

# NETWORKING IN THE CLOUD



Scott Taylor

Network Architect

**Internet2**



ipv6tech

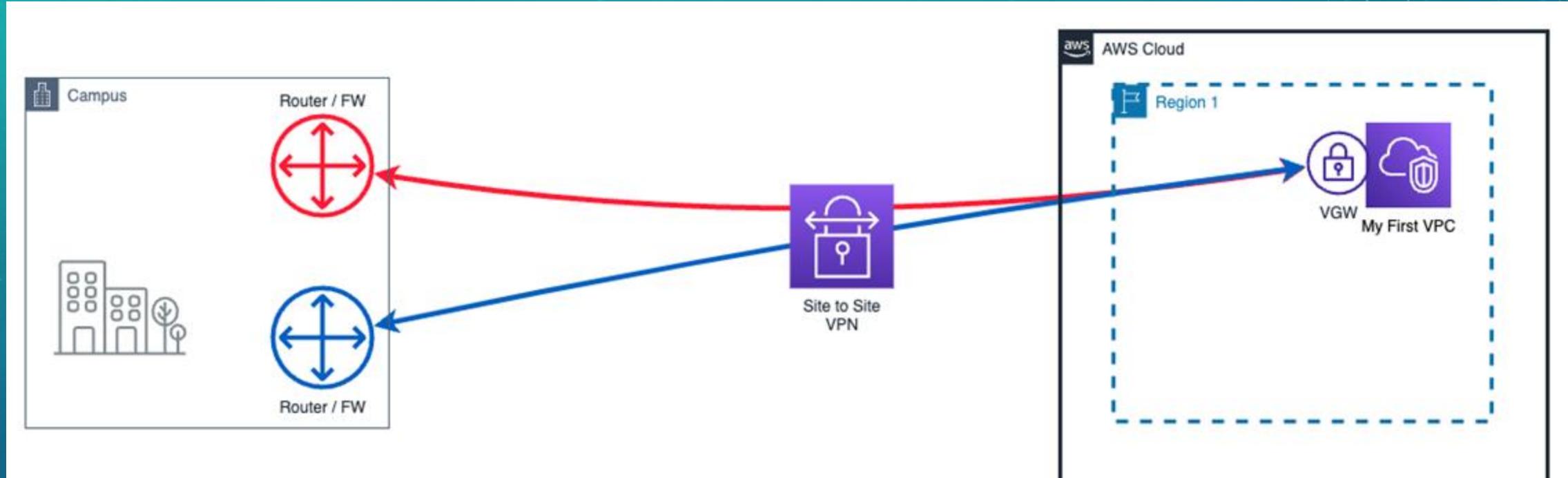


[staylor@internet2.edu](mailto:staylor@internet2.edu)

# HYBRID AND MULTICLOUD



# Hybrid



# Multicloud

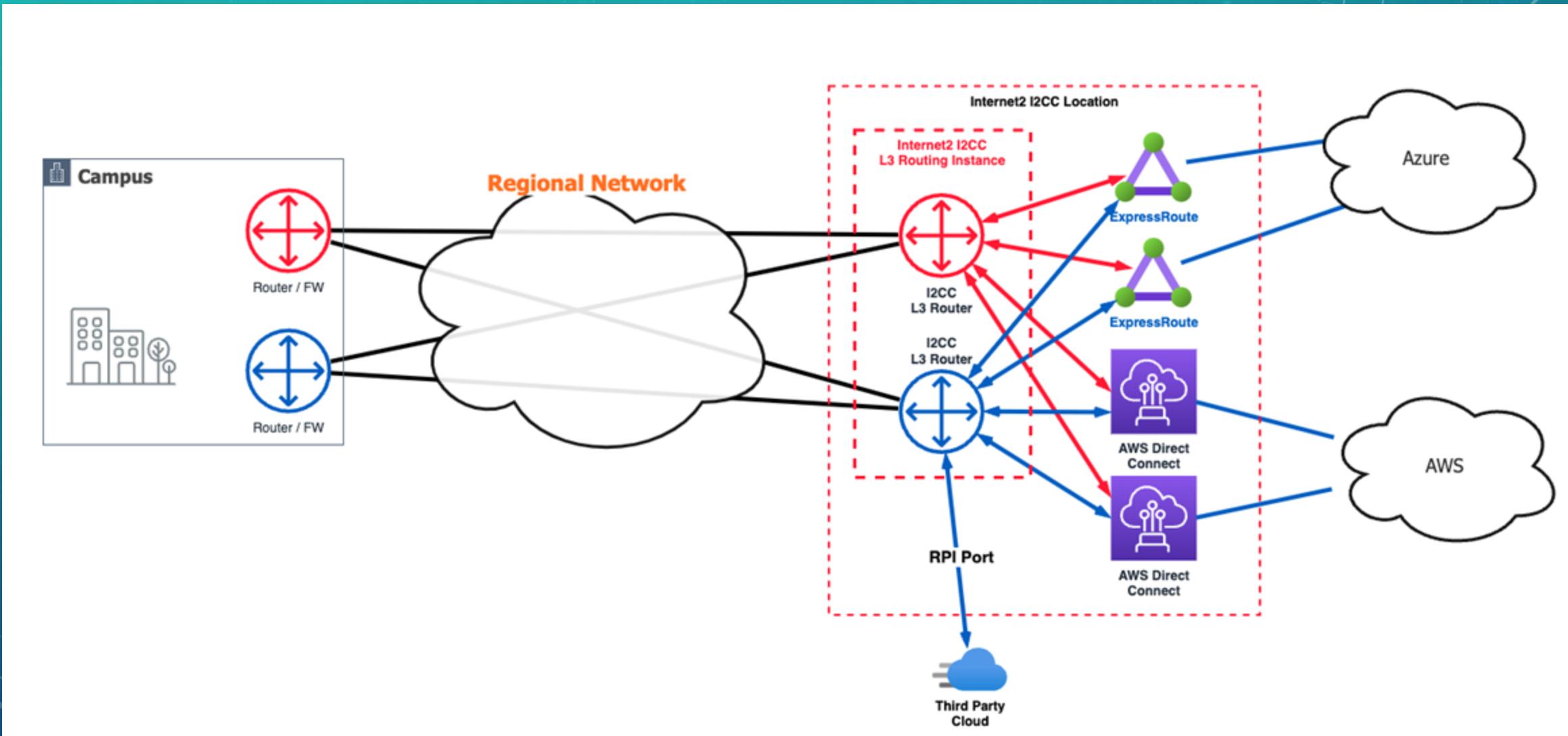
## Multicloud definition

Source: Google Cloud

Multicloud refers to using services from more than one public cloud provider at the same time. A multicloud environment allows your cloud environments to be private, public, or a combination of both.

The primary goal of a multicloud strategy is to give you flexibility to operate with the best computing environment for each workload.

# Multicloud



# INTERNET2 CLOUD CONNECT

## I2CC

# Internet2 Areas of Focus in Support of R&E



## COMMUNITY

Internet2 is a community providing network, cloud and identity solutions, as well as research support and services tailored for R&E.

---

Our trusted, secure network empowers higher education, research institutions, government entities and cultural organizations.

# Getting to the Cloud



## Internet2 Peer Exchange

**I2PX** Use of the community's existing 3Tbps of peering capabilities to the major cloud providers for access to cloud SaaS services (e.g., Zoom or Office 365)

## Internet2 Cloud Connect

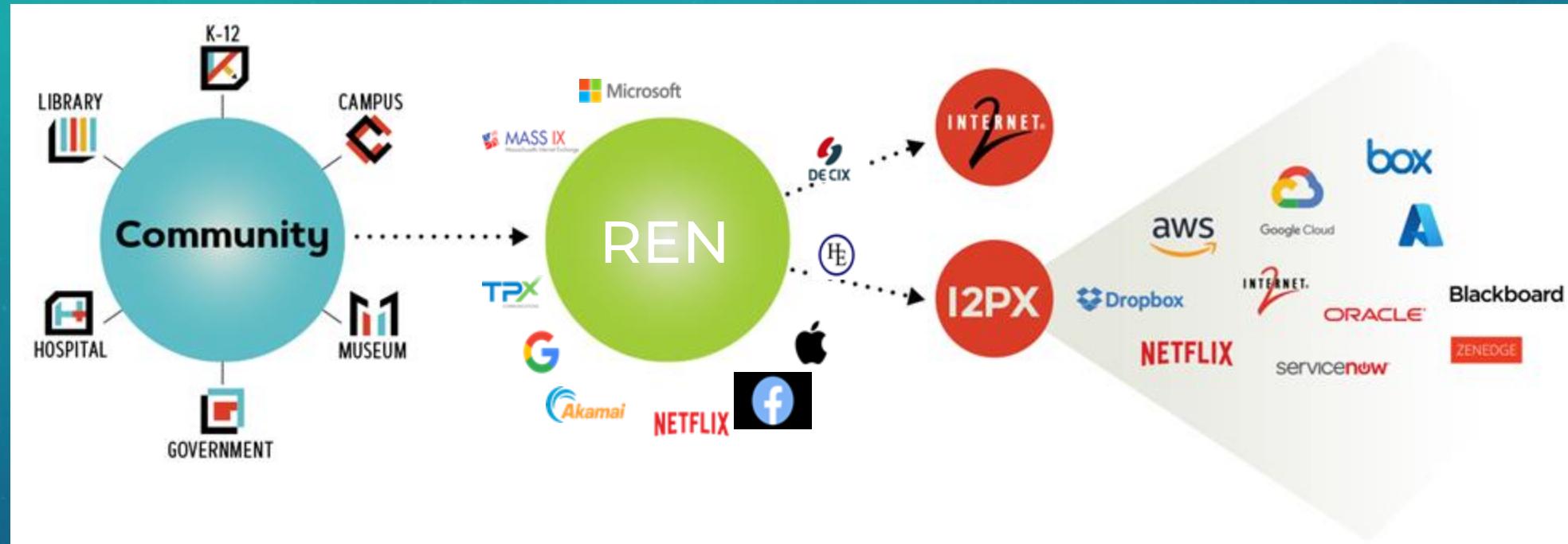
**I2CC** Enables members to use the Internet2 and their regional's infrastructure to obtain up to 5Gbps of "direct-connect" private Layer 2 and Layer 3 access to Amazon, Google, Microsoft, or Oracle cloud platforms at no additional fee. Extending your data center to the cloud. (Cloud provider fees apply)

## Internet2 Rapid Private Interconnect

**I2RPI** Provides private 10G interconnections at major peering points across the country at low annual rates. Leverages current investment in <regional network> and Internet2 infrastructures to reach cloud providers, for dedicated access or improved resiliency. May be used to connect to any commercial provider located at the peering point.

# DESIGNED FROM THE GROUND UP TO MEET THE R&E NEEDS

## Internet2 Peer Exchange I2PX



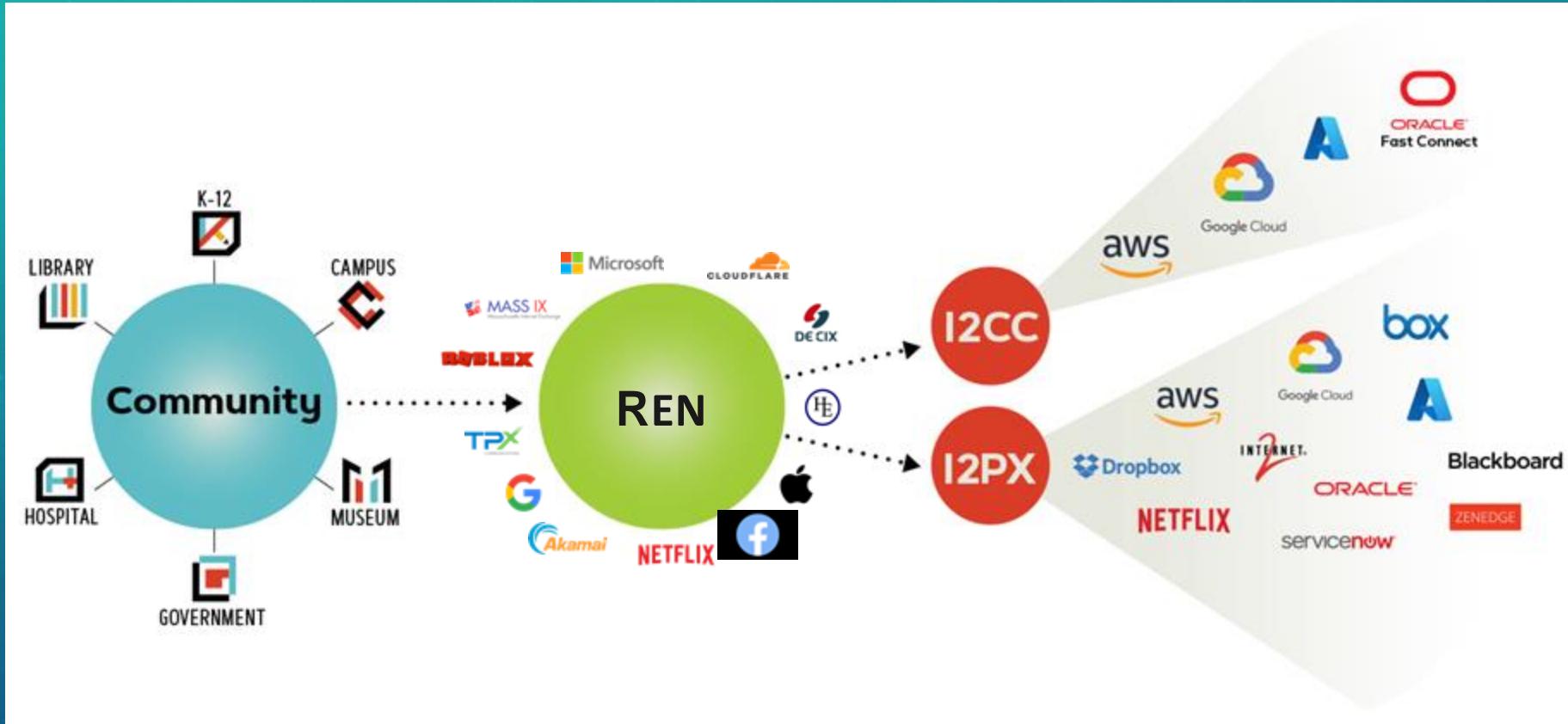
Allows REN to have high performing on-net access to cloud service providers, avoiding the commodity internet

