Orphans
cml-mininode	0.34	0.78	0.99	15.49	1.11	14.07	224.29	73.24	151.06	0	0.00 GB	0 / 66	0 / 0
CPU	0.13%			MEMORY	7.20%			DISK	32.65%			0	OK



9 IOL Router nodes started

CPU barely changed Only using 2.50GB!

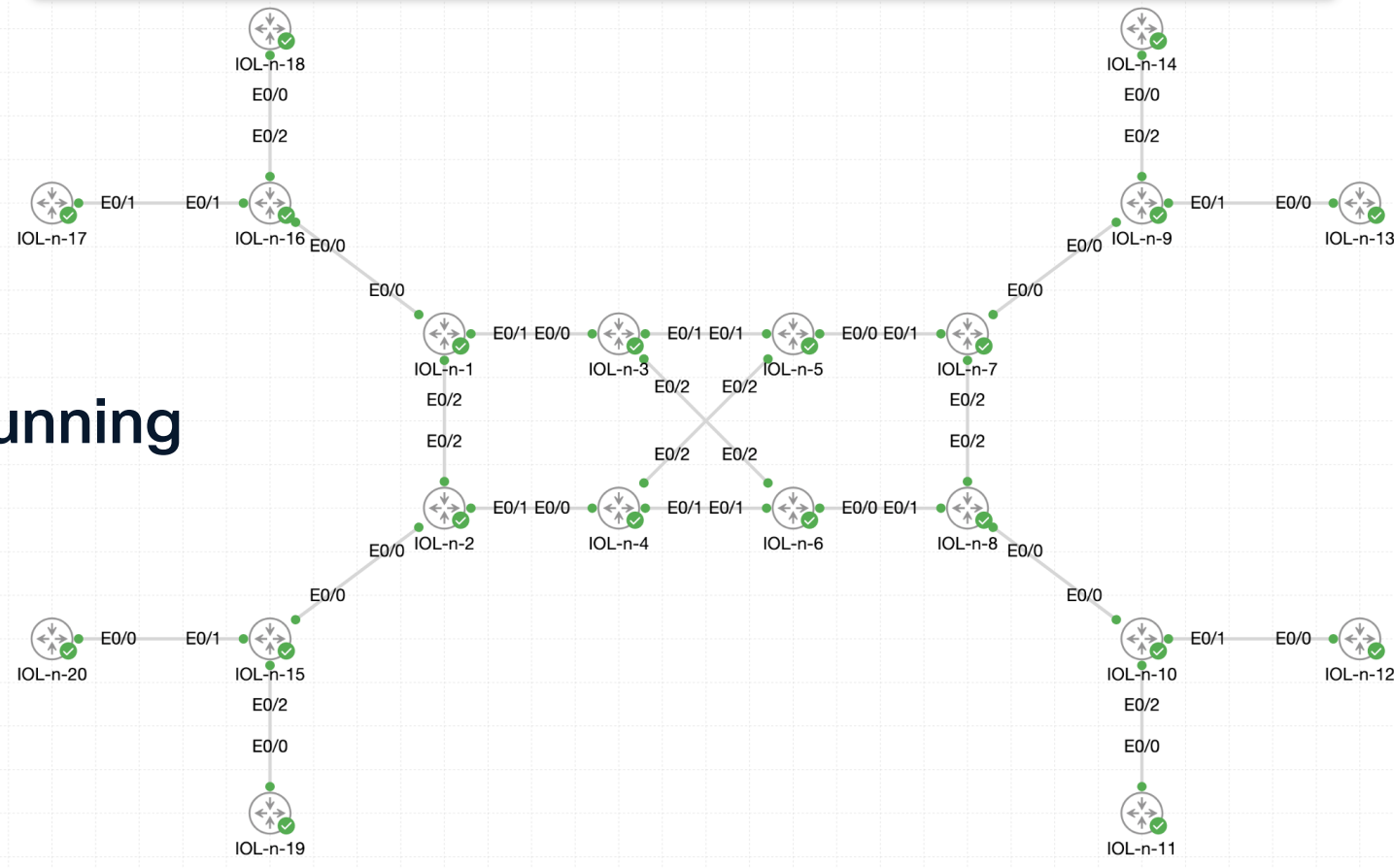
8 GB of RAM Allocated



cml-mininode

CPU / Load Avg			Memory [GB]			Disk [GB]			VM Stats		Running / Total	
1 min	5 min	15 min	Total	Used	Free	Total	Used	Free	Allocated CPUs	Allocated Memory	Nodes	Orphans
0.39	0.56	0.87	15.49	2.50	12.66	224.29	75.18	149.11	8	8.00 GB	8 / 74	-1 / -1

CPU	3.61%	MEMORY	16.13%	DISK	33.52%		62	OK
-----	-------	--------	--------	------	--------	--	----	----



All IOL routers running

< 1% CPU 4.4GB RAM

cml-mininode	CPU / Load Avg			Memory [GB]			Disk [GB]			VM Stats		Running / Total	
	1 min	5 min	15 min	Total	Used	Free	Total	Used	Free	Allocated CPUs	Allocated Memory	Nodes	Orphans
	0.13	0.23	0.34	15.49	4.57	10.59	224.29	78.81	145.49	20	20.01 GB	20 / 86	0 / 0

CPU

0.63%

MEMORY

29.52%

DISK

35.14%

591

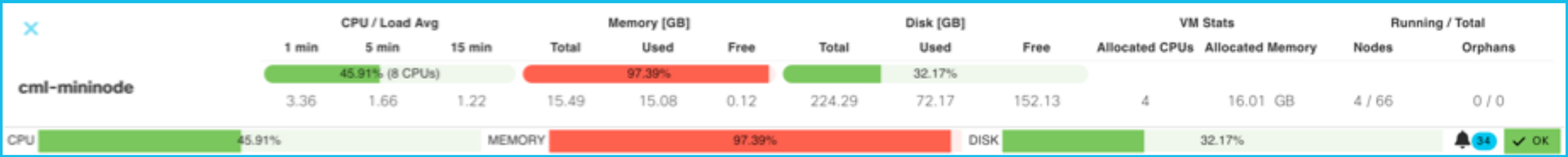
OK

20GB Allocated

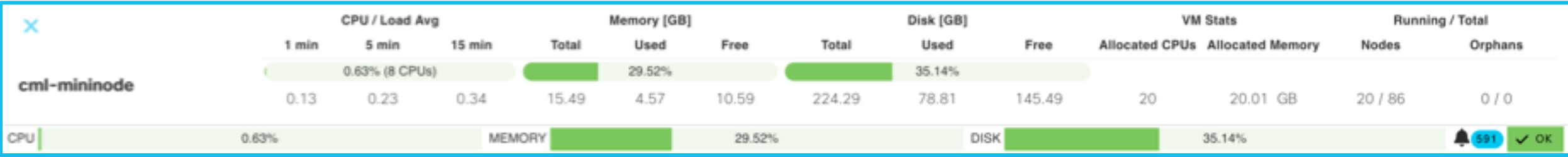
Boot comparison

20x Cat8000v (only 4 started) vs. 20x IOL routers (all running)

20x 8000v lab: 45% CPU utilization, 97% memory utilization. 4 booting nodes.



20x IOL router lab: .63% CPU utilization, 29.52% memory utilization. All nodes running.



The background of the slide is an abstract pattern of flowing, wavy lines in various shades of blue, from light sky blue to deep navy blue. A large, solid white rectangle is positioned on the left side of the slide, serving as a backdrop for the main text.

Build networks

Where do you start with this blank canvas?

	CPU / Load Avg			Memory [GB]			Disk [GB]			VM Stats		Running / Total	
	1 min	5 min	15 min	Total	Used	Free	Total	Used	Free	Allocated CPUs	Allocated Memory	Nodes	Orphans
cml-mininode	0.13	0.14 (8 CPUs)	0.25	15.49	1.13	14.03	224.29	78.81	145.49	0	0.00 GB	0 / 86	0 / 0
CPU	0.13%			MEMORY	7.28%			DISK	35.14%			0	

Ideas to populate your Canvas

Rapid Prototyping

- Test existing network configurations
- Test network migrations
- Experiment with changes to your network

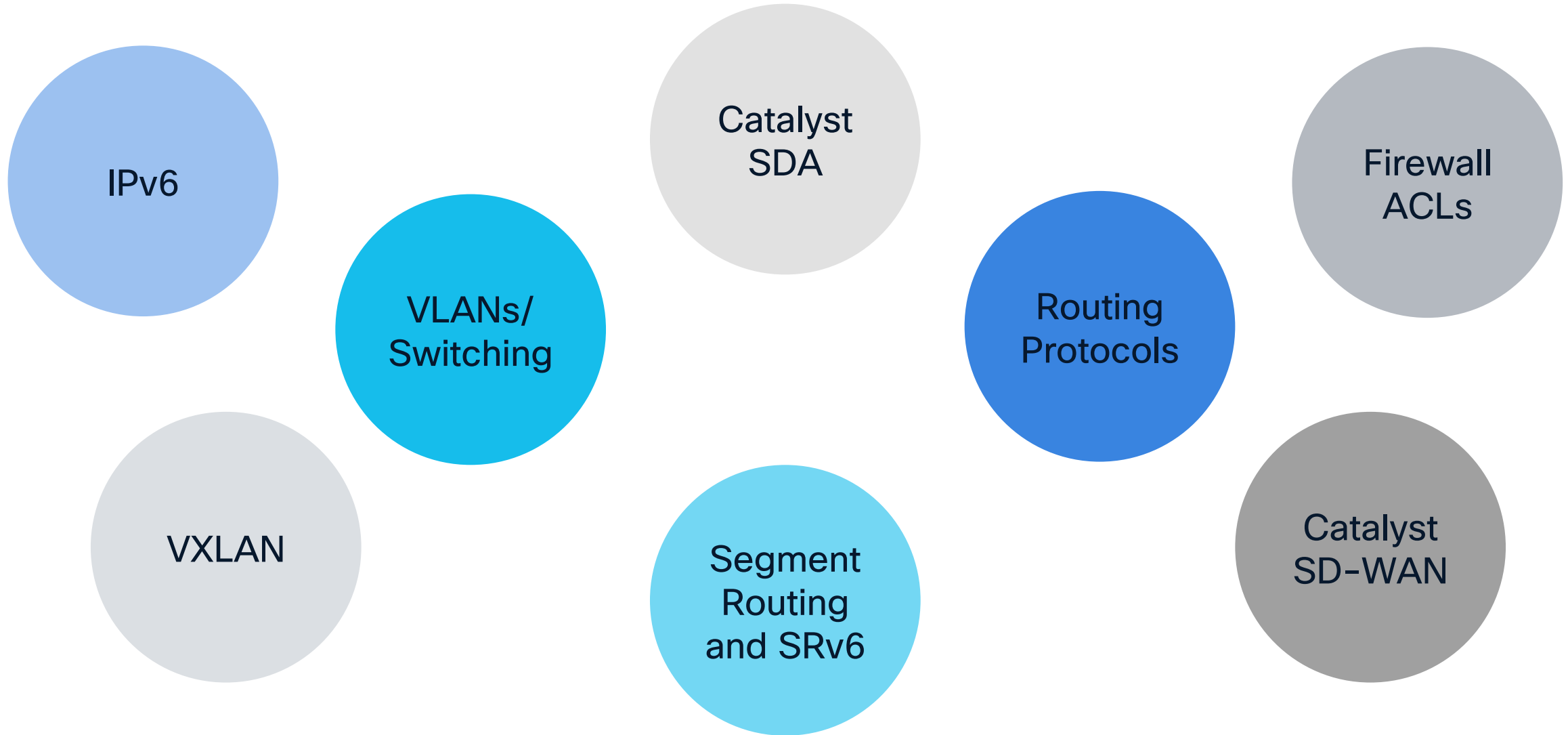
Protocol Experience

- Deploy IPv6, BGP, VXLAN

Skill Development

- Design a CCNA / CCNP / CCIE Lab

Sample technologies that can be operated in CML



The background of the slide is an abstract design featuring flowing, wavy lines in various shades of blue and white. A large, solid white rectangular box is positioned on the left side of the slide, serving as a backdrop for the main text.