Designed from the ground up to focus on hosting cloud providers most valued by the R&E community

Available to REN members today at no additional fee

# Leveraging R&E Networks for Direct Cloud Connections

## Internet2 Cloud Connect I2CC



REN members can connect at Layer 2 or Layer 3

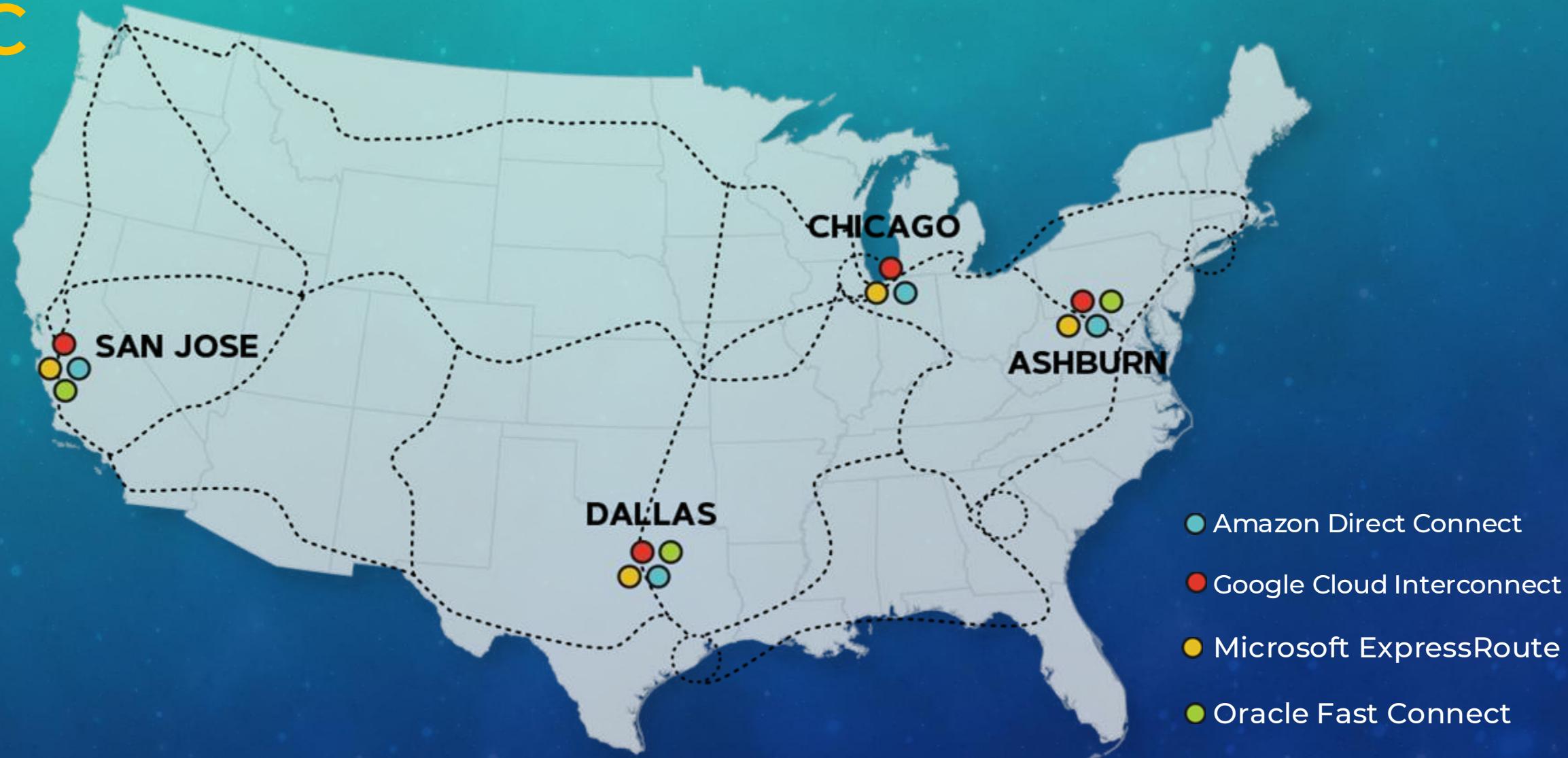
REN members can use Cloud Connect with up to 5Gbps connections to Amazon Direct Connect, Google Cloud Partner Interconnect, Microsoft Azure Express Route or Oracle FastConnect services

Available to REN members today at no additional fee

# Nationwide Connectivity

Internet2 Cloud Connect

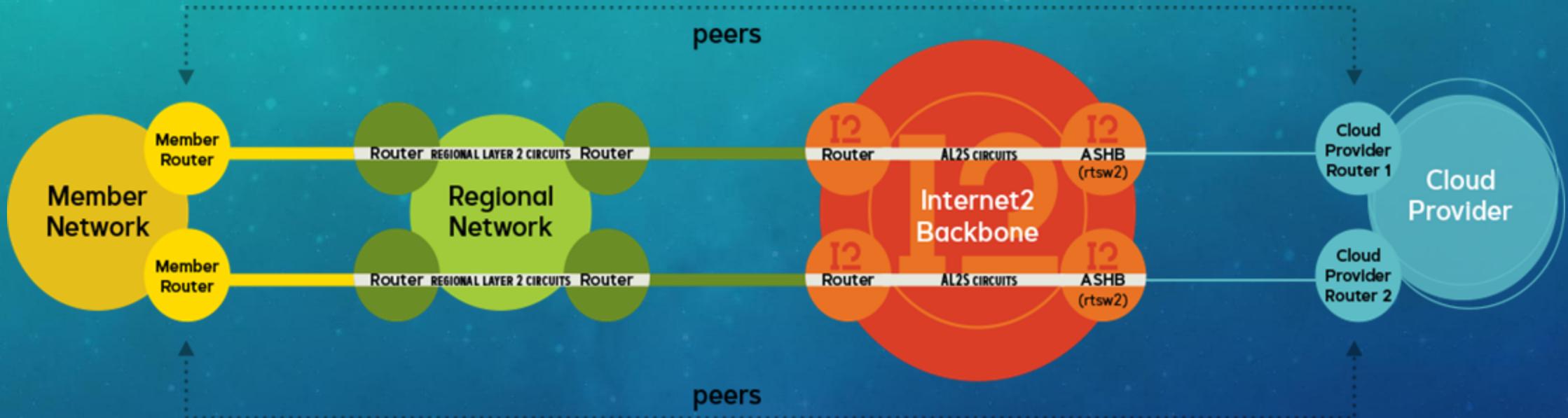
I2CC



# Layer 2 Connection Option

## Internet2 Cloud Connect

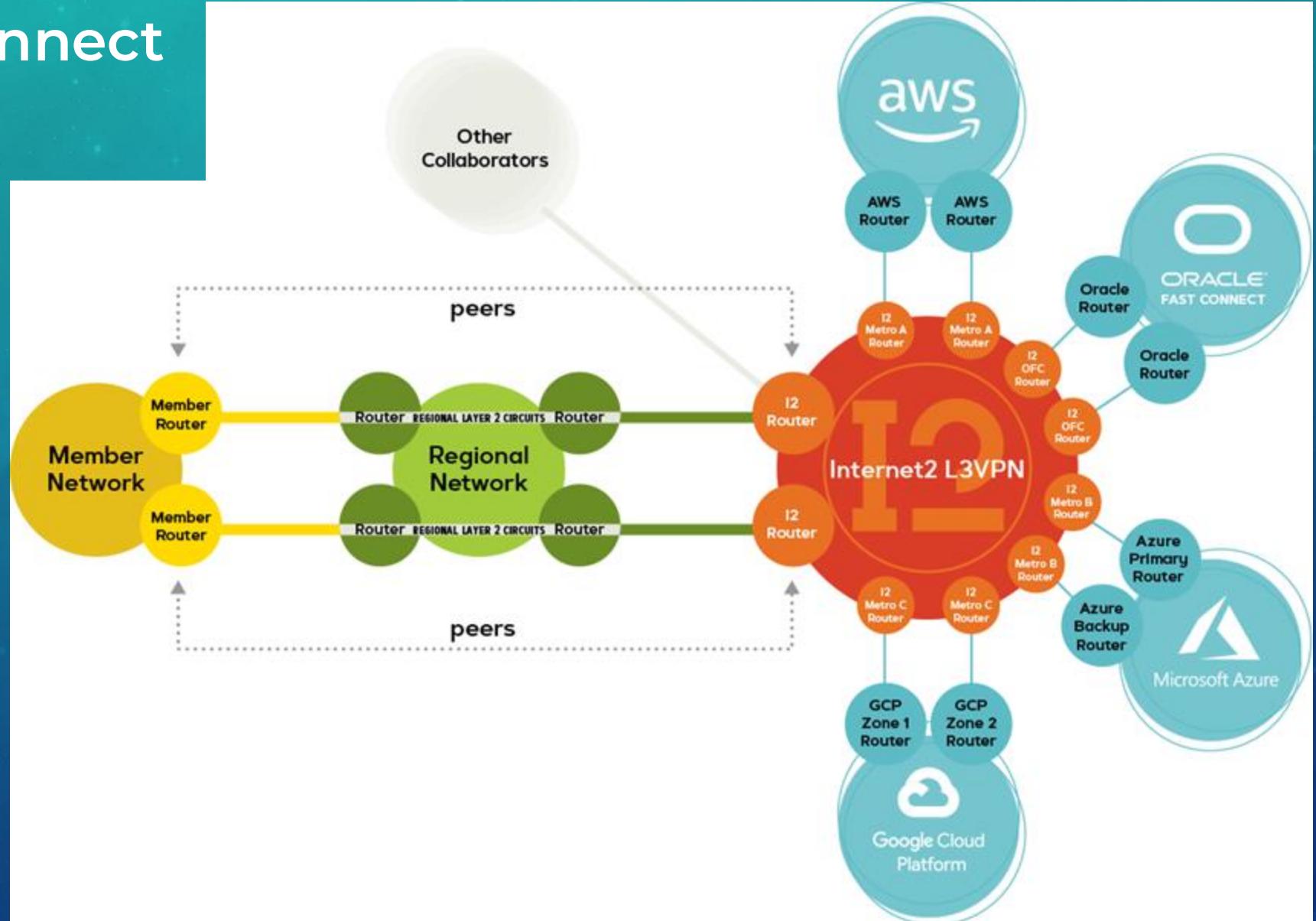
I2CC



# Layer 3 Connection Option

## Internet2 Cloud Connect

I2CC



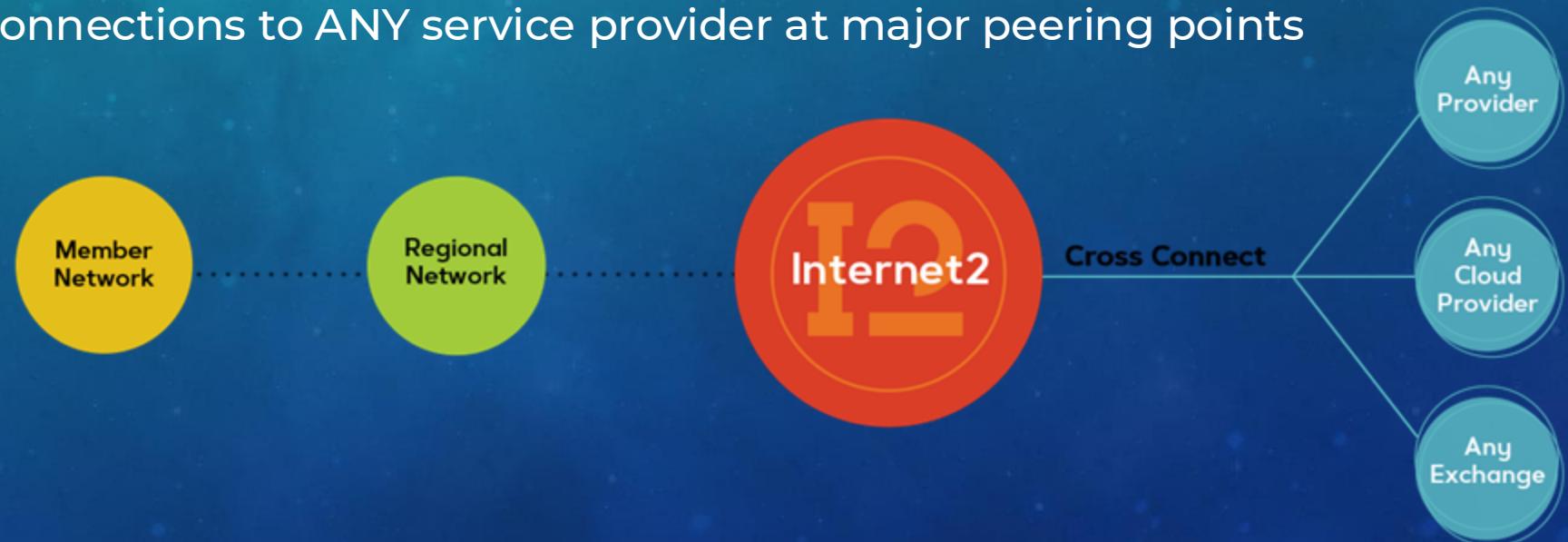
# Flexible Connections to Any Provider

## Internet2 Rapid Private Interconnect

### I2RPI

Available through Network Connectors for an additional fee

- Connect at Layer 2 or Layer 3
- Private 10G dedicated connections to Amazon Direct Connect, Google Cloud Interconnect, Microsoft Azure ExpressRoute, or Oracle Fast Connect services
- Private 10G dedicated connections to ANY service provider at major peering points



# Nationwide Connectivity

## Internet2 Rapid Private Interconnect

I2RPI can be used to provide private direct connects to any provider with some examples being 10G connections to SIP service providers, esports exchanges or other cloud providers.



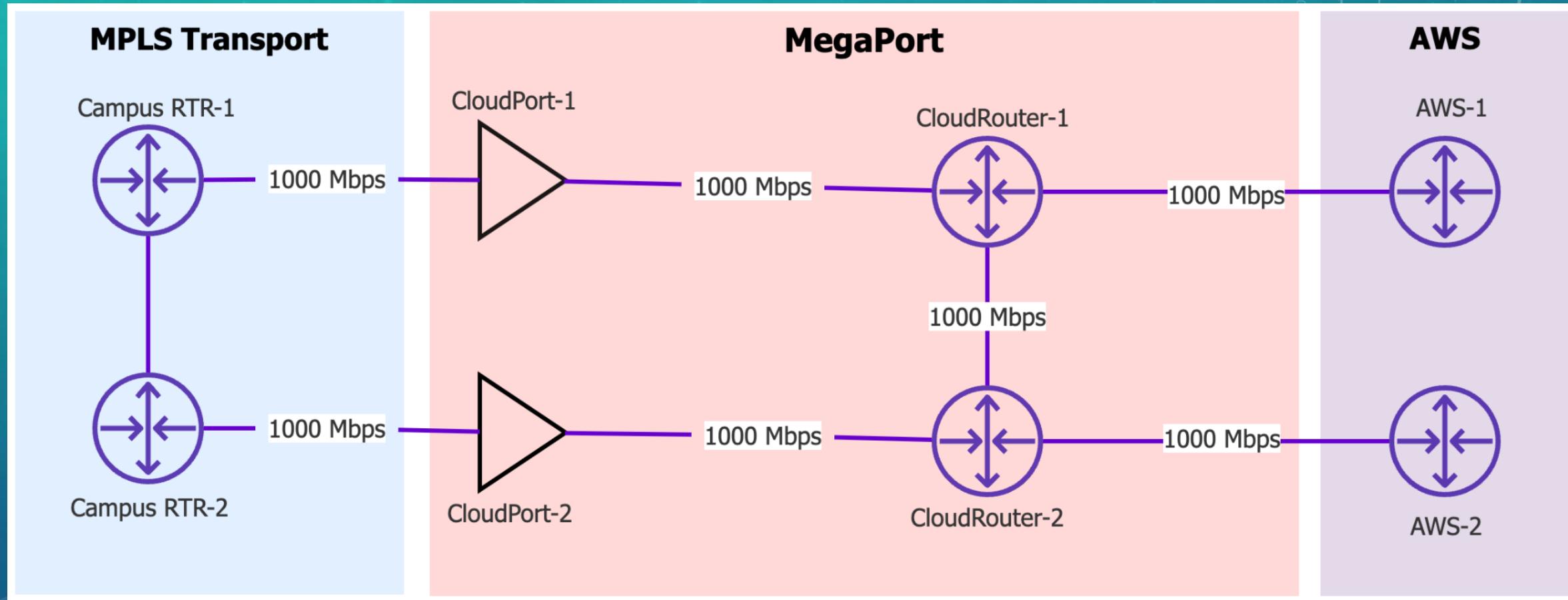
# WHY, HOW, AND WHEN TO USE I2CC

# Why, how, and when to use I2CC

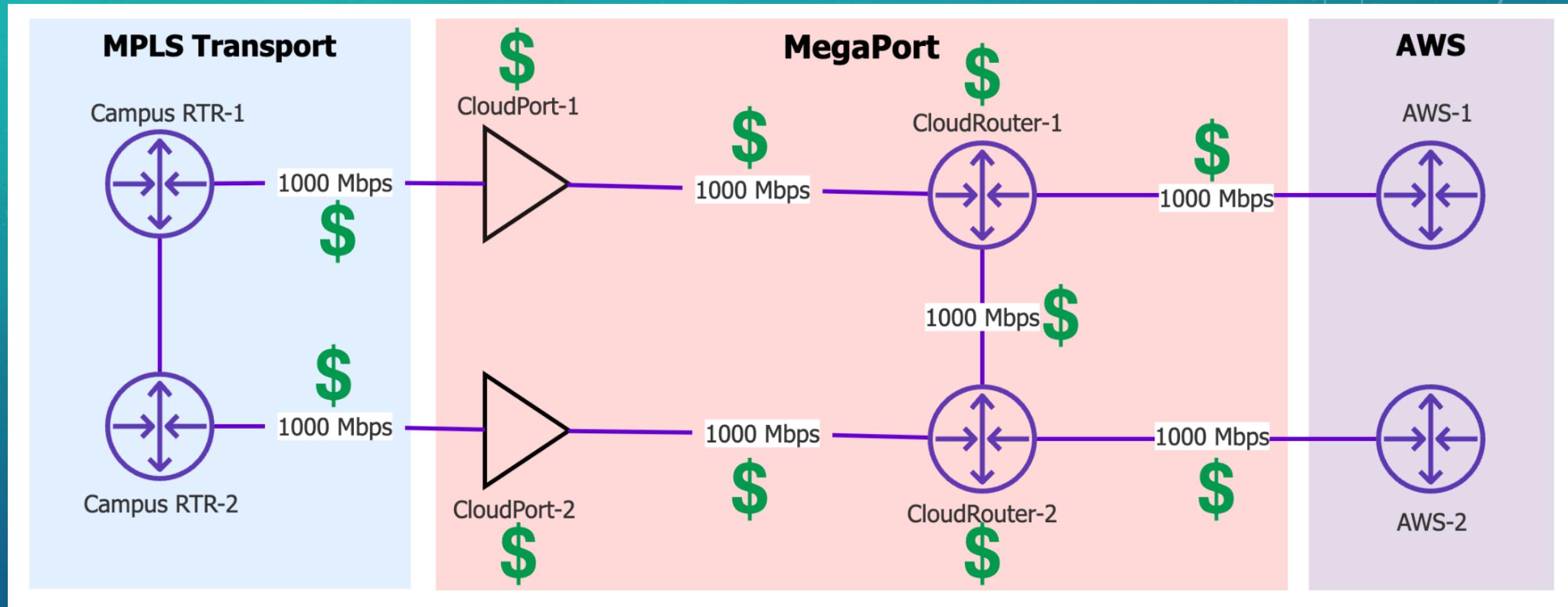
- Boost Network Performance
- Architect for Resiliency
- Simplify Connectivity
- Better Supportability
- Reduce Costs



# Reduce Costs

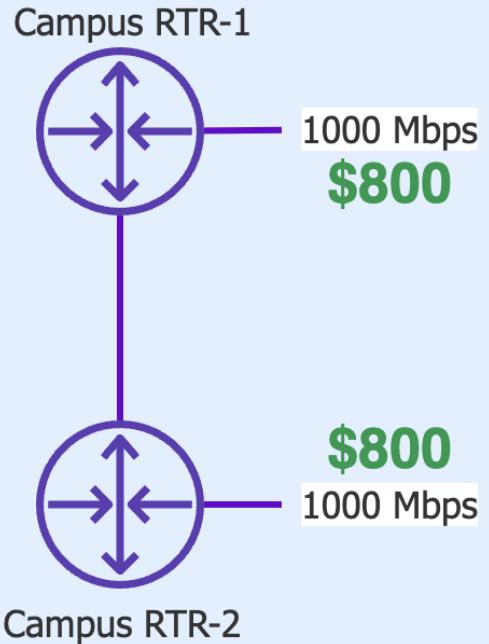


# Commercial Example



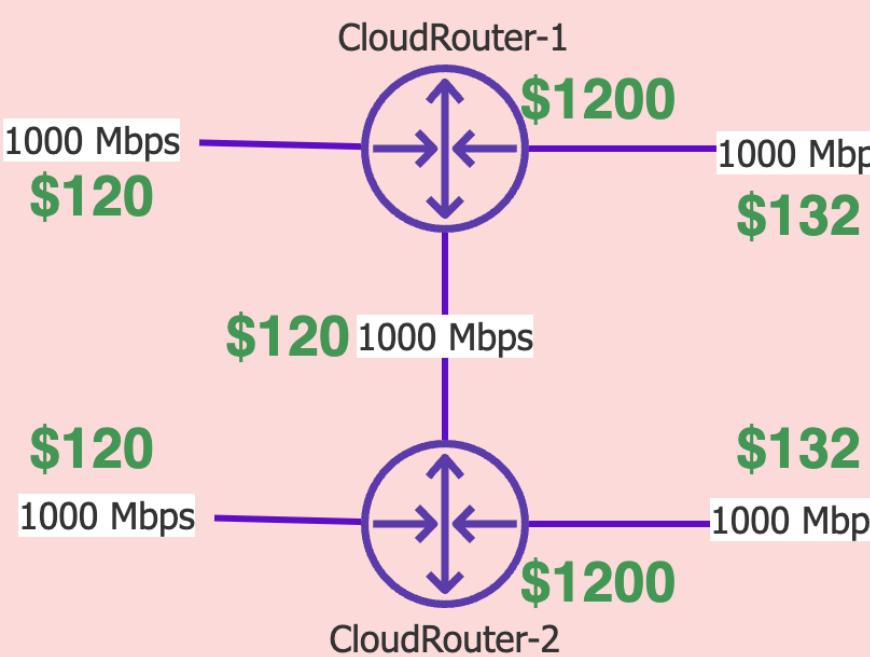
# Monthly Expense

## MPLS Transport



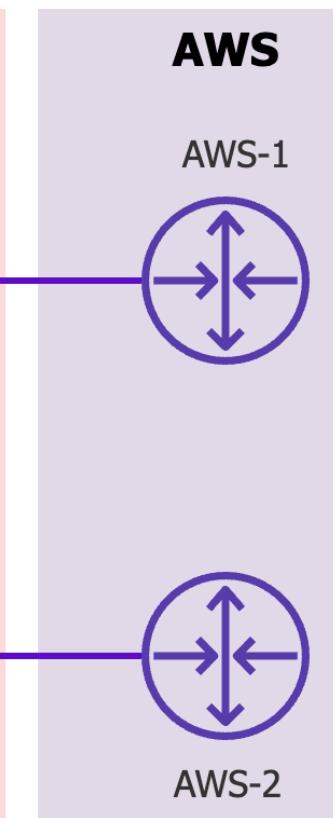
**Transport Monthly  
Expense = \$1600**