Let's build

Step 1: Configure a jump host

Components added

- External Connector
 - Bridge Mode
- Ubuntu Node
 - DNS server (BIND9)
 - NTP (chrony)
 - Squid (Proxy)
 - Python / PIP
 - Create 3 – Interfaces
 - To external LAN
 - To OoB Management
 - To CML Lab Network



SETTINGS CONNECTIVITY CONFIG INTERFACES

STOP WIPE CLONE DELETE

Ubuntu
Node Name
ubuntu-services
Tags
VNI100100
Image Definition
Ubuntu 24.04 - 04 Oct 2024
Compute
RAM
2048
CPUs
1
CPU Limit
100
Storage

CPU

0.25%

MEMORY

10.91%

DISK

35.15%

30

OK

Leverage CML node **config** to jumpstart your nodes

SETTINGS CONNECTIVITY **CONFIG** INTERFACES

 Configuration is locked: Wipe this node to edit its configuration.

Configuration file
user-data

SAVE

REFRESH

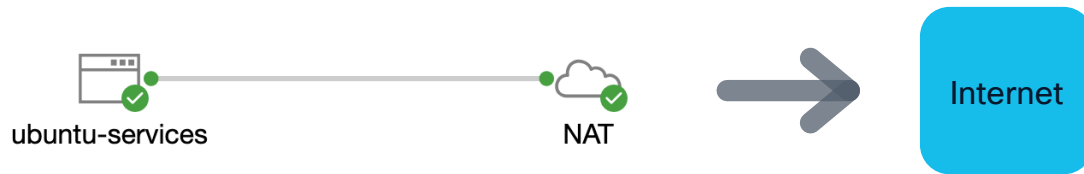
FETCH

RESTORE

```
20 #External LAN
21   dhcp4: false
22   addresses:
23     - 192.168.1.210/24
24   routes:
25     - to: default
26       via: 192.168.1.1
27   nameservers:
28     addresses:
29       - 192.168.1.1
30   ens3:
31     # Out of Band network
32     dhcp4: false
33     addresses:
34       - 10.255.255.210/24
35   ens4:
36     #CML Internal Networks
37     dhcp4: false
38     addresses:
39       - 172.16.1.210/24
40       - 2001:db8:cafe:100::210/64
41     routes:
42       - to: 172.16.1.0/12
43         via: 172.16.1.254
44       - to: 10.0.0.0/9
45         via: 172.16.1.254
46       - to: 2001:db8::/32
47         via: 2001:db8:cafe:100::1/64
```

External connectivity options

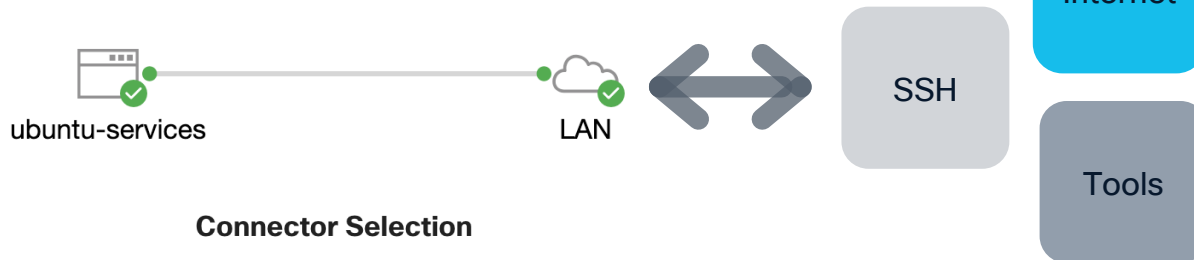
NAT vs. Bridge Mode



Connector Selection

NAT: (virbr0) 
Start typing custom external connector and confirm with Enter

- NAT
 - You want your CML nodes to access external resources only, like the Internet.



Connector Selection

System Bridge: (bridge0) 
Start typing custom external connector and confirm with Enter

- Bridge
 - You want CML nodes and external systems accessible to each other.
 - Connect to platforms and devices outside CML
 - Create out-of-band management access
 - Expose web-ui of CML nodes

Add interfaces **before** starting the node.

Before starting node

SETTINGS CONNECTIVITY CONFIG INTERFACES			
+ ADD 4 INTERFACES		REFRESH ADDRESSES	
Interface	Connected To	MAC Address	IP Addresses i
 Ethernet0/0			N/A
 Ethernet0/1			N/A
 Ethernet0/2			N/A
 Ethernet0/3			N/A

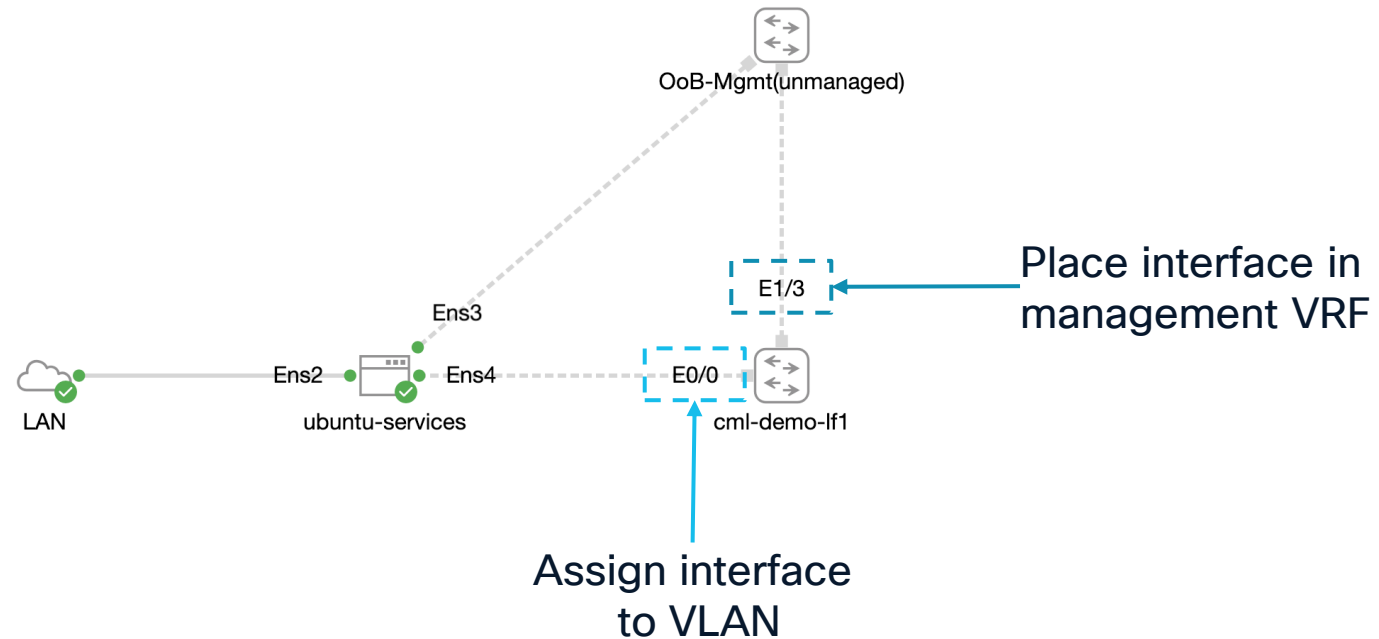
After starting node

SETTINGS CONNECTIVITY CONFIG INTERFACES			
+ ADD 4 INTERFACES		REFRESH ADDRESSES	
Interface	Connected To	MAC Address	IP Addresses i
 Ethernet0/0		aa:bb:cc: 00:26:00	
 Ethernet0/1		aa:bb:cc: 00:26:10	
 Ethernet0/2		aa:bb:cc: 00:26:20	
 Ethernet0/3		aa:bb:cc: 00:26:30	