## MegaPort



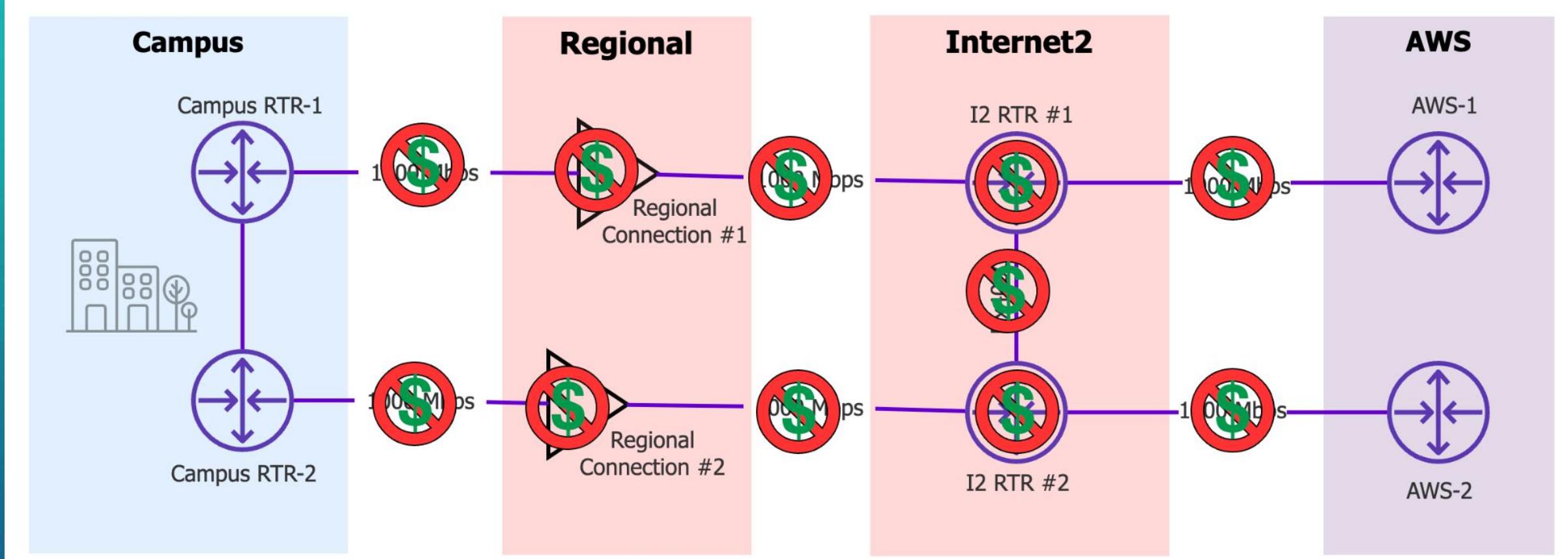
**Megaport Monthly  
Expense = \$4024**

## AWS



**Total Monthly  
Expense = \$5624**

# I2CC Monthly Savings



Total monthly saving: \$5,624

# INSIGHT CONSOLE OVERVIEW

# Internet2 Insight Console

## Sections covered

- **Community** – Organize child organizations and add users
- **Interfaces** – View interfaces or VLANs and delegate VLANs to other Orgs
- **Virtual Networks** – Configure new connections/services
- **Looking Glass** – Troubleshoot

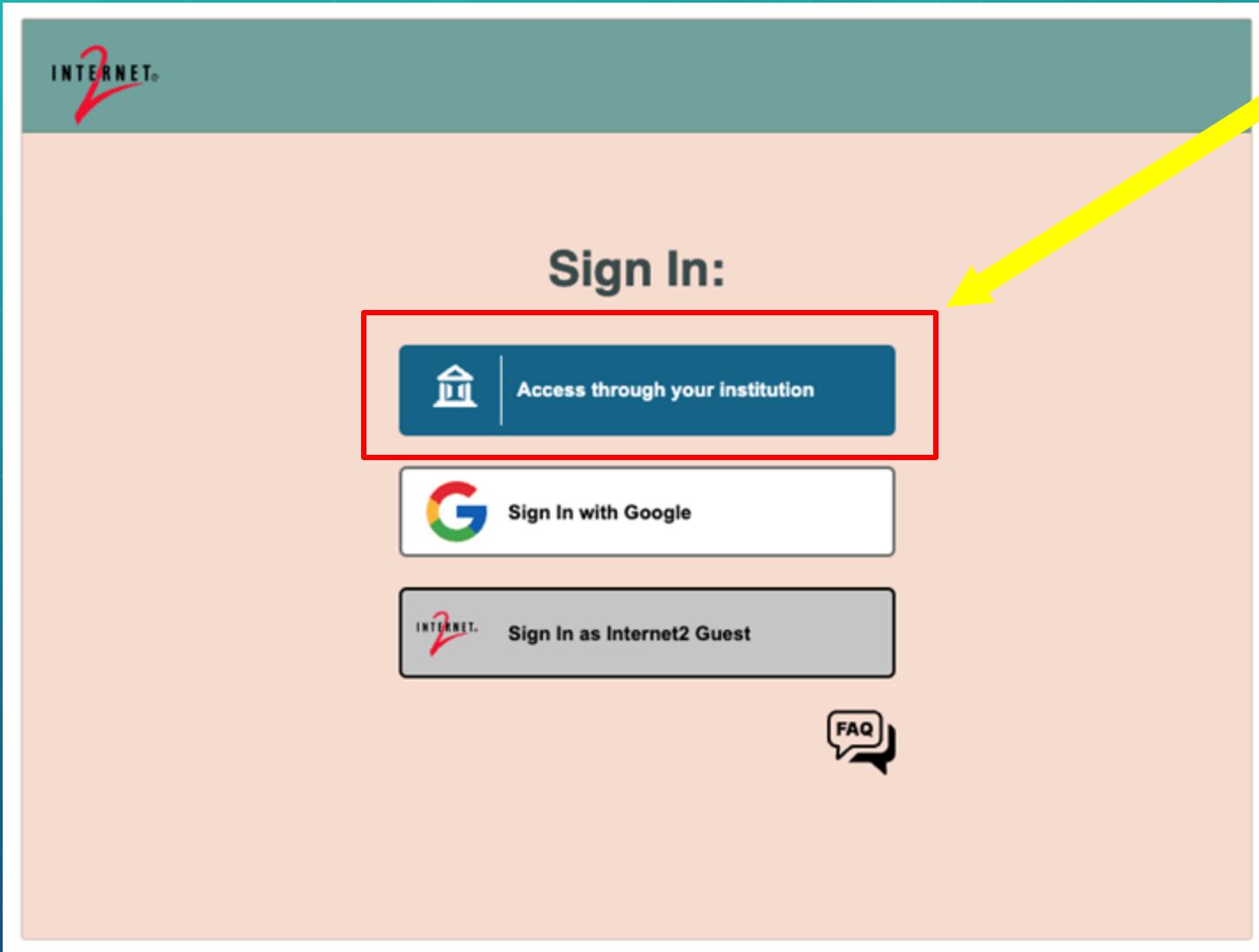
# Internet2 Insight Console

<https://console.internet2.edu/#/>

The screenshot shows the Internet2 Network map with several network paths highlighted in different colors (purple, red, yellow, green, blue) against a grayscale background map of North America. A vertical color scale on the left indicates path quality or utilization percentages from 0% to 100%. Below the map are several navigation and management links:

- Virtual Networks: Build private L3VPNs and L2VLANs
- Looking Glass: Run commands on Internet2 routers
- Interfaces: View stats and manage VLANs
- Community: Manage organizations and people
- Grafana: View statistics
- Network Operations Center: Service Requests, Ops Calendar
- Documentation: Learn how to use Insight Console

# Internet2 Insight Console



- Access through your institution is the preferred method.
- If your institution uses Incommon you'll likely have the ability to sign in.
- You might need Internet2 to create or move your institution into the correct hierarchical tree structure.

# Community

Organize child organizations and add users

Insight Console

Search Organizations and Virtual Networks

Home Virtual Networks Looking Glass Community Interfaces

Organizations

No organization selected

- NoX (Northern Crossroads)
  - American Antiquarian So...
  - Assumption College
  - Bay Path University
  - Bentley University
  - Berklee College
  - Boston College
  - Boston University
  - Bowdoin College
  - Brandeis University
  - CAP Maine
  - CAP Massachusetts
  - CAP New Hampshire
  - CAP Vermont
  - Champlain College
  - College of the Holy Cross
  - Community College Syst...
  - Dartmouth College

# Interfaces

The screenshot shows the 'Insight Console' interface with the 'Interfaces' tab selected. A yellow arrow points from the 'Interfaces owned by me' section to the 'NoX (Northern Crossroads)' interface entry. Another yellow arrow points from the 'Interfaces delegated to me' section to the 'NoX (Northern Crossroads)' interface entry. A third yellow arrow points from the 'NoX (Northern Crossroads)' interface entry in the 'Interfaces owned by me' section down to the 'VLAN Delegations' table.

**Interfaces owned by me**

- Harvard University (Platform) - HundredGigE0/0/0/24 (core1.bost2)
- NoX (Northern Crossroads) (Platform Interface) - HundredGigE0/0/0/24 (core2.newy32aoa)

**Interfaces delegated to me**

- NoX (Northern Crossroads) (Platform) - HundredGigE0/0/0/24 (core1.alba)
- NoX (Northern Crossroads) (Platform) - HundredGigE0/0/0/24 (core2.newy32aoa)

**NoX (Northern Crossroads) (Platform Interface)**

HundredGigE0/0/0/24  
core2.newy32aoa  
New York, NY

**Statistics**

core2.newy32aoa.net.internet2.edu - HundredGigE0/0/0/24

Graph showing traffic over time (May 17 to May 23):

- Input: 16.6 Gb/s Mean, 13.4 Gb/s Last, 29.2 Gb/s Max
- Output: 6.74 Gb/s Mean, 8.02 Gb/s Last, 48.5 Gb/s Max

**VLAN Delegations**

VLAN range start	VLAN range end	Delegated to
3521	3530	Harvard University

View interfaces or VLANs and delegate VLANs to other organizations

# VIRTUAL NETWORKS

Insight Console | Services | Search Organizations and Virtual Networks | Impersonate | Provide Feedback | Documentation | Scott Taylor |

Virtual Network Spaces / Space

**Virtual Network Space**

**Title** Azure ExpressRoute - Ashburn - DAS-BE...  
**Name** VNSPACE-10027  
**Owner** CEN (Connecticut Education Network)  
**Last Modified** 2023-10-27T21:13:16.101246+00:00 by OESS  
**Created** 2023-10-27T21:13:16.101240+00:00 by OESS  
**Virtual Space ID** 504f5084-49f0-4b5a-ac8a-e3fa5cb017c1  
**Notes**  
OESS Workgroup CEN;  
OESS L3VPN 3506;  
**Objects**  
Virtual Network Space  
VNROUTER-10027  
CEN (Connecticut Education Network)  
Microsoft  
Microsoft  
CEN (Connecticut Education Network)  
Microsoft  
Microsoft  
**Add**  
Add Virtual Router | Add Virtual Switch  
**Collaborators**

**CEN (Connecticut Education Network) ↗ Internet2 Hartford, CT**

**Connection** Live Details

**ASN** 65003 55038

**IPv6** Not configured Not configured

**IPv4** ✓ Up 10.199.254.1/30 10.199.254.2/30

**Internet2 Subinterface**  
HundredGigE0/0/0/25.752 on core1.hart2

Grafana



200 Mb/s  
0 b/s 03:00 06:00 09:00 12:00

core1.hart2.net.internet2.edu - HundredGigE0/0/0/25.752 - core1.hart2.net.internet2.edu - HundredGigE0/0/0/25.752 -

**Provisioning Status** Provisioned  
[2023-10-27T22:21:02+00:00] [NSO] [PROVISIONED]

**Microsoft Washington DC ↗ Internet2 Ashburn, VA**

**Connection** Live Details

**ASN** 12076 55038

**IPv6** Not configured Not configured

**IPv4** ✓ Up 192.168.100.254/30 192.168.100.253/30

**Internet2 Subinterface**  
TenGigE0/0/0/12/2.5005 on agg3.ashb

Grafana



100 Mb/s  
0 b/s 03:00 06:00 09:00 12:00

agg3.ashb.net.internet2.edu - TenGigE0/0/0/12/2.5005 - agg3.ashb.net.internet2.edu - TenGigE0/0/0/12/2.5005 -

**Provisioning Status** Provisioned  
[2023-10-27T22:21:13:16+00:00] [Azure] [PROVISIONED]  
[2023-10-27T22:21:02+00:00] [NSO] [PROVISIONED]

**Internet2 New York, NY ↗ CEN (Connecticut Education Network)**

**Connection** Live Details

**ASN** 55038 65002

**IPv6** Not configured Not configured

**IPv4** ✓ Up 10.199.254.6/30 10.199.254.5/30

**Internet2 Subinterface**  
Bundle-Ether200.3766 on core1.newy32aoa

Grafana



20 Mb/s  
0 b/s 03:00 06:00 09:00 12:00

# NETWORKING COMPONENTS

# Hosted v Dedicated Cloud Connections

The Internet2 Cloud Connect “*Hosted*” connections are often referred to as *Partner* or *Provider* connections

Feature	Hosted	Dedicated (RPI Interface)
Supported Cloud Service Providers (CSP)	<ul style="list-style-type: none"><li>AWS Hosted Connect</li><li>Google Cloud Partner Interconnect</li><li>Microsoft Azure Express Route</li><li>Oracle Cloud FastConnect (via I2CC)</li></ul>	<ul style="list-style-type: none"><li>AWS Dedicated Connect</li><li>Google Cloud Dedicated Interconnect</li><li>Microsoft Azure ExpressRoute Direct</li><li>Oracle Cloud FastConnect</li></ul>
Shared Port (with rate shaping)	Yes	No
Speeds	50 Mbps through 10 Gbps <i>(depends on the CSP)</i>	10 Gbps
Time to Provision	< 10 minutes <i>(depends on the CSP)</i>	Typically 72 hours or more <i>(could be up to 30 days)</i> <i>(depends on the CSP and colocation facility)</i>

# Best Practices

Build **dedicated** connections into each region that you have infrastructure

Leverage **redundant** connections in each region

Consider VPN for **backup** connectivity

Use **BGP** where possible for dynamic routing

Use **BFD** wherever possible for quicker failover (< 1-second)  
(typical default holdtime is 90 – 180 seconds)

# Why Layer 3

We came here to learn and play with networking and routing, right?

While we can build Layer 2 connections into the clouds at some point you need to configure Layer 3 addressing and routing to move bits around.

BGP is universally leveraged for dynamic routing

Static routes are universally leveraged for static routing

# IP Address Planning

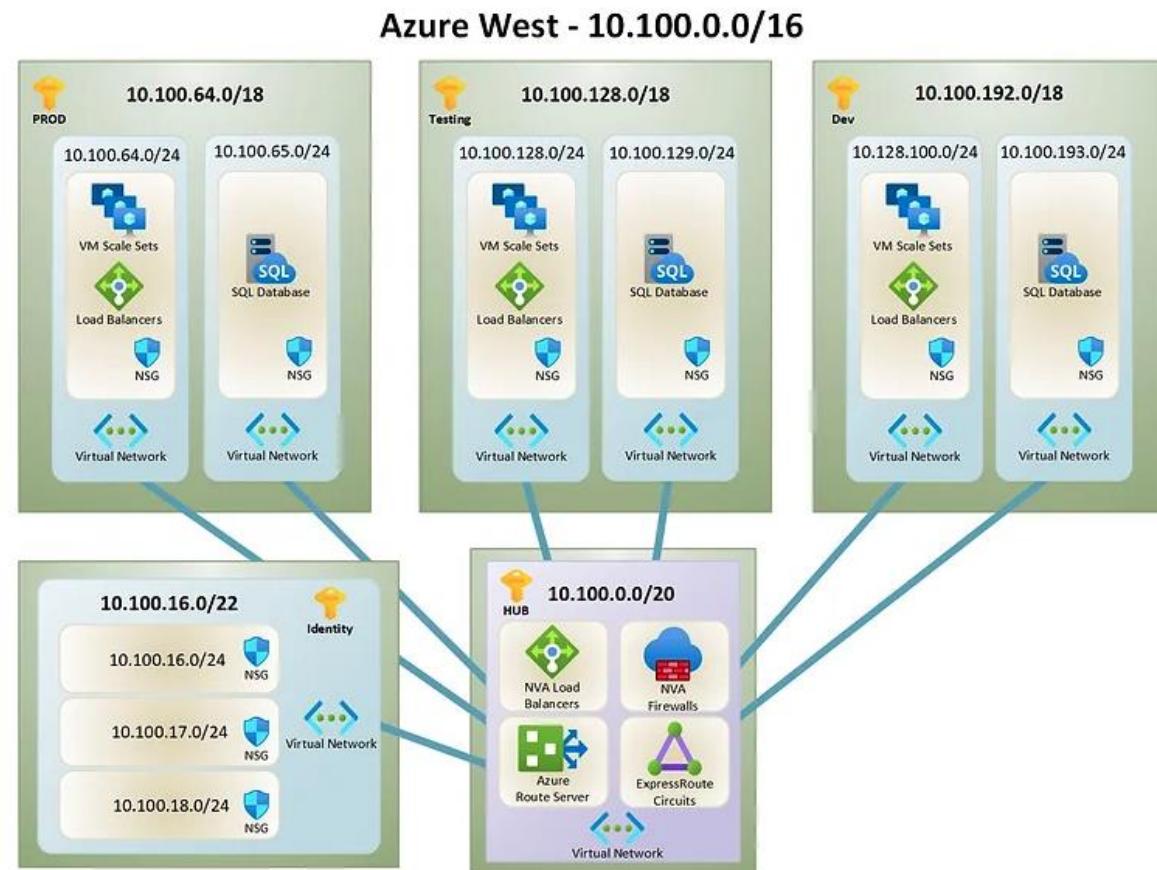
## IP Planning is critical !!!

- Ensure nonoverlapping address / CIDR ranges are used
- Don't use entire private CIDR ranges
- Plan and reserve space for future
- Fewer large virtual networks rather than multiple small virtual networks to prevent overhead
- Use IPv6 where possible
  - Gain experience
  - Future proof services
  - Same rules as above apply to IPv6 space

# IP Address Planning

## Private IPv4 addresses

RFC 1918 name	IP address range	Largest CIDR block (subnet mask)
24-bit block	10.0.0.0 – 10.255.255.255	10.0.0.0/8 (255.0.0.0)
20-bit block	172.16.0.0 – 172.31.255.255	172.16.0.0/12 (255.240.0.0)
16-bit block	192.168.0.0 – 192.168.255.255	192.168.0.0/16 (255.255.0.0)



## Identity-West-Vnet - 10.100.16.0/22

1. Production-DC-Subnet 10.100.16.0/24
2. Testing-DC-Subnet 10.100.17.0/24
3. Dev-DC-Subnet 10.100.18.0/24

## Identity-East-Vnet - 10.200.16.0/22

1. Production-DC-Subnet 10.200.16.0/24
2. Testing-DC-Subnet 10.200.17.0/24
3. Dev-DC-Subnet 10.200.18.0/24

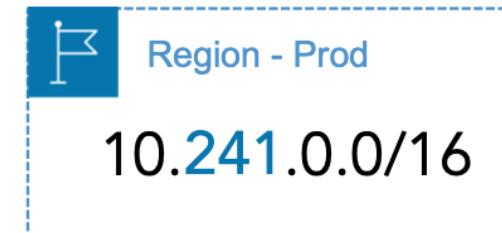
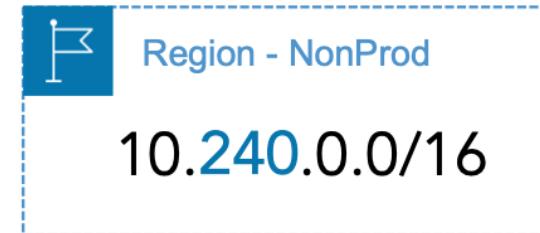
# IP Address Planning



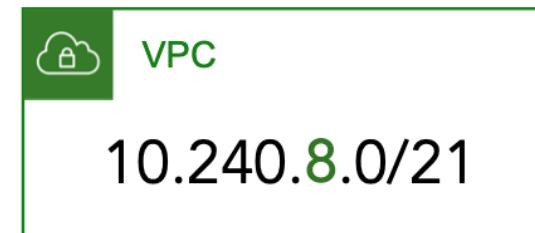
IP addressing  
still matters!



Even numbered  
**/16** allocated to all  
non-production



Odd numbered  
**/16** allocated to  
all production



3<sup>rd</sup> octet matches between  
NonProd and Prod VPCs.

```
> ipcalc 10.240.0.0/12
Address: 10.240.0.0
Netmask: 255.240.0.0 = 12
Wildcard: 0.15.255.255
=>
Network: 10.240.0.0/12
HostMin: 10.240.0.1
HostMax: 10.255.255.254
Broadcast: 10.255.255.255
Hosts/Net: 1048574
00001010.1111 0000.0000000.00000000
11111111.1111 0000.0000000.00000000
00000000.0000 1111.11111111.11111111
00001010.1111 0000.0000000.00000000
00001010.1111 0000.0000000.00000001
00001010.1111 1111.11111111.11111110
00001010.1111 1111.11111111.11111111
Class A, Private Internet
```

# ASN Planning

- Internet2 Cloud/Virtual Router to use ASN 55038
- Google Cloud Router to use ASN 16550 (*for partner interconnects*)
- Azure ExpressRoute to use ASN 12076
- Oracle FastConnect to use ASN 31898
- AWS DirectConnect to use a private ASN you configure << DANGER!

# ASN Planning

- ASN Planning is important especially as you enter multiple clouds and want to extend your private network or combine CSP's into a multicloud environment.
- Know your campus/data center ASN architecture
- Best practice to use a unique ASN for each Cloud Region
- Leverage private 16-bit and 32-bit ASNs
  - Private ASN ranges (RFC 6996): 64512 - 65534; 4200000000 - 4294967294

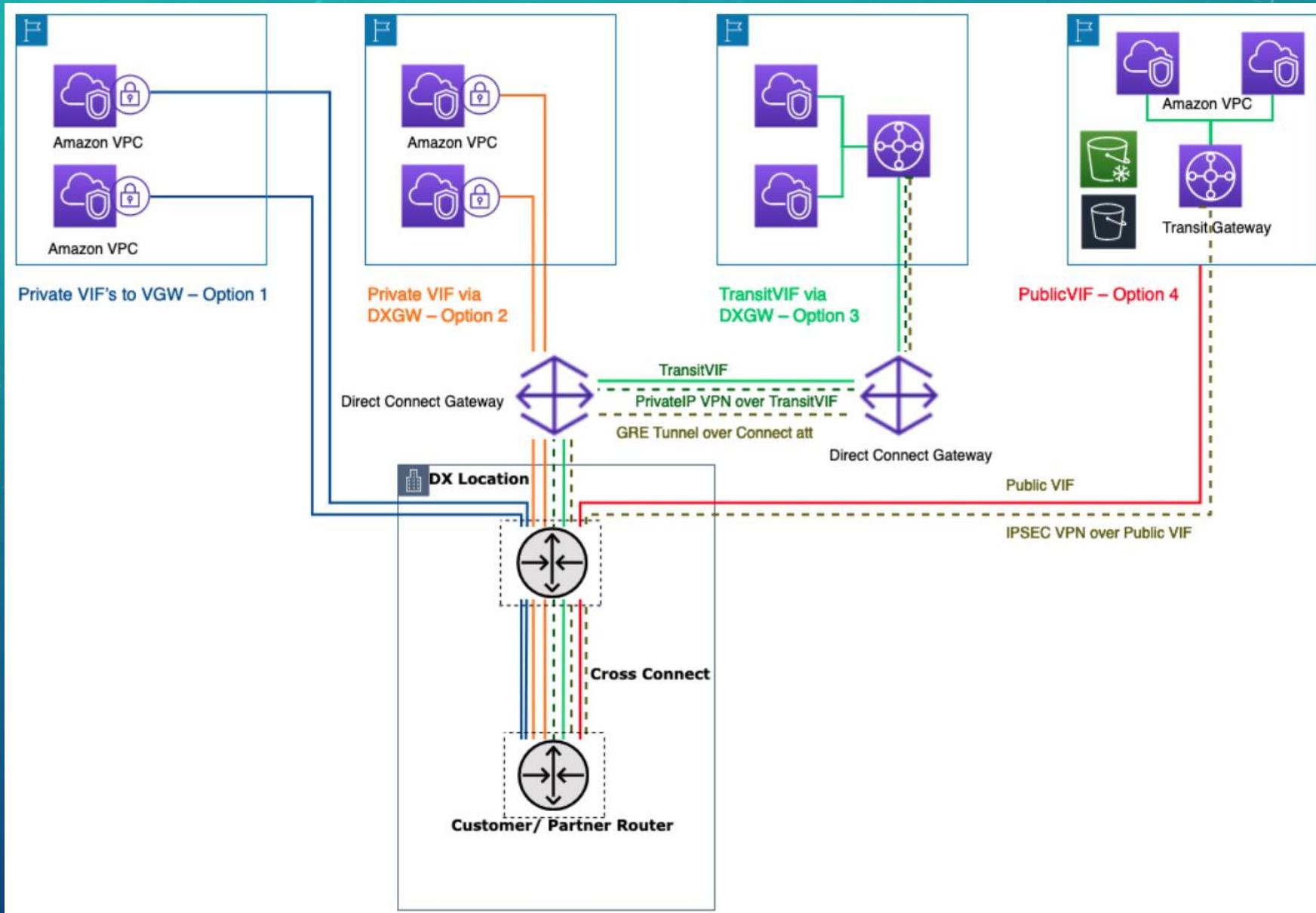
AWS connections start in Insight Console/Virtual Networks  
Accept the hosted connection in the AWS Console > AWS Direct Connect > Connections