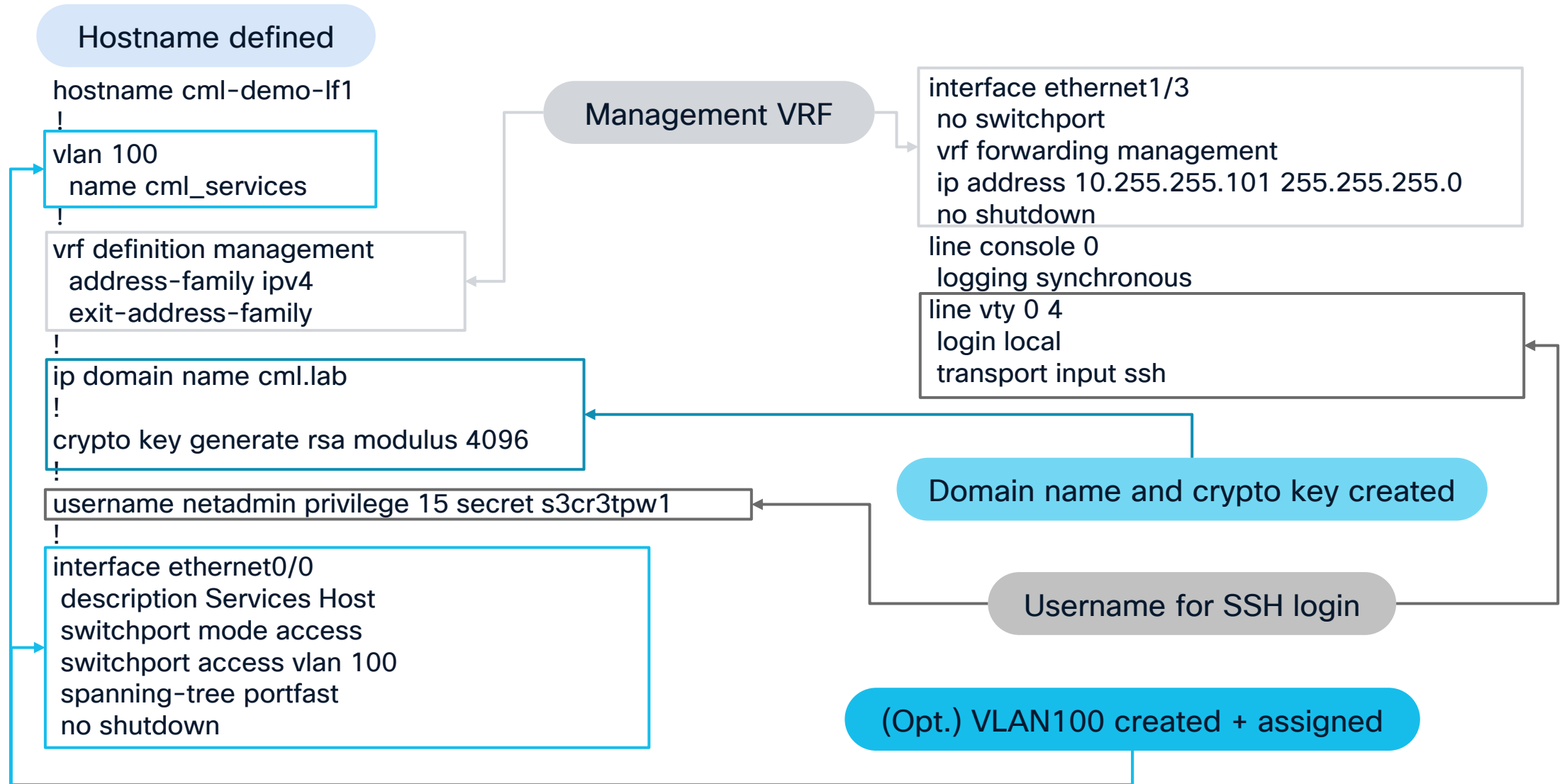
Building out our internal services network

New components

- **OoB-Mgmt switch**
 - Unmanaged Switch node
 - No license usage!
- **cml-demo-lf1**
 - IOL-L2 node
 - Access switch for internal services
 - DNS, NTP
 - Management port
 - Out-of-band access
 - For scripts, ansible, etc

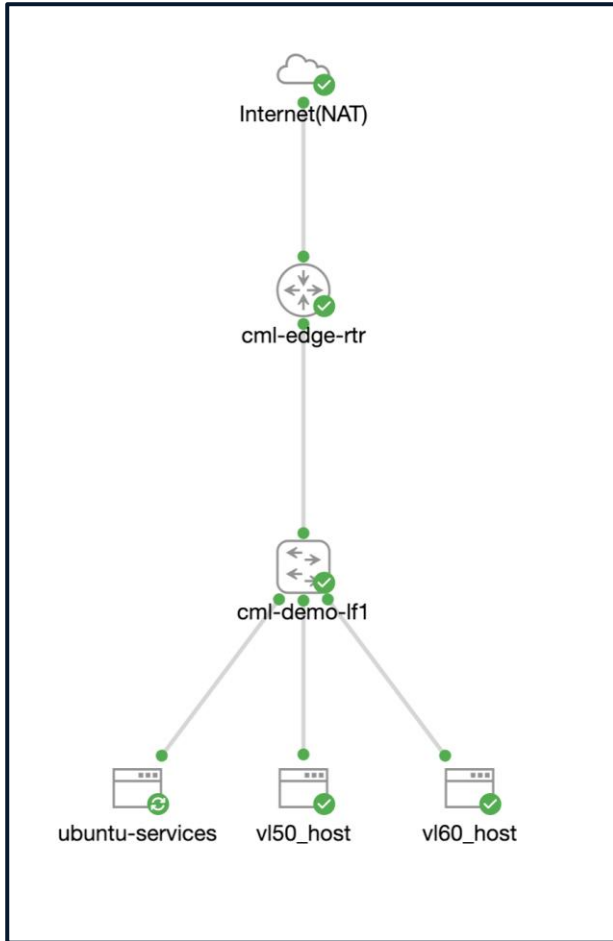


Example IOL-L2 node startup config

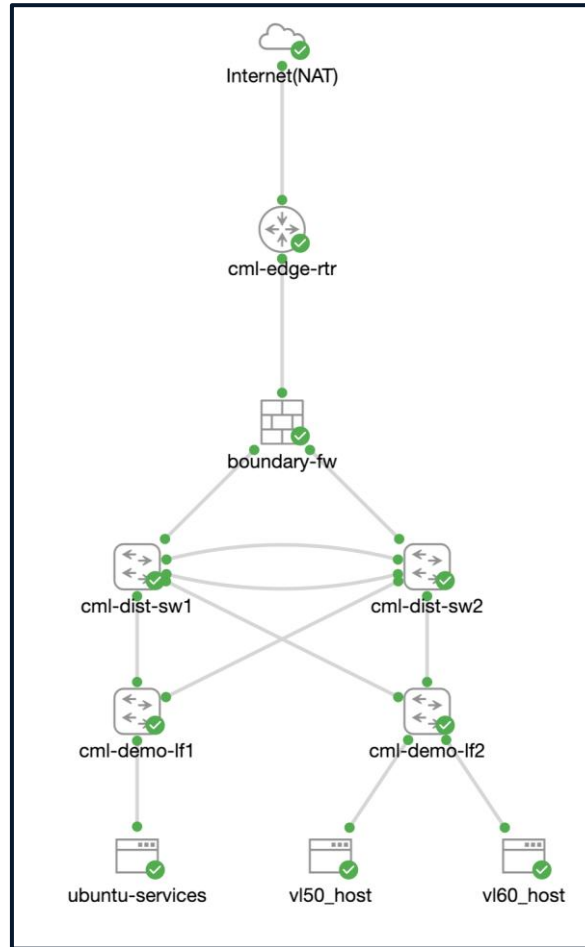


Ideas to expand your services network

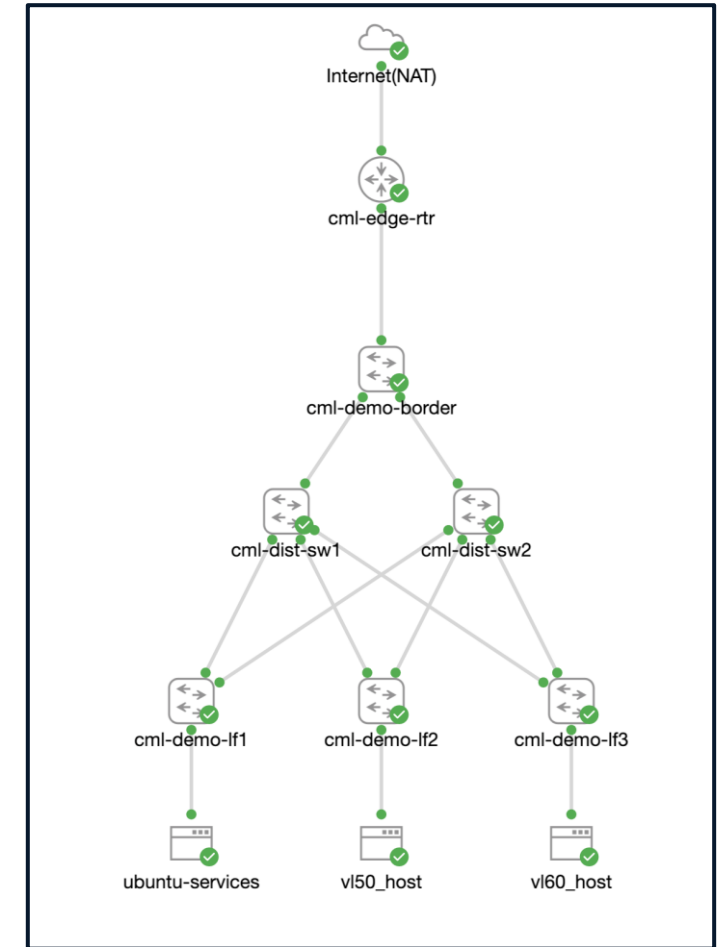
Single Router and Switch



Access + Distribution w/ Firewall

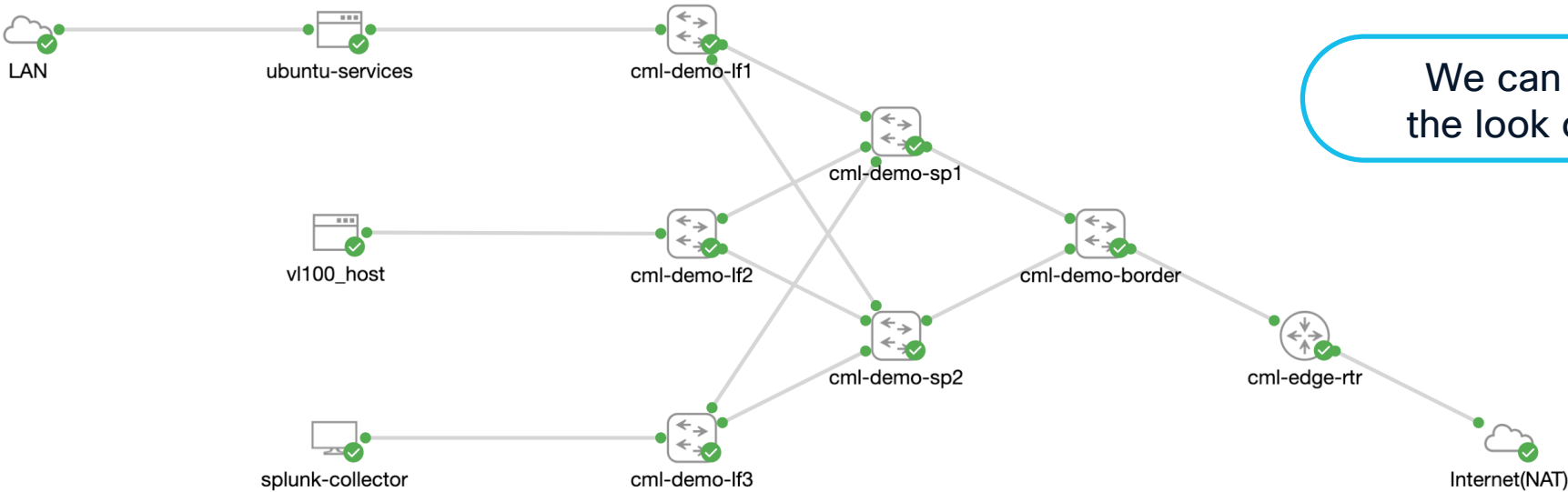


VXLAN Fabric



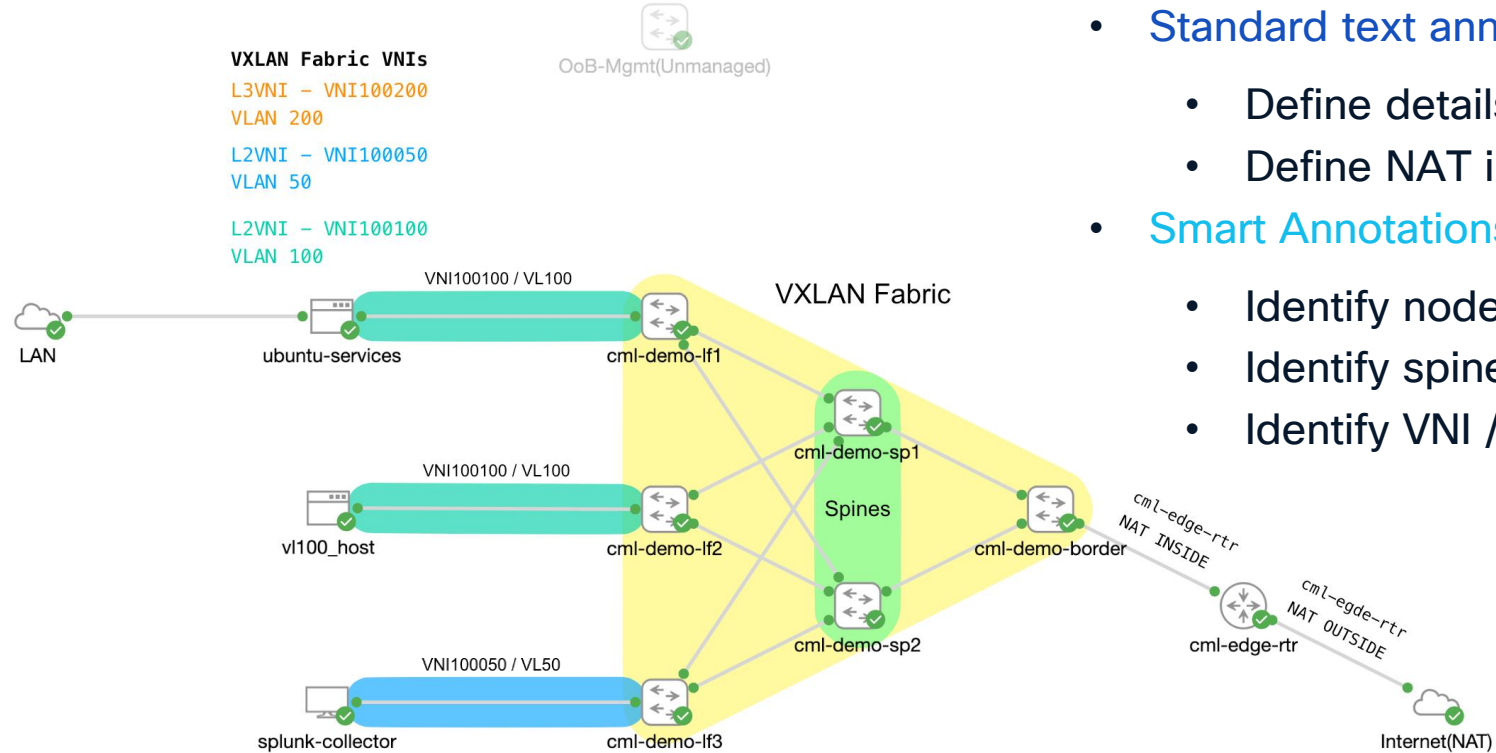
OoB-Mgmt(Unmanaged)

Data Center VXLAN Fabric with Internet Access



We can improve the look of this lab

Annotated and documented lab



- Standard text annotations
 - Define details on VNIs in fabric
 - Define NAT inside and outside
- Smart Annotations
 - Identify nodes in fabric
 - Identify spines
 - Identify VNI / VLAN link

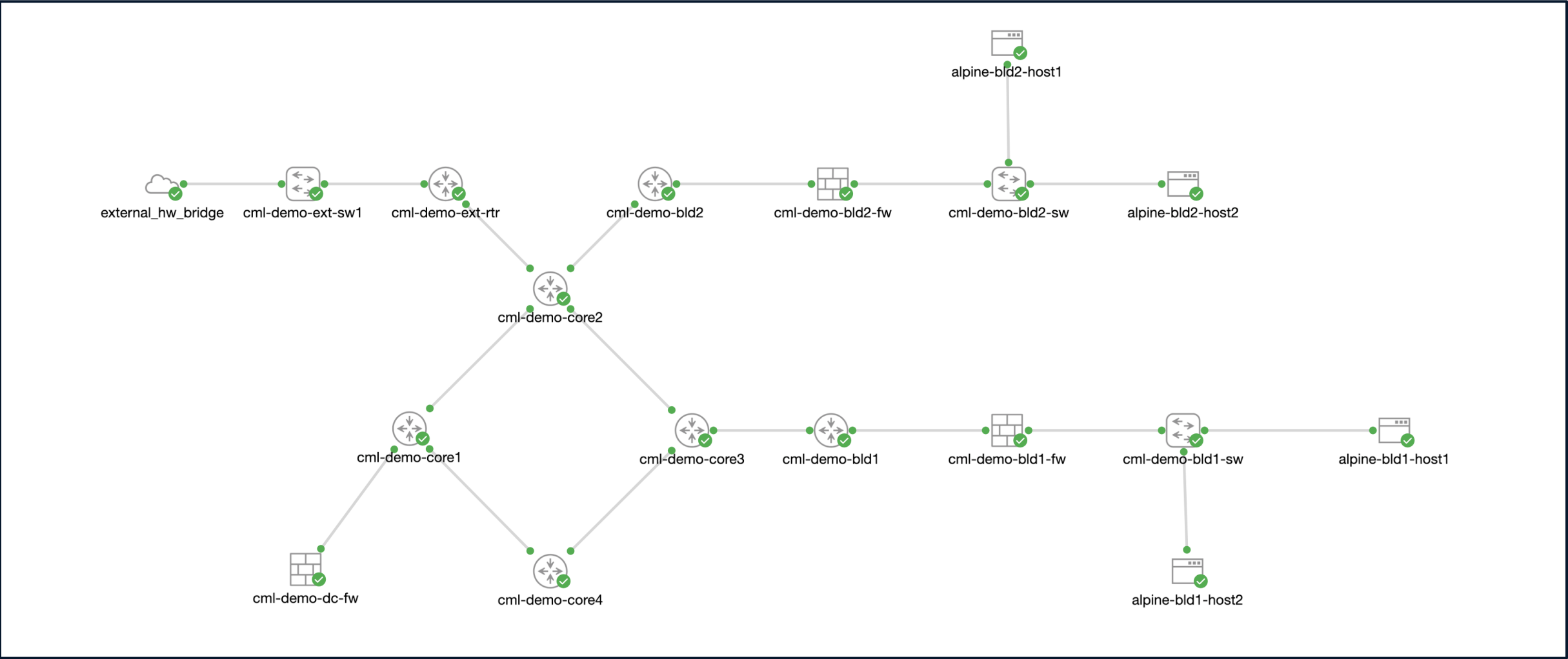
Much better!

We still have plenty of resources for more nodes

	CPU / Load Avg			Memory [GB]			Disk [GB]			VM Stats		Running / Total	
	1 min	5 min	15 min	Total	Used	Free	Total	Used	Free	Allocated CPUs	Allocated Memory	Nodes	Orphans
cml-mininode	1.38% (8 CPUs)				32.61%			38.39%					
	0.46	0.59	0.53	15.49	5.05	10.11	224.29	86.11	138.18	9	13.51 GB	11 / 108	0 / 0
CPU	1.38%			MEMORY	32.61%			DISK	38.39%			 161	 OK