- AWS services typically makes use of private ASN range 64512 – 65534

Specific Services:

- DXGW: ASN Range: 64512 – 65534
- VPG: ASN Default: 64512 (Custom allowed 64512 – 65534)
  - TGW: ASN Range: 64512 – 65534

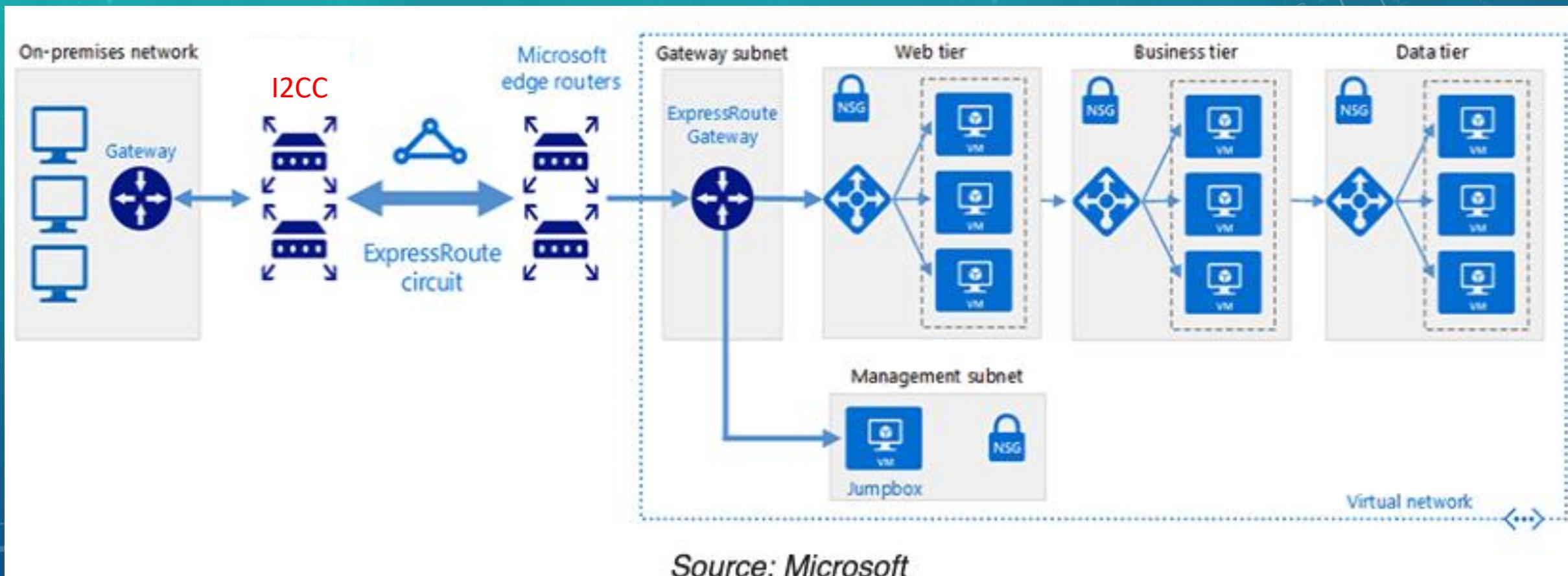
# AWS: Let me count the ways



# Azure

Azure connections start in the Azure portal

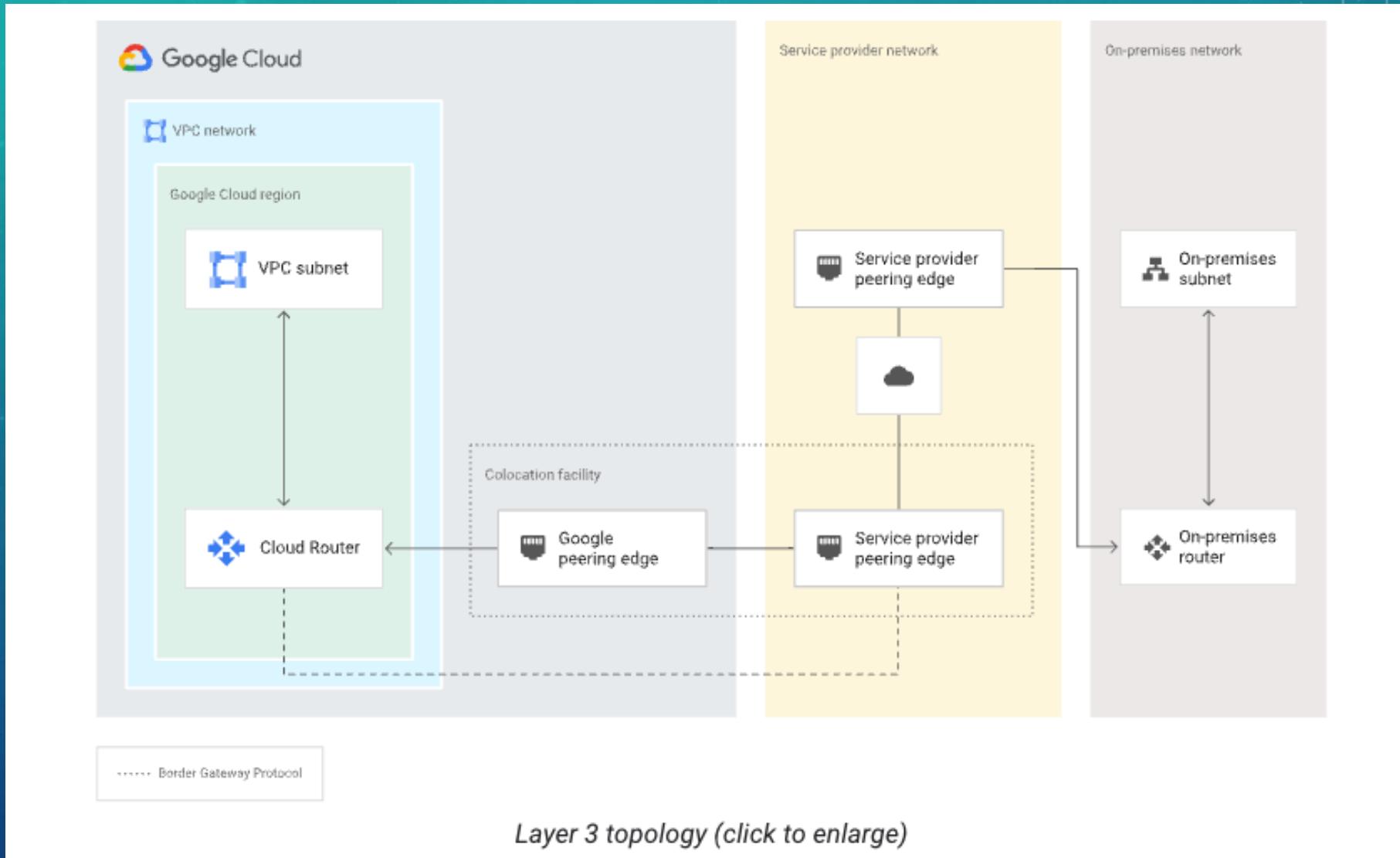
- Create a new ExpressRoute; copy the “SERVICE ID”
- Use service ID in Insight Console



Source: Microsoft

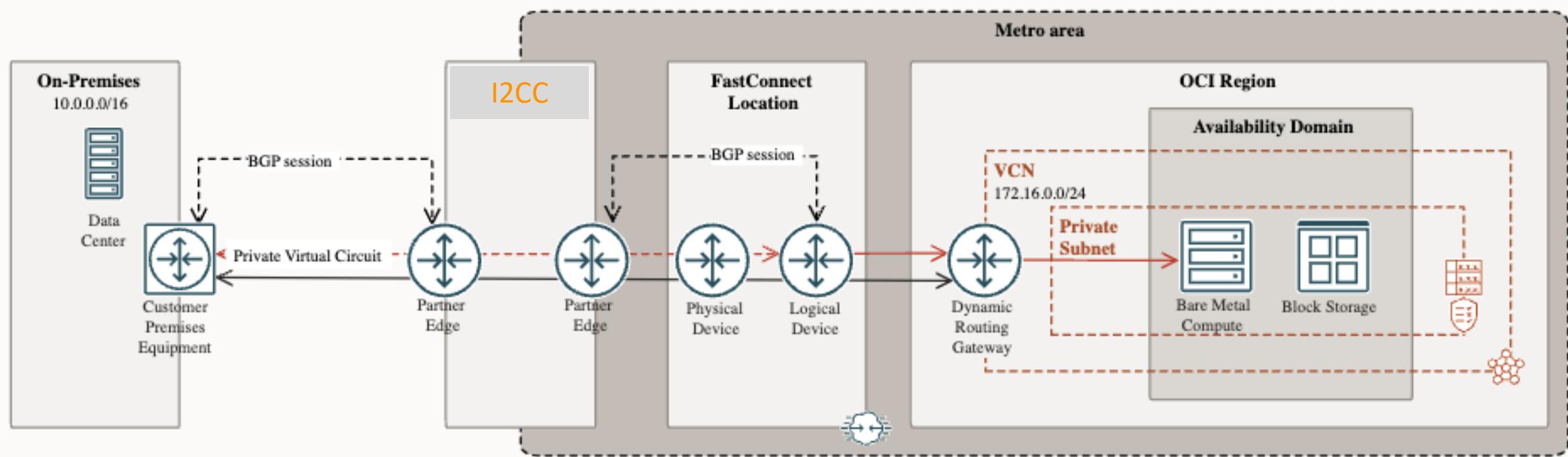
# Google Cloud

Google Partner Interconnect connections start in Google Cloud



# Oracle Cloud

Oracle FastConnect connections start in Oracle Cloud



# PREFIX LIMITS

## AWS Direct Connect

Private peering: Accepts up to 100 prefixes each for IPv4 and IPv6

Public peering: Accepts up to 1000 prefixes

BGP state goes to idle (BGP peering goes down)

## Azure Express Route

Private peering: Accepts up to 4000 prefixes

Public peering: Accepts up to 200 prefixes

BGP session is dropped

## Oracle FastConnect

Public peering: Accepts up to 200 prefixes

Private peering: Accepts up to 2000 prefixes

BGP session brought down?