Extend out your network

Create an enterprise core or a service provider network





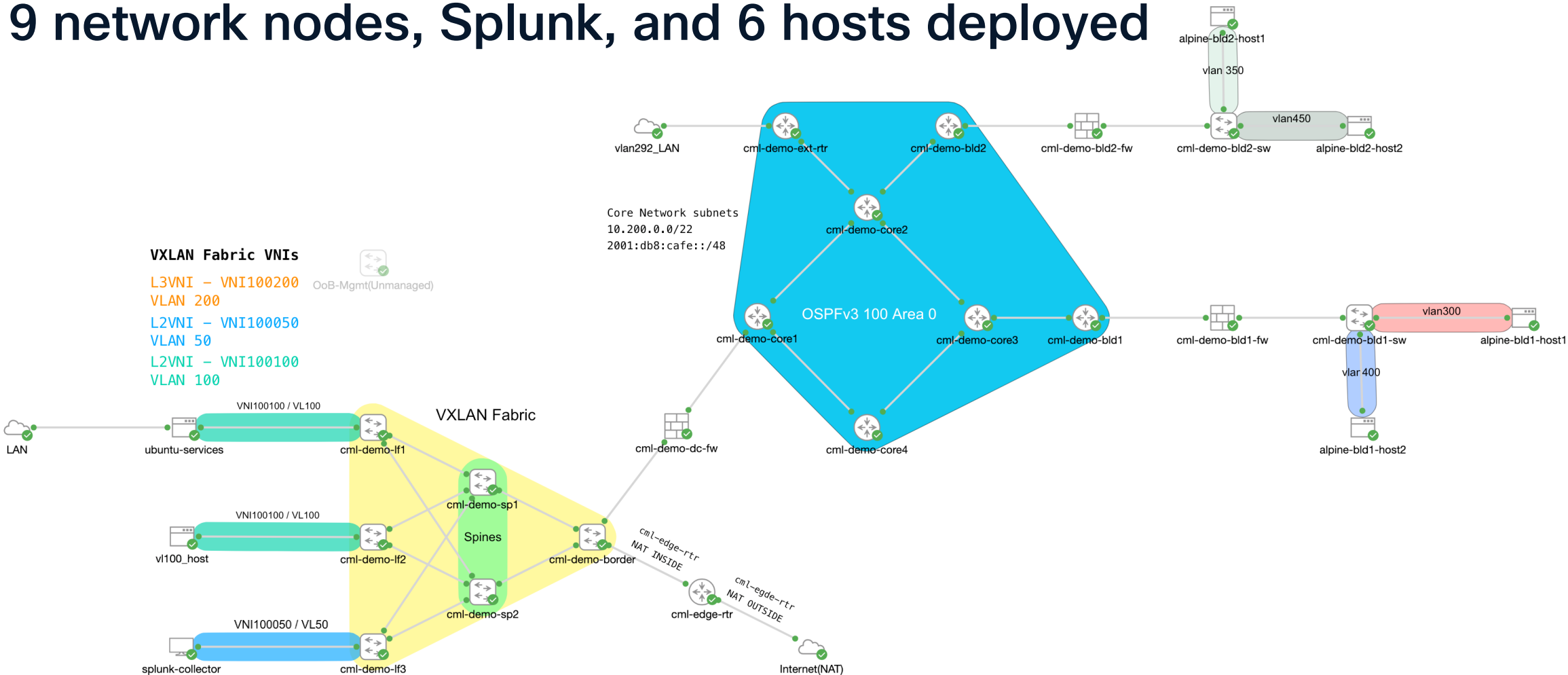
LAB

NODES

PANES

GUIDE

19 network nodes, Splunk, and 6 hosts deployed



CPU

7.52%

MEMORY

77.01%

DISK

37.46%

494 OK

All licenses used.

Included 3rd party nodes*, external connector, and unmanaged switch do not consume licenses

Node Licenses



*Alpine, Desktop, Server, Trex, Ubuntu, WAN Emulator node types

Oversubscribed but everything is running

	CPU / Load Avg			Memory [GB]			Disk [GB]			VM Stats		Running / Total	
	1 min	5 min	15 min	Total	Used	Free	Total	Used	Free	Allocated CPUs	Allocated Memory	Nodes	Orphans
cml-mininode	4.54% (8 CPUs)			76.54%			37.47%			25	30.51 GB	27 / 117	0 / 0
	0.98	1.16	1.11	15.49	11.86	3.30	224.29	84.03	140.26				
CPU	4.54%			MEMORY	76.54%			DISK	37.47%			494	
												OK	

Sure...but can you PROVE it is doing anything?

The background of the slide features a dynamic, abstract pattern of flowing, wavy lines in various shades of blue, from light sky blue to deep navy blue. A prominent white rectangular box is positioned on the left side of the slide, serving as a backdrop for the main text.

Operate your network

How do you know the network is working?

Can we access the lab from the jump host? Are we providing services? Can our hosts reach the internet?

```
netadmin@ubuntu-services: ~  
~ ssh netadmin@192.168.1.210 ok | 21:52:40  
netadmin@192.168.1.210's password:  
Welcome to Ubuntu 24.04.2 LTS (GNU/Linux 6.8.0-45-generic x86_64)  
  
* Documentation:  https://help.ubuntu.com  
* Management:    https://landscape.canonical.com  
* Support:       https://ubuntu.com/pro  
  
System information as of Sun Apr 20 21:52:43 EDT 2025  
  
System load:          0.0  
Usage of /:           3.8% of 60.95GB  
Memory usage:         18%  
Swap usage:           0%  
Processes:            116  
Users logged in:      1  
IPv4 address for ens2: 192.168.1.210  
IPv6 address for ens2: 2600:4040:b62c:1900:5054:ff:fe29:8cee  
  
* Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s  
  just raised the bar for easy, resilient and secure K8s cluster deployment.  
  
https://ubuntu.com/engage/secure-kubernetes-at-the-edge  
  
Expanded Security Maintenance for Applications is not enabled.  
  
0 updates can be applied immediately.  
  
Enable ESM Apps to receive additional future security updates.  
See https://ubuntu.com/esm or run: sudo pro status  
  
*** System restart required ***  
Last login: Sun Apr 20 21:50:10 2025 from 192.168.1.153  
netadmin@ubuntu-services:~$ |
```

```
netadmin@ubuntu-services: ~  
v150_host:~$ nslookup time.cml.lab  
Server:          172.16.1.210  
Address:         172.16.1.210:53  
  
Name:   time.cml.lab  
Address: 10.255.255.210  
Name:   time.cml.lab  
Address: 172.16.1.210  
  
v150_host:~$ |
```

```
netadmin@ubuntu-services: ~  
v150_host:~$ wget https://www.ciscolive.com/ --no-check-certificate  
Connecting to www.ciscolive.com (23.204.243.84:443)  
saving to 'index.html'  
index.html 100% |*****| 76766 0:00:00 ETA  
'index.html' saved  
v150_host:~$ |
```

Packet Capture

DNS query response for time.cml.lab

Leaf connection

Wireshark · Packet 411 · BRKOPS-1104_Demo_Topology-cml-demo-lf3-Ethernet1_0_-_cml-demo-sp1-Ethernet0_2.pcap

> Ethernet II, Src: aa:bb:cc:00:96:20 (aa:bb:cc:00:96:20), Dst: aa:bb:cc:00:99:01 (aa:bb:cc:00:99:01)

> Internet Protocol Version 4, Src: 10.168.100.101, Dst: 10.168.100.103

> User Datagram Protocol, Src Port: 4789, Dst Port: 4789

Virtual eXtensible Local Area Network

> Flags: 0x0800, VXLAN Network ID (VNI) Group Policy ID: 0

> VXLAN Network Identifier (VNI): 100200

> Reserved: 0

> Ethernet II, Src: aa:bb:cc:80:9a:00 (aa:bb:cc:80:9a:00), Dst: aa:bb:cc:80:99:00 (aa:bb:cc:80:99:00)

> Internet Protocol Version 4, Src: 172.16.1.210, Dst: 172.17.1.10

0100 = Version: 4

.... 0101 = Header Length: 20 bytes (5)

> Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)

Total Length: 90

Identification: 0x0bcf (3023)

> 000. = Flags: 0x0

...0 0000 0000 0000 = Fragment Offset: 0

Time to Live: 63

Protocol: UDP (17)

Header Checksum: 0x14c7 [validation disabled]

[Header checksum status: Unverified]

Source Address: 172.16.1.210

Destination Address: 172.17.1.10

[Stream index: 1]

> User Datagram Protocol, Src Port: 53, Dst Port: 45709

> Domain Name System (response)

Transaction ID: 0xa901

> Flags: 0x8580 Standard query response, No error

Questions: 1

Answer RRs: 2

Authority RRs: 0

Additional RRs: 0

> Queries

> time.cml.lab: type A, class IN

> Answers

> time.cml.lab: type A, class IN, addr 172.16.1.210

> time.cml.lab: type A, class IN, addr 10.255.255.210

VXLAN L3VNI

Original Frame

Change link conditions

The diagram illustrates a network topology. On the left, a node labeled 'cml-edge-rtr' is connected to a cloud icon labeled 'Internet(NAT)'. The connection is represented by a blue line with a green dot at the 'cml-edge-rtr' end and a green checkmark at the 'Internet(NAT)' end. A black circle with a white exclamation mark is positioned near the 'cml-edge-rtr' node, and the text 'OUTSIDE' is written next to it.

SETTINGSCONNECTIVITY

STOPDISCONNECTDELETE

Link Statistics

Node	Interface	Running	Packets
cml-edge-rtr	Ethernet0/0	☒	43945
internet(nat)	port	☒	890

Link Condition

Bandwidth

0

kbps

Latency

1

ms

Jitter

2

ms

Loss

10

ms

☒ Enable

APPLY

RESET

Adjusting link condition

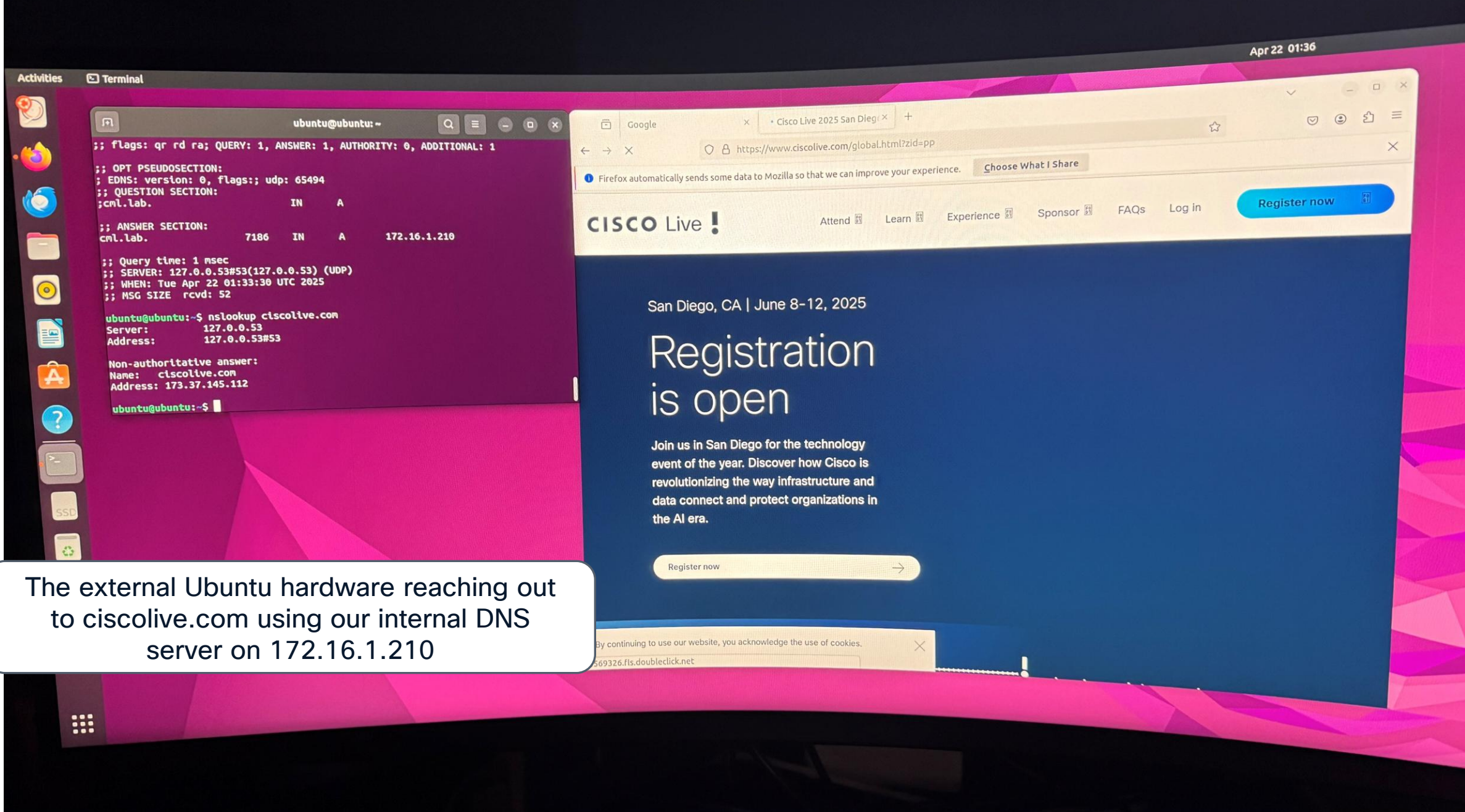
Before and after state of adding 10% loss