## Google Cloud Interconnect/Cloud Router

Less straightforward, no published limits on Interconnect; limits exist on Cloud Router Important number to keep in mind is 250 prefixes

BGP doesn't go down instead uses deterministic route dropping behavior

# FOLLOW ALONG DEMONSTRATION

# CONCEPT

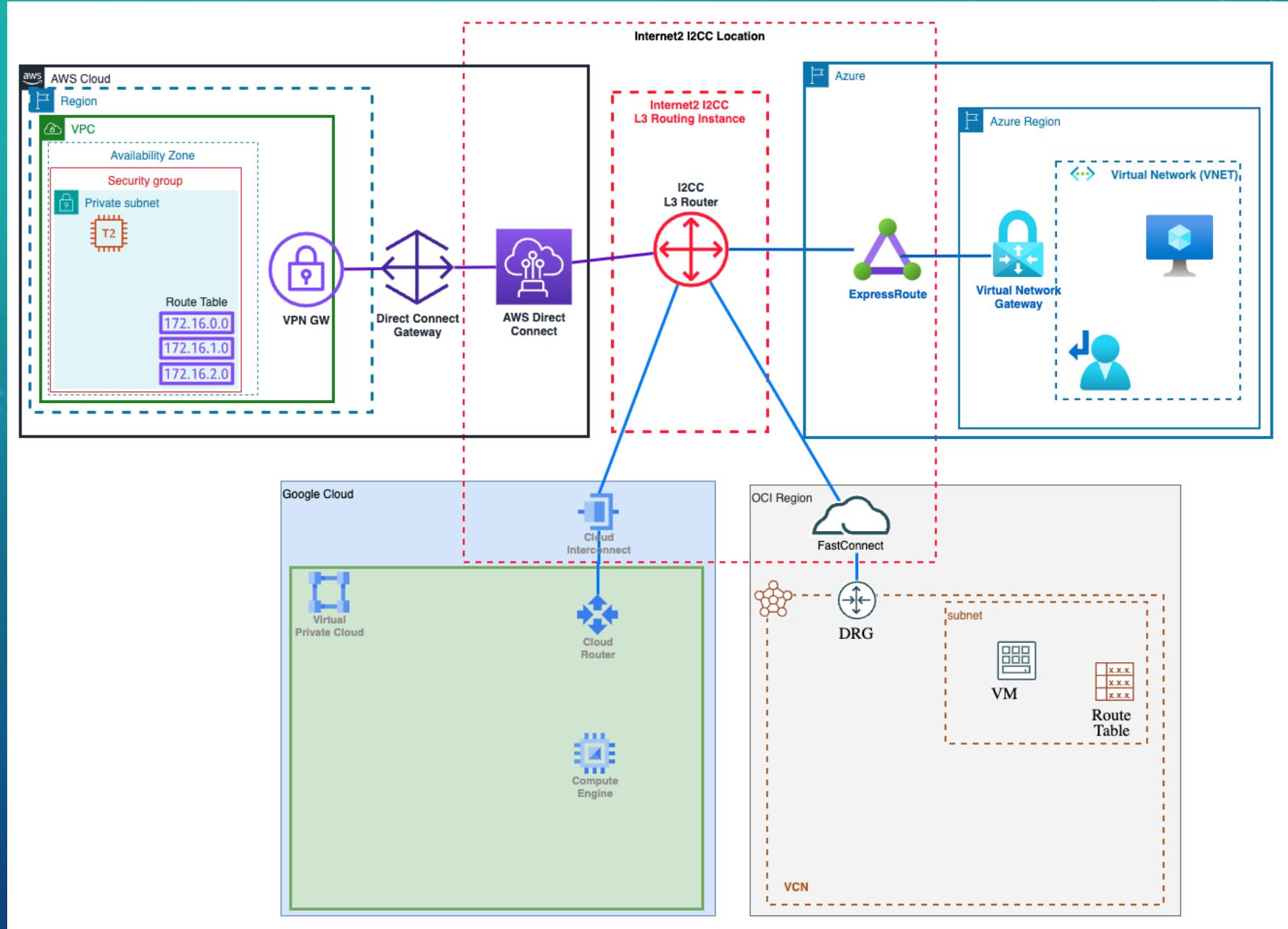
Leveraging Internet2 Cloud Connect we will establish private connections to the cloud service providers and learn how to inspect prefixes seen on the Internet2 Cloud Router.

- Private peerings
- Non-redundant connections
- Lowest bandwidth
- Internet2 Virtual Routers / Cloud Routers are a distributed resource and fully redundant.
  - It is not necessary to have more than one Internet2 Cloud Router

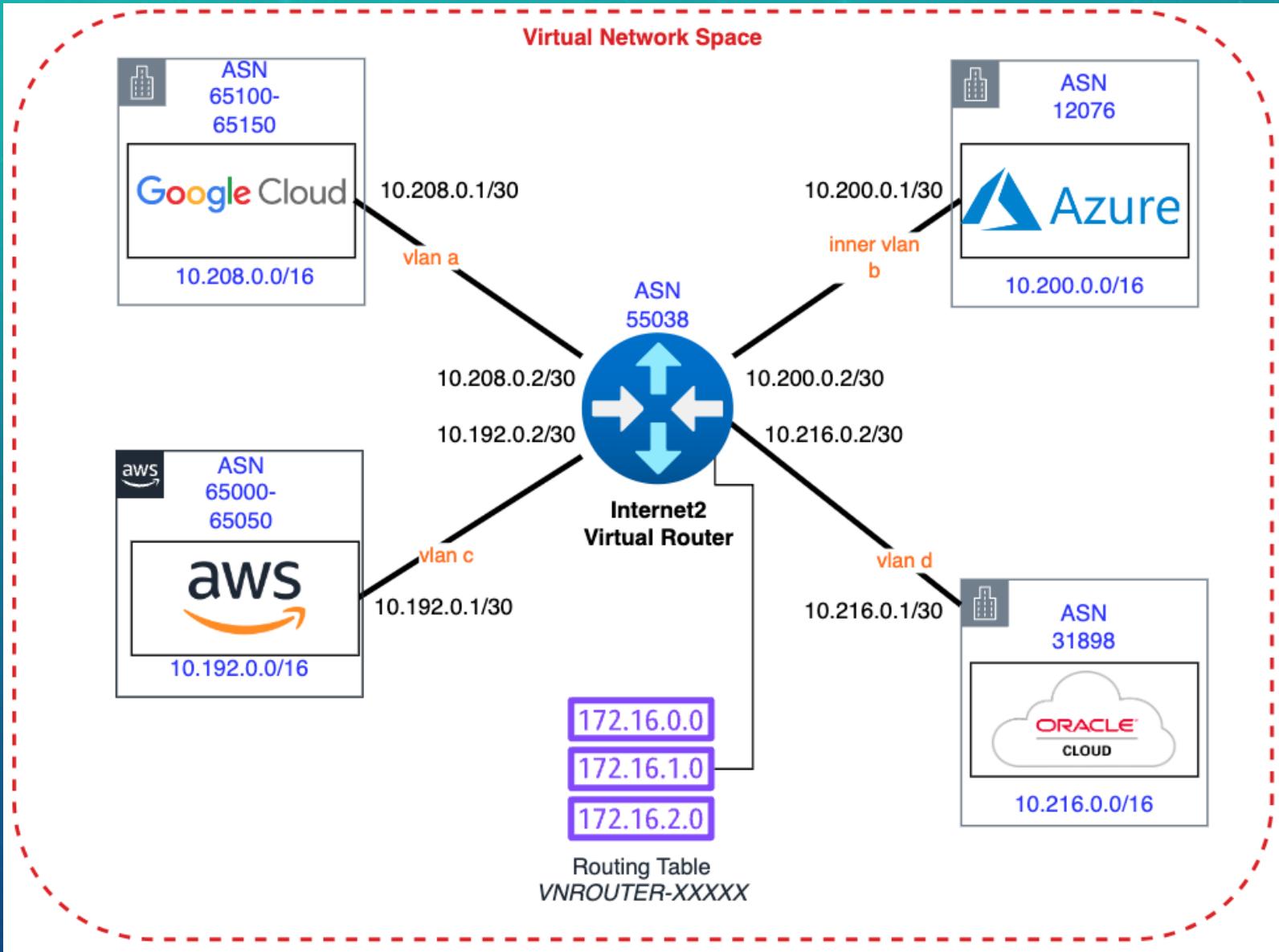
! Today you can't peer the Internet2 cloud routers together

IPv6 addressing is optional for our follow along

# Multicloud



# Address Plan



# Addressing

AWS VPC 10.192.0.0/16

Subnets

DX Peering: 10.192.0.0/30

TGW: 10.192.0.240/28

Public: 10.192.1.0/24

Azure VNET 10.200.0.0/16

Subnets

ER Peering: 10.200.0.0/30

VNG: 10.200.0.240/28

Public: 10.2.2.0/24

Google VPC 10.208.0.0/16

Subnets

Public: 10.208.1.0/24

Oracle VCN 10.216.0.0/16

Subnets

Public: 10.216.1.0/24

# Address Plan

## Visual Subnet Calculator

Network Address

10.192.0.0

Network Size

/ 10

✓

✓

Go Tools ▾



Subnet Address	Range of Addresses	Usable IPs	Hosts	Note	Split/Join
10.192.0.0/13	10.192.0.0 – 10.199.255.255	10.192.0.1 – 10.199.255.254	524286	AWS	/13
10.200.0.0/13	10.200.0.0 – 10.207.255.255	10.200.0.1 – 10.207.255.254	524286	Azure	/13
10.208.0.0/13	10.208.0.0 – 10.215.255.255	10.208.0.1 – 10.215.255.254	524286	Google Cloud	/13
10.216.0.0/13	10.216.0.0 – 10.223.255.255	10.216.0.1 – 10.223.255.254	524286	Oracle Cloud	/13
10.224.0.0/13	10.224.0.0 – 10.231.255.255	10.224.0.1 – 10.231.255.254	524286	FUTURE	/13
10.232.0.0/13	10.232.0.0 – 10.239.255.255	10.232.0.1 – 10.239.255.254	524286	FUTURE	/13
10.240.0.0/13	10.240.0.0 – 10.247.255.255	10.240.0.1 – 10.247.255.254	524286	FUTURE	/13
10.248.0.0/13	10.248.0.0 – 10.255.255.255	10.248.0.1 – 10.255.255.254	524286	FUTURE	/13

<https://visualsubnetcalc.com>

# AWS specific example

## Visual Subnet Calculator

Network Address		Network Size			
Subnet Address	Range of Addresses	Usable IPs	Hosts	Note	
10.192.0.0/30	10.192.0.0 – 10.192.0.3	10.192.0.1 – 10.192.0.2	2	AWS I2CR Network	/17
10.192.0.4/30	10.192.0.4 – 10.192.0.7	10.192.0.5 – 10.192.0.6	2		/18
10.192.0.8/29	10.192.0.8 – 10.192.0.15	10.192.0.9 – 10.192.0.14	6		/19
10.192.0.16/28	10.192.0.16 – 10.192.0.31	10.192.0.17 – 10.192.0.30	14		/20
10.192.0.32/27	10.192.0.32 – 10.192.0.63	10.192.0.33 – 10.192.0.62	30		/21
10.192.0.64/26	10.192.0.64 – 10.192.0.127	10.192.0.65 – 10.192.0.126	62		/22
10.192.0.128/26	10.192.0.128 – 10.192.0.191	10.192.0.129 – 10.192.0.190	62		/23
10.192.0.192/27	10.192.0.192 – 10.192.0.223	10.192.0.193 – 10.192.0.222	30		/24
10.192.0.224/28	10.192.0.224 – 10.192.0.239	10.192.0.225 – 10.192.0.238	14		/25
10.192.0.240/28	10.192.0.240 – 10.192.0.255	10.192.0.241 – 10.192.0.254	14	AWS TGW Subnet	/26
10.192.1.0/24	10.192.1.0 – 10.192.1.255	10.192.1.1 – 10.192.1.254	254	AWS Public Subnet	/27
10.192.2.0/23	10.192.2.0 – 10.192.3.255	10.192.2.1 – 10.192.3.254	510		/28
10.192.4.0/22	10.192.4.0 – 10.192.7.255	10.192.4.1 – 10.192.7.254	1022		/29
10.192.8.0/21	10.192.8.0 – 10.192.15.255	10.192.8.1 – 10.192.15.254	2046		/30
10.192.16.0/20	10.192.16.0 – 10.192.31.255	10.192.16.1 – 10.192.31.254	4094		
10.192.32.0/19	10.192.32.0 – 10.192.63.255	10.192.32.1 – 10.192.63.254	8190		
10.192.64.0/18	10.192.64.0 – 10.192.127.255	10.192.64.1 – 10.192.127.254	16382		
10.192.128.0/17	10.192.128.0 – 10.192.128.1	10.192.128.1 – 10.192.128.2	32766		