Before conditioning

netadmin@ubuntu-services: ~									
My traceroute [v0.95]									
v1100_host (172.16.1.10) -> ciscolive.com (173.37.145.112) 2025-05-28T13:17:56+0000									
Keys: Help Display mode Restart statistics Order of fields quit									
		Packets		Pings					
Host	Loss%	Snt	Last	Avg	Best	Wrst	StDev		
1. 172.16.1.254	0.0%	41	0.6	0.5	0.4	0.6	0.1		
2. 192.168.254.1	0.0%	41	1.3	1.3	1.1	1.5	0.1		
3. 192.168.255.1	0.0%	41	1.4	1.3	1.2	1.5	0.1		
4. 192.168.1.1	0.0%	40	2.0	1.9	1.7	2.1	0.1		
5. lo0-100.BLTMMMD-VFTTP-322.verizon-gni.net	0.0%	40	7.1	6.2	3.2	13.2	2.3		
6. 100.41.25.6	0.0%	40	6.7	7.5	3.7	31.8	5.0		
7. 0.ae1.GW1.DFW27.ALTER.NET	0.0%	40	41.4	41.2	38.3	60.9	3.7		
8. Internet-gw.customer.alter.net	0.0%	40	40.2	41.8	39.7	47.9	1.7		
9. 128.107.4.5	0.0%	40	42.2	41.6	39.4	44.0	1.1		
10. alln01-mds2-dmzbb-gw2-be92.cisco.com	0.0%	40	40.1	40.2	38.0	42.5	1.3		
11. alln01-mds2-dmzcc-gw2-por2.cisco.com	0.0%	40	40.8	42.1	39.6	52.2	2.0		
12. alln01-mds2-fab1-sw3812-dmzcc2uplink.cisco.co	0.0%	40	40.7	40.5	38.4	43.4	1.3		
alln01-mds2-fab1-sw3812-dmzcc1uplink.cisco.com									
13. (waiting for reply)									
14. (waiting for reply)									
15. hsrp-173-37-145-65.cisco.com	0.0%	40	41.4	42.0	39.9	47.2	1.5		
16. www2-realm.cisco.com	0.0%	40	40.0	41.4	39.0	46.7	1.5		

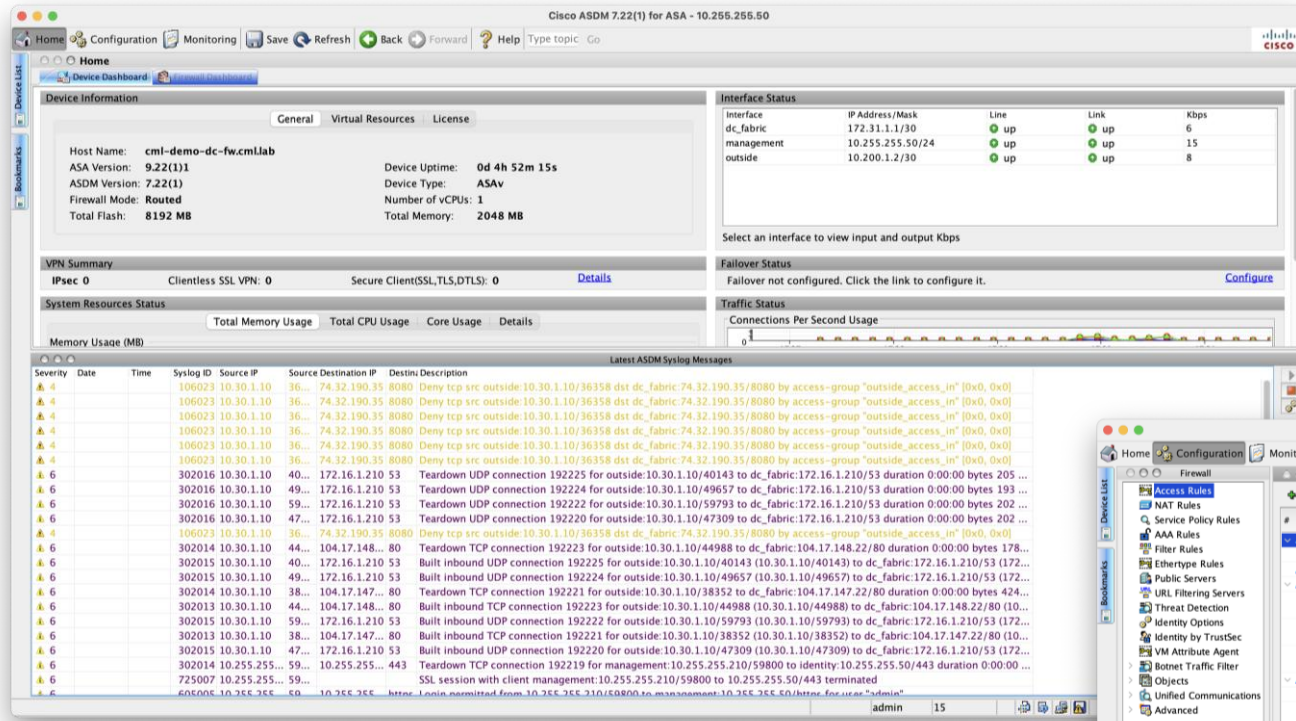
After conditioning

netadmin@ubuntu-services: ~									
My traceroute [v0.95]									
v1100_host (172.16.1.10) -> ciscolive.com (173.37.145.112) 2025-05-28T13:22:14+0000									
Keys: Help Display mode Restart statistics Order of fields quit									
		Packets		Pings					
Host	Loss%	Snt	Last	Avg	Best	Wrst	StDev		
1. 172.16.1.254	0.0%	41	0.6	0.4	0.3	0.6	0.1		
2. 192.168.254.1	0.0%	41	1.3	1.3	1.1	1.5	0.1		
3. 192.168.255.1	14.6%	41	1.7	1.5	1.3	2.7	0.2		
4. 192.168.1.1	27.5%	41	2.1	1.9	1.7	2.1	0.1		
5. lo0-100.BLTMMMD-VFTTP-322.verizon-gni.net	17.1%	41	3.0	8.0	3.0	70.5	11.7		
6. 100.41.25.6	14.6%	41	4.2	7.2	4.0	28.9	5.1		
7. 0.ae1.GW1.DFW27.ALTER.NET	24.4%	41	41.8	42.1	38.4	57.1	4.6		
8. Internet-gw.customer.alter.net	22.0%	41	41.7	41.8	39.4	43.6	1.2		
9. 128.107.4.5	17.5%	41	42.4	42.1	40.0	48.7	1.7		
10. alln01-mds2-dmzbb-gw2-be92.cisco.com	20.5%	40	40.9	40.3	38.2	42.6	1.3		
11. alln01-mds2-dmzcc-gw2-por2.cisco.com	12.5%	40	42.8	42.1	39.8	44.3	1.3		
12. alln01-mds2-fab1-sw3812-dmzcc2uplink.cisco.co	12.5%	40	40.6	41.2	38.6	53.7	2.5		
alln01-mds2-fab1-sw3812-dmzcc1uplink.cisco.com									
13. (waiting for reply)									
14. (waiting for reply)									
15. hsrp-173-37-145-65.cisco.com	15.4%	40	42.5	41.9	39.9	44.6	1.2		
16. www2-realm.cisco.com	28.2%	40	42.3	41.4	39.5	43.6	1.2		



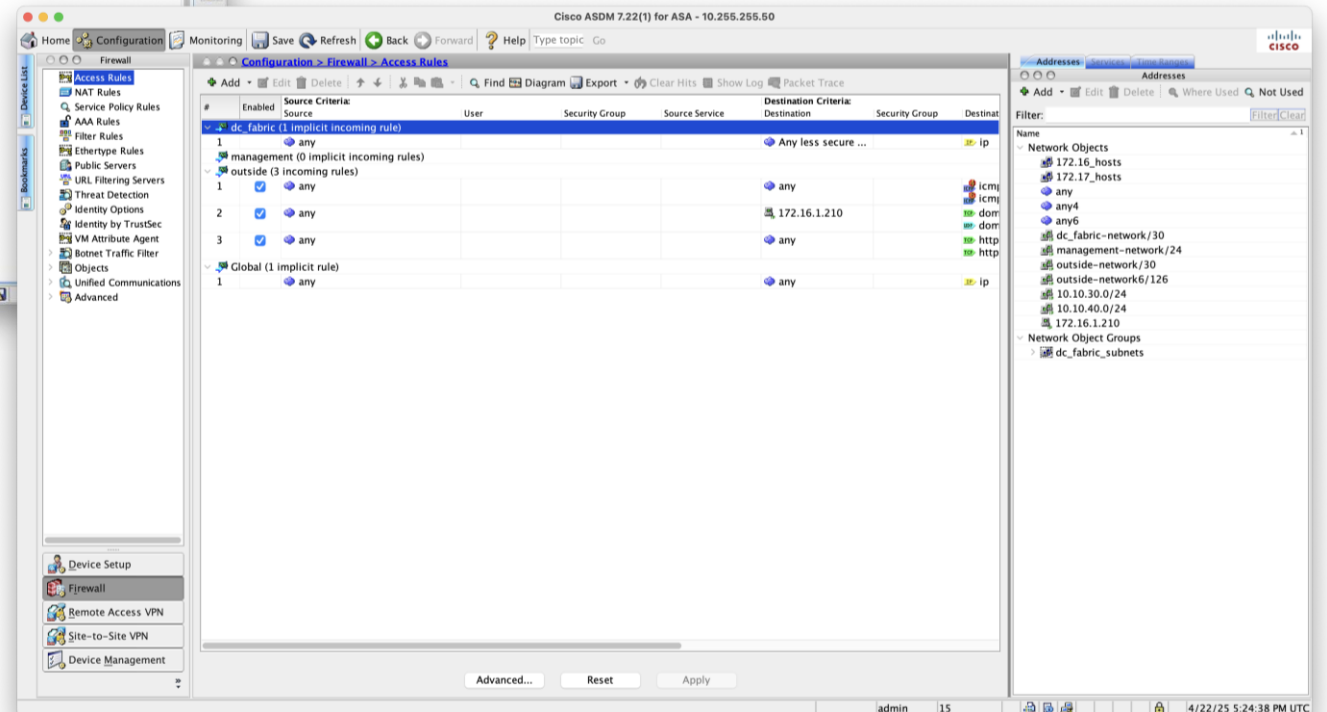
The external Ubuntu hardware reaching out to ciscolive.com using our internal DNS server on 172.16.1.210

Operate your firewalls



Monitor firewall for sessions, permitted/denied traffic

Manage policy, update rules, understand behavior



Deploy the Splunk container



SETTINGSCONNECTIVITYCONFIGINTERFACES

Configuration is locked: Wipe this node to edit its configuration.

Configuration file

boot.sh

SAVE

REFRESH

FETCH

RESTORE

1# insert more commands here

2ip address add 172.17.1.51/24 dev eth0

3ip link set dev eth0 up

4ip route add default via 172.17.1.254 dev eth0

5ip link set mtu 1300 dev eth0

6exit 0

SETTINGSCONNECTIVITYCONFIGINTERFACES

Configuration is locked: Wipe this node to edit its configuration.

Configuration file

environment

SAVE

REFRESH

FETCH

RESTORE

1SPLUNK_START_ARGS=--accept-license

2SPLUNK_PASSWORD=s3cr3tpw1

Access the Splunk instance in CML

Login | Splunk

Not Secure http://172.17.1.51:8000/en-US/account/login?return_to=%2Fen-US%2F

admin

.....

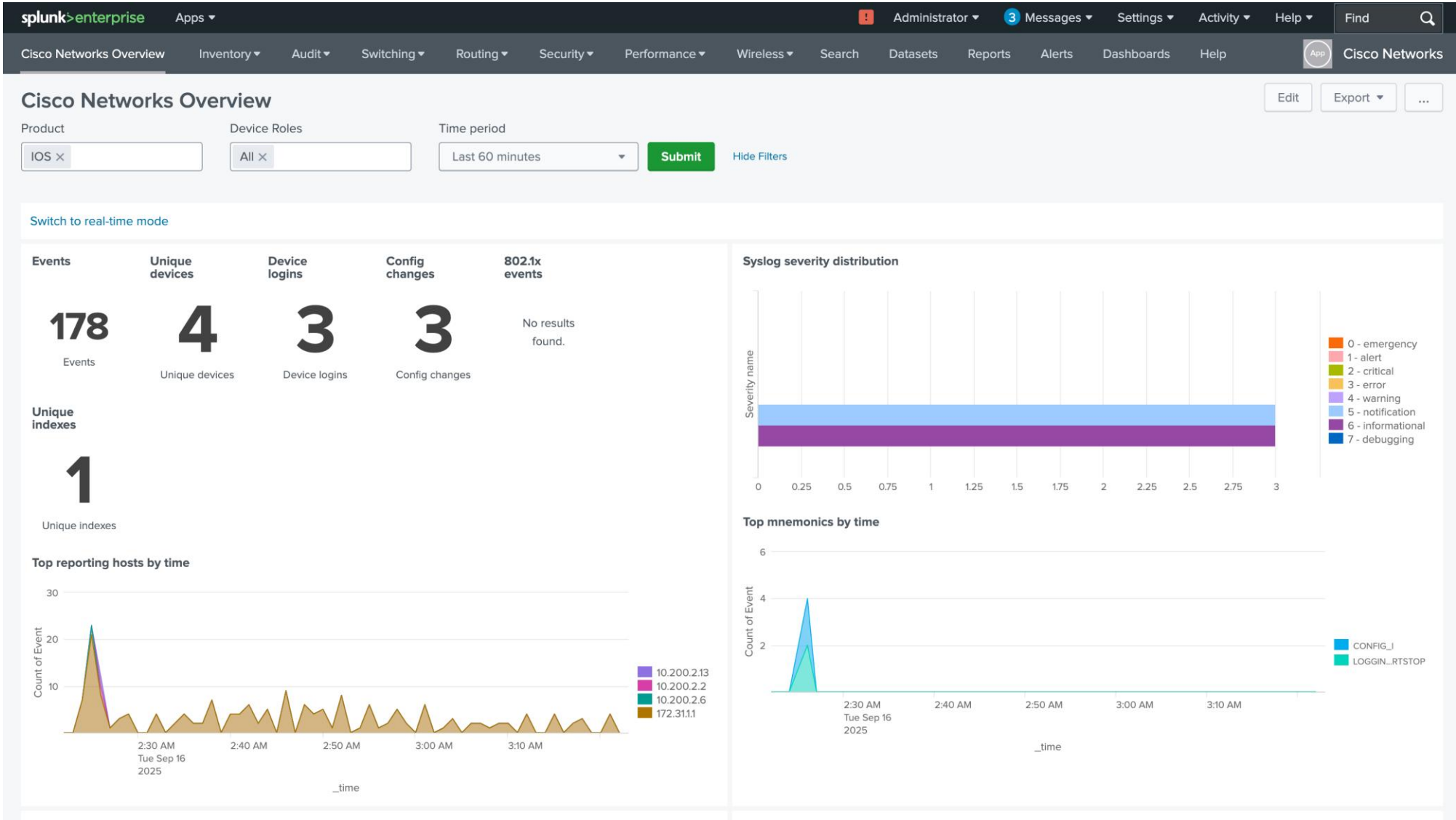
Sign In

First time signing in?

© 2005-2025 Splunk Inc.



Deploy the Splunk> Enterprise Container



The background of the slide is an abstract design featuring flowing, wavy lines in various shades of blue and white. A large, white rectangular box is positioned on the left side of the slide, serving as a container for the main text.

A final thought

The only limit to what you can build is your imagination...(and resources)

```
netadmin@ubuntu-services: ~/cml_ios_assistant

You: Hello, what can you do
Gemini: I can help you manage and troubleshoot Cisco IOS-based network devices in your test environment. I have access to devices named 'demo-lf1', 'demo-lf2', 'demo-lf3', 'demo-sp1', 'demo-sp2', and 'demo-border'.

Here are some of the things I can do:

* **Connect to devices**: I can establish connections to your specified network devices.
* **Execute commands**: I can send various Cisco IOS commands, such as 'show running-config' or 'show ip interface brief', to retrieve information from the devices.
* **Configure device settings**: I can assist you in configuring device settings like IP addressing, VLANs, routing protocols, and Access Control Lists (ACLs).
* **Save configurations**: I can save the running configurations on your devices.
* **Retrieve details**: I can fetch specific details from the devices based on your queries.
* **Troubleshoot the network**: I can help you in diagnosing and resolving network issues.

Before making any changes, I will always display the proposed changes for your review and provide explanations and references. I will also prevent any changes that I believe might impact the management interface of the devices.

How can I assist you today?

You: 
```

```
netadmin@ubuntu-services: ~/cml_ios_assistant

Here's a brief summary of its configuration:

* **VRF Definitions**: Two VRFs are defined: 'cml_demo' and 'management'.
* **VLANs**: VLAN 100 (named "Servers") and VLAN 200 (named "CML_tenant") are configured. These VLANs are associated with EVPN instance 1 and have respective VNIs.
* **Interfaces**:
  * 'Loopback0' (192.168.100.101/32) and 'Loopback2' (10.168.100.101/32) are configured for routing.
  * 'Ethernet0/0' is an access port for VLAN 100.
  * 'Ethernet1/0' and 'Ethernet1/1' are layer 3 interfaces using IP unnumbered Loopback0.
  * 'Ethernet1/3' is a management interface in the 'management' VRF (10.255.255.101/24).
  * 'Vlan100' and 'Vlan200' are configured within the 'cml_demo' VRF, with 'Vlan100' having an IP address of 172.16.1.254/24.
  * 'nve1' (Network Virtualization Edge) is configured for VXLAN, sourcing from 'Loopback2' and participating in VNIs 100100 and 100200.
* **Routing Protocols**:
  * **OSPF 100**: is running on Loopback0, Loopback2, Ethernet1/0, and Ethernet1/1.
  * **ISIS VXLAN_UNDERLAY**: is running on Loopback0.
  * **BGP 65000**: is configured with neighbors 192.168.100.201 and 192.168.100.202 for 'l2vpn evpn' and 'ipv4 vrf cml_demo' address families.
* **EVPN**: EVPN is enabled and configured to use VXLAN encapsulation, with 'Loopback0' as the router ID and automatic route target generation based on VNI.
* **User Management**: A local user 'netadmin' is configured.

You: 
```

```
netadmin@ubuntu-services: ~/cml_ios_assistant

You: Can you review the configurations of demo-lf1, lf2, lf3, and border. Based on the configurations, can you suggest a configuration to deploy vlan 800 with a VNI of 100800 to the fabric? Please use a multicast address of 239.0.0.80 and an IP address of 172.18.80.254/24 for the vlan interface.

Warning: there are non-text parts in the response: ['thought_signature'], returning concatenated text result from text parts. Check the full candidates.content.parts accessor to get the full model response.
Gemini: You're looking to deploy VLAN 800 as a Layer 3 VNI (L3VNI) with specific routing capabilities within your fabric. This involves assigning an IP address to the VLAN interface and associating it with a multicast group for BUM (Broadcast, Unknown-unicast, Multicast) traffic.

Based on the configurations of 'demo-lf1', 'demo-lf2', 'demo-lf3', and 'demo-border', and incorporating your requirements for VLAN 800 (VNI 100800, multicast address 239.0.0.80, and IP address 172.18.80.254/24 for the VLAN interface), here is the proposed configuration. This configuration aligns with how other routed VLANs (e.g., VLAN 50 and 100) are set up in your environment, using a multicast group for the L3VNI.

**Proposed Configuration for demo-lf1, demo-lf2, demo-lf3, and demo-border:**

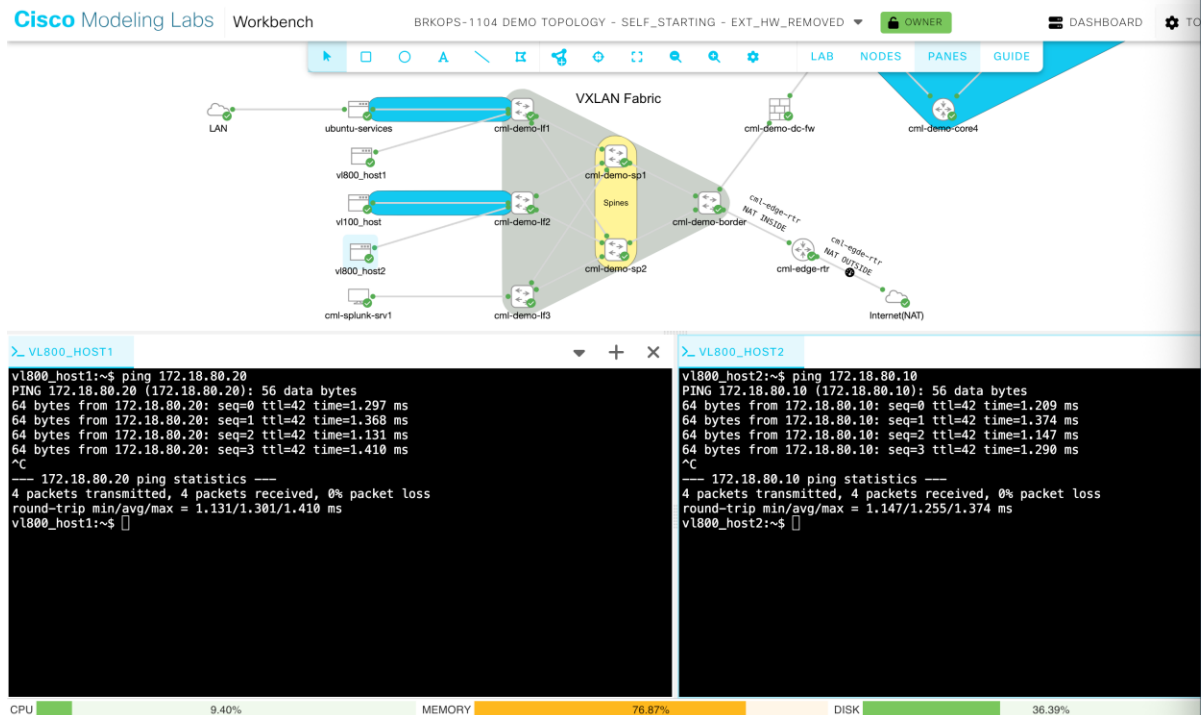
'''
l2vpn evpn instance 3 vlan-based
 encapsulation vxlan
!
vlan configuration 800
 member evpn-instance 3 vni 100800
!
vlan 800
 name New_VLAN_800
!
interface Vlan800
 vrf forwarding cml_demo
 ip address 172.18.80.254 255.255.255.0
 no autostate
!
interface nve1
 member vni 100800 mcast-group 239.0.0.80
'''

**Explanation of the Configuration:**

* **l2vpn evpn instance 3 vlan-based**: Defines a new EVPN instance (number 3) specifically for VLAN-based services. This instance number is currently unused across your devices.
* **encapsulation vxlan**: Specifies that VXLAN will be used as the encapsulation method for this EVPN instance.
* **vlan configuration 800**: Enters VLAN configuration mode for VLAN 800.
* **member evpn-instance 3 vni 100800**: Associates VLAN 800 with EVPN instance 3 and assigns it a Virtual Network Identifier (VNI) of 100800.
* **vlan 800**: Enters VLAN interface configuration mode for VLAN 800.
* **name New_VLAN_800**: Assigns a descriptive name to VLAN 800.
* **interface Vlan800**: Creates a Switched Virtual Interface (SVI) for VLAN 800.
* **vrf forwarding cml_demo**: Assigns this SVI to the 'cml_demo' Virtual Routing and Forwarding (VRF) instance. This means that routing for this VLAN will occur within the 'cml_demo' routing table.
* **ip address 172.18.80.254 255.255.255.0**: Assigns the specified IP address and subnet mask to the VLAN 800 interface, making it the default gateway for devices in VLAN 800 connected to these leaf switches.
* **no autostate**: Prevents the VLAN interface from automatically shutting down if no active access ports are assigned to it, which is good practice for SVIs acting as gateways.
* **interface nve1**: Enters the configuration mode for the Network Virtualization Edge (NVE) interface, which is responsible for VXLAN encapsulation and decapsulation.
* **member vni 100800 mcast-group 239.0.0.80**: Adds VNI 100800 to the NVE interface and associates it with
```