# Insight Console Access

Everyone registered was added to a workshop Organization

Navigate to <https://console.internet2.edu>

Under *Virtual Networks* search for **class-workshop**

# Insight Console Access

Suggest that everyone create a new **Virtual Network Space**

Create a **router** in your network space

We do not have a mock campus environment for this hand-on lab

# LOOKING GLASS

## TIPS & TRICKS

# Looking Glass Tip & Tricks

- 1 Bookmark your query so you can quickly return and re-run the same query

The screenshot shows the "Looking Glass | Insight Console" window. The URL in the address bar is highlighted with a yellow box: `https://console.internet2.edu/#/looking-glass?command=show+bgp+vrf+I2PX+neighbor+198.71.47.247+routes&nodes=core1.hart2`. The main content area displays the output of the command `show bgp vrf I2PX neighbor 198.71.47.247 routes`. On the left, there is a list of nodes under the heading "Core Router". The node `core1.hart2` is selected (indicated by a checked checkbox) and highlighted with a yellow box. Other nodes listed include `core1.houh`, `core1.hous`, `core1.indi`, `core1.jack`, `core1.jcsn`, and `core1.kans`. The right pane shows the detailed BGP route information for the selected node.

```
Nodes selected: 1 show bgp vrf I2PX neighbor 198.71.47.247 routes

core1.hart2 > show bgp vrf I2PX neighbor 198.71.47.247 routes

Tue Apr 30 13:14:44.560 UTC
BGP VRF I2PX, state: Active
BGP Route Distinguisher: 163.253.0.7:8
VRF ID: 0x60000002
BGP router identifier 163.253.0.7, local AS number 11537
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000002 RD version: 2591868684
BGP main routing table version 2591869012
BGP NSR Initial initSync version 6697447 (Reached)
BGP NSR/ISSU Sync-Group versions 0/0

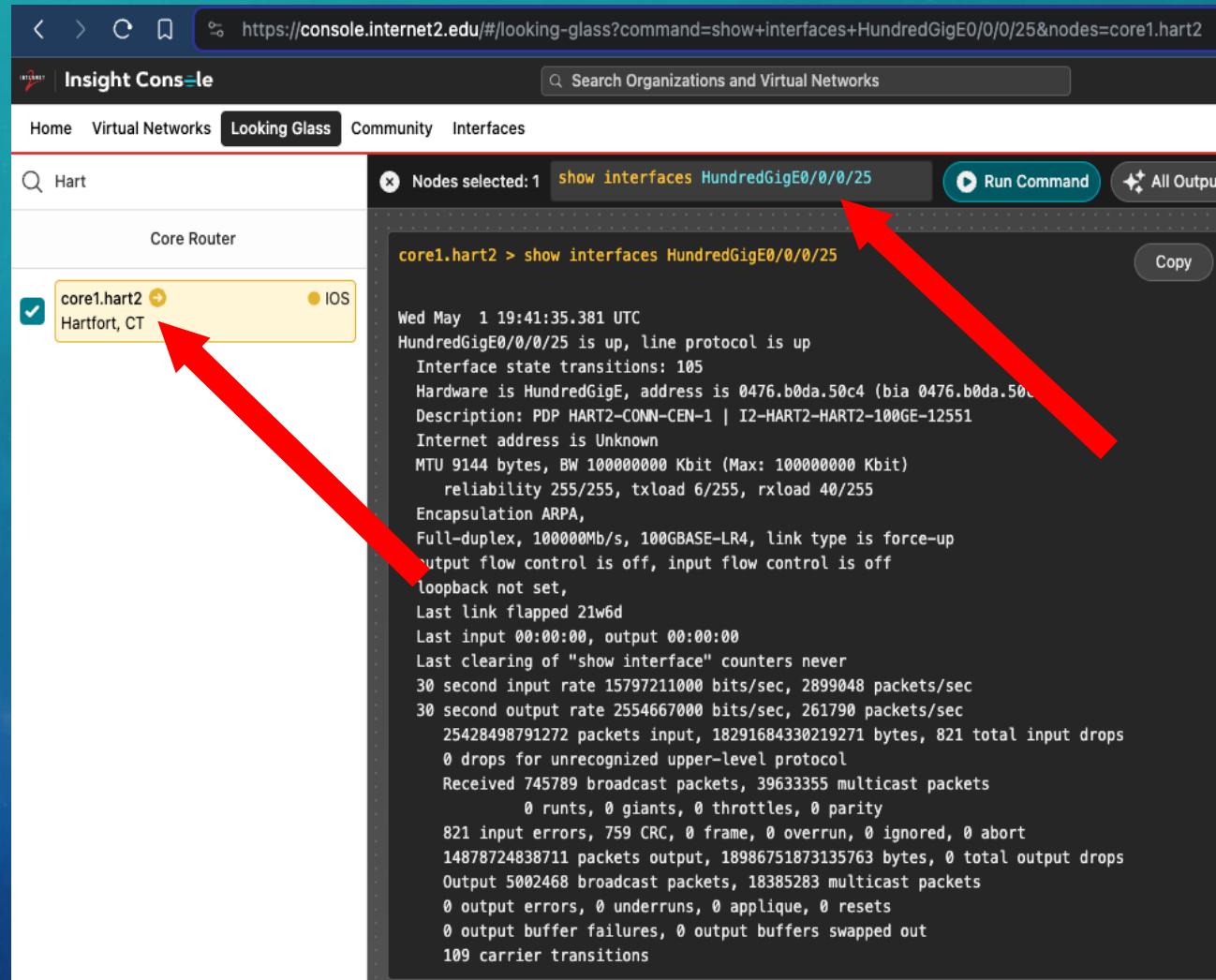
Status codes: s suppressed, d damped, h history, * valid, > best
               i - internal, r RIB-failure, S stale, N Nexthop-discard
Origin codes: i - IGP, e - EGP, ? - incomplete
Network          Next Hop          Metric LocPrf Weight Path
Route Distinguisher: 163.253.0.7:8 (default for vrf I2PX)
Route Distinguisher Version: 2591868684
* 38.81.108.0/22    198.71.47.247      0    200      0 22742 i
* 38.81.109.0/24    198.71.47.247      1    200      0 22742 i
* 38.81.110.0/24   198.71.47.247      0    200      0 22742 i
```

# Looking Glass Tip & Tricks

② Show Interface state/counters/link flaps/etc.

Useful for:

- Network Connector Interfaces  
e.g. *CEN - Hart2 HundredGigE0/0/0/25*



The screenshot shows the Insight Console Looking Glass interface. On the left, a tree view shows 'Hart' and 'Core Router' with 'core1.hart2' selected. A red arrow points from this selection to the command input field on the right. The input field contains the command `show interfaces HundredGigE0/0/0/25`. The output pane displays detailed interface statistics for 'core1.hart2 > show interfaces HundredGigE0/0/0/25'. The output includes:

```
Wed May 1 19:41:35.381 UTC
HundredGigE0/0/0/25 is up, line protocol is up
  Interface state transitions: 105
  Hardware is HundredGigE, address is 0476.b0da.50c4 (bia 0476.b0da.50c4)
  Description: PDP HART2-CONN-CEN-1 | I2-HART2-HART2-100GE-12551
  Internet address is Unknown
  MTU 9144 bytes, BW 10000000 Kbit (Max: 10000000 Kbit)
    reliability 255/255, txload 6/255, rxload 40/255
  Encapsulation ARPA,
  Full-duplex, 100000Mb/s, 100GBASE-LR4, link type is force-up
  output flow control is off, input flow control is off
  loopback not set,
  Last link flapped 21w6d
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters never
  30 second input rate 15797211000 bits/sec, 2899048 packets/sec
  30 second output rate 2554667000 bits/sec, 261790 packets/sec
    25428498791272 packets input, 18291684330219271 bytes, 821 total input drops
    0 drops for unrecognized upper-level protocol
    Received 745789 broadcast packets, 39633355 multicast packets
      0 runts, 0 giants, 0 throttles, 0 parity
    821 input errors, 759 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
    14878724838711 packets output, 18986751873135763 bytes, 0 total output drops
    Output 5002468 broadcast packets, 18385283 multicast packets
    0 output errors, 0 underruns, 0 applique, 0 resets
    0 output buffer failures, 0 output buffers swapped out
    109 carrier transitions
```

# Looking Glass Tip & Tricks

The screenshot displays the Insight Console interface, specifically the Looking Glass section. On the left, a search bar shows 'agg3' and a list of nodes: 'agg3.ashb' (selected), 'agg3.dall3', 'agg3.eqch', and 'agg3.sanj'. A command bar at the top right shows 'Nodes selected: 1 show interfaces TenGigE0/0/0/12/2.5005' with 'Run Command' and 'All Output' buttons. The main area shows the output of the 'show interfaces TenGigE0/0/0/12/2.5005' command for the selected node.

**Output of 'show interfaces TenGigE0/0/0/12/2.5005':**

```
Wed May 1 20:19:49.357 UTC
TenGigE0/0/0/12/2.5005 is up, line protocol is up
  Interface state transitions: 1
  Hardware is VLAN sub-interface(s), address is 00bc.6055.6832
  Description: ASHB-CONN-MICROSOFT-3, SDP VNROUTER-10027-VNL3CONN-10117, OESS-VRF-3506
  Internet address is 192.168.100.249/30
  MTU 9152 bytes, BW 10000000 Kbit (Max: 10000000 Kbit)
    reliability 255/255, txload 0/255, rxload 0/255
  Encapsulation 802.1Q Virtual LAN, VLAN Id 30, 2nd VLAN Id 30,
  loopback not set,
  Last link flapped 6w4d
  ARP type ARPA, ARP timeout 04:00:00
  Last input 00:00:00, output 00:00:00
  Last clearing of "show interface" counters never
  30 second input rate 3244000 bits/sec, 528 packets/sec
  30 second output rate 1416000 bits/sec, 559 packets/sec
    4894514353 packets input, 2269037165025 bytes, 0 total input drops
    0 drops for unrecognized upper-level protocol
    Received 2 broadcast packets, 0 multicast packets
    9110510098 packets output, 11105261187453 bytes, 0 total output drops
    Output 0 broadcast packets, 0 multicast packets
```

On the right, there are two panels: 'Internet2' and 'BGP Status'. The 'Internet2' panel shows network details like IPv6 and IPv4 addresses, ASN, MTU, and BFD settings. The 'BGP Status' panel shows BGP status as 'IPv4 Up'. Below these are 'Statistics' and 'Provisioner' tabs. At the bottom, a graph shows traffic over time for the interface 'agg3.ashb.net.internet2.edu - TenGigE0/0/0/12/2.5005'.

**Cloud Provider Interfaces**  
e.g. Azure – Agg3.ASHB  
TenGigE0/0/12/2.5005

Red arrow pointing to the 'Subinterface\*' field in the configuration panel.

Green arrow pointing to the graph showing traffic over time.

# Looking Glass Tip & Tricks

## 3 View routing table for Virtual Networks

Newer: show bgp vrf VNROUTER-XXXXX

- unless migrated from OESS -

Older: show bgp vrf OESS-VRF-XXXX

Insight Console Services

Virtual Network Spaces / Space

**Virtual Network Space**

- Title: Azure ExpressRoute - Ashburn - DAS-BE...
- Name: VNSPACE-10027
- Owner: CEN (Connecticut Education Network)
- Last Modified: 2023-10-27T21:13:16.101246+00:00 by OESS
- Created: 2023-10-27T21:13:16.101240+00:00 by OESS
- Virtual Space ID: 504f5084-49f0-4b5a-acd1-1c0cb017c1
- Notes:  
OESS Workgroup CEN;  
OESS L3VPN 3506;

**Virtual Router** VNROUTER-10027

CEN (Conn. Ed. Network) **Internet2** Hartford, CT

ASN 65003 55038

IPv6 Not configured Not configured

IPv4 ✓ Up 10.199.254.1/30 10.199.254.2/30

Internet2 Subinterface HundredGigE0/0/0/25.752 on core1.hart2

Grafana

Insight Console

Home Virtual Networks Looking Glass Community Interfaces

Filter by node name or location

Aggregation Router

- agg1.ashb Ashburn, VA
- agg1.dall3 Dallas, TX
- agg1.eqch Chicago, IL
- agg1.losa2

Nodes selected: 1 show bgp vrf OESS-VRF-[REDACTED]

core1.alba > show bgp vrf OESS-VRF-[REDACTED]

Thu May 2 00:39:01.609 UTC  
BGP VRF OESS-VRF-[REDACTED], state: Active  
BGP Route Distinguisher: 163.253.0.8:1505  
VRF ID: 0x60000007  
BGP router identifier 163.253.0.8, local AS number 11537  
Non-stop routing is enabled  
BGP table state: Active  
Table ID: 0xe0000007 RD version: 2517572168  
BGP main routing table version 2523420179  
BGP NSR Initial initsync version 5873544 (Reached)  
BGP NSR/ISSU Sync-Group versions 0/0

Status codes: s suppressed, d damped, h history, \* valid, > best  
i - internal, r RIB-failure, S stale, N Nexthop-discard  
Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher:	163.253.0.8:1505	(default for vrf OESS-VRF-[REDACTED])			
Route Distinguisher Version:	2517572168				
*> 10.0.0.0/8	10.240.141.33				i [REDACTED]
*>i10.37.0.0/16	163.253.0.81			100	0 64809 i
*>i10.38.0.0/15	163.253.0.81			100	0 64809 i
*>i10.137.0.0/16	163.253.0.81			100	0 64809 i
*>i10.138.0.0/16	163.253.0.81			100	0 64809 i
*>i10.139.0.0/17	163.253.0.81			100	0 64809 i
*>i10.139.128.0/18	163.253.0.81			100	0 64809 i
*>i10.139.192.0/19	163.253.0.81			100	0 64809 i
*>i10.139.224.0/20	163.253.0.81			100	0 64809 i
*>i10.139.240.0/21	163.253.0.81			100	0 64809 i
*>i10.139.248.0/21	163.253.0.81			100	0 64809 i

# Clean-up your cloud

## Don't forget!!!

**!** Delete all your resources in the various CSP's

No need for a large bill at the end of the month!

*Thank you!*