Deployed and configured. Automation + AI + CML

Your gateway to experimenting with LLMs



```
netadmin@ubuntu-services: ~/cml_ios_assistant

*Nov 4 21:23:53.536: %SEC_LOGIN-5-LOGIN_SUCCESS: Login Success [user: netadmin] [Source: 10.255.255.210] [localport: 22] at 21:23:53 UTC Tue Nov 4 2025
*Nov 4 21:23:53.536: %SSH-5-SSH2_USERAUTH: User 'netadmin' authentication for SSH2 Session from 10.255.255.210 (tty = 0) using crypto cipher 'aes128-ctr', hmac 'hmac-sha2-256-etm@openssh.com' Succeeded
CMD: 'terminal width 511' 21:23:53 UTC Tue Nov 4 2025
CMD: 'terminal length 0' 21:23:53 UTC Tue Nov 4 2025
CMD: 'show running-config' 21:23:53 UTC Tue Nov 4 2025
CMD: 'exit' 21:23:53 UTC Tue Nov 4 2025
*Nov 4 21:23:53.946: %SYS-6-LOGOUT: User netadmin has exited tty session 2(10.255.255.210)
*Nov 4 21:23:53.946: %SSH-5-SSH2_CLOSE: SSH2 Session from 10.255.255.210 (tty = 0) for user 'netadmin' using crypto cipher 'aes128-ctr', hmac 'hmac-sha2-256-etm@openssh.com' closed
*Nov 4 21:24:47.421: %SSH-5-SSH2_SESSION: SSH2 Session request from 10.255.255.210 (tty = 0) using crypto cipher 'aes128-ctr', hmac 'hmac-sha2-256-etm@openssh.com' Succeeded
*Nov 4 21:24:47.654: %SEC_LOGIN-5-LOGIN_SUCCESS: Login Success [user: netadmin] [Source: 10.255.255.210] [localport: 22] at 21:24:47 UTC Tue Nov 4 2025
*Nov 4 21:24:47.655: %SSH-5-SSH2_USERAUTH: User 'netadmin' authentication for SSH2 Session from 10.255.255.210 (tty = 0) using crypto cipher 'aes128-ctr', hmac 'hmac-sha2-256-etm@openssh.com' Succeeded
CMD: 'terminal width 511' 21:24:47 UTC Tue Nov 4 2025
CMD: 'terminal length 0' 21:24:47 UTC Tue Nov 4 2025
CMD: 'configure terminal' 21:24:47 UTC Tue Nov 4 2025
CMD: 'vlan configuration 800' 21:24:48 UTC Tue Nov 4 2025
CMD: 'member vni 100800' 21:24:48 UTC Tue Nov 4 2025
CMD: 'exit' 21:24:48 UTC Tue Nov 4 2025
CMD: 'vlan 800' 21:24:48 UTC Tue Nov 4 2025
CMD: 'name LLM_VLAN' 21:24:48 UTC Tue Nov 4 2025
CMD: 'exit' 21:24:48 UTC Tue Nov 4 2025
CMD: 'interface Vlan800' 21:24:48 UTC Tue Nov 4 2025
CMD: 'vrf forwarding cml_demo' 21:24:48 UTC Tue Nov 4 2025
CMD: 'ip address 172.18.80.254 255.255.255.0' 21:24:48 UTC Tue Nov 4 2025
CMD: 'no autostate' 21:24:48 UTC Tue Nov 4 2025
CMD: 'ip pim sparse-mode' 21:24:48 UTC Tue Nov 4 2025
CMD: 'exit' 21:24:48 UTC Tue Nov 4 2025
CMD: 'interface nve1' 21:24:48 UTC Tue Nov 4 2025
CMD: 'member vni 100800 mcast-group 239.0.0.80' 21:24:48 UTC Tue Nov 4 2025
CMD: 'end' 21:24:48 UTC Tue Nov 4 2025
*Nov 4 21:24:48.459: %SYS-5-CONFIG_I: Configured from console by netadmin on vty0 (10.255.255.210)
CMD: 'exit' 21:24:48 UTC Tue Nov 4 2025
*Nov 4 21:24:48.503: %SYS-6-LOGOUT: User netadmin has exited tty session 2(10.255.255.210)
*Nov 4 21:24:48.503: %SSH-5-SSH2_CLOSE: SSH2 Session from 10.255.255.210 (tty = 0) for user 'netadmin' using crypto cipher 'aes128-ctr', hmac 'hmac-sha2-256-etm@openssh.com' closed
*Nov 4 21:24:49.160: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan800, changed state to down
*Nov 4 21:27:44.282: %SSH-5-SSH2_SESSION: SSH2 Session request from 10.255.255.210 (tty = 0) using crypto cipher 'aes128-ctr', hmac 'hmac-sha2-256-etm@openssh.com' Succeeded
*Nov 4 21:27:44.514: %SEC_LOGIN-5-LOGIN_SUCCESS: Login Success [user: netadmin] [Source: 10.255.255.210] [localport: 22] at 21:27:44 UTC Tue Nov 4 2025
*Nov 4 21:27:44.514: %SSH-5-SSH2_USERAUTH: User 'netadmin' authentication for SSH2 Session from 10.255.255.210 (tty = 0) using crypto cipher 'aes128-ctr'
```

Additional Resources

- Cisco Live Lab Topology, documentation, and configurations
 - <https://github.com/roguerouter/CiscoLive-BRKOPS-1104-Lab>
- CML Free Tier!
 - <https://software.cisco.com/download/home/286193282/type/286326381/release/CML-Free>
- CML Resource Calculator
 - <https://www.cisco.com/c/dam/en/us/products/collateral/cloud-systems-management/modeling-labs/resource-calculator.xlsx>
- CML Documentation
 - <https://developer.cisco.com/docs/modeling-labs/>
- IOS-XE VXLAN Configuration Guide
 - https://www.cisco.com/c/en/us/td/docs/switches/lan/catalyst9300/software/release/17-15/configuration_guide/vxlan/b_1715_bgp_evpn_vxlan_9300_cg.html
- Cloud-Init configuration options (Ubuntu node)
 - <https://cloudinit.readthedocs.io/en/latest/>
- Free Splunk Learning Resources
 - https://www.splunk.com/en_us/training/free-courses/overview.html

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or via LinkedIn <https://www.linkedin.com/in/matt-Leuschner>

Thank you

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