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The bridge to possible

Architecting Hybrid Multi-Cloud Infrastructures

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Distinguished, Solutions Engineer

BRKDCN-2616

A little bit about David...

Cisco role: Distinguished, Solutions Engineer, Cross domain architecture, strategic customer engagements, Technology Strategy, Senior Technical Talent

Unofficial Title: “A person that needs to learn how to say, “No.”

Experience: been at Cisco ½ my life.

Fun fact 1: An awesome husband; Father of a daughter and twin boys

Fun fact 2: Written / published 4 books; 4 video series and working on my last one ☺

Fun fact 3: Enjoy the outdoors, music, working out, running, etc.

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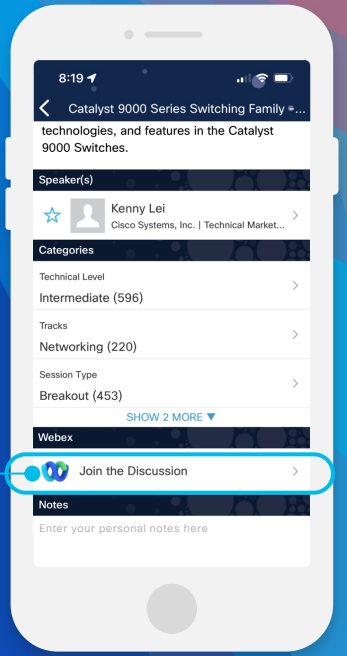

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Abstract
Architecting Hybrid / Multi-Cloud Infrastructures

Abstract: Cloud continues to be the disruptor; customers have been on the Cloud Journey for several years. This session will address the following Architectural trends and provide guidance for the growing demand of Users and Applications being Everywhere in a Multi-Cloud world. As applications and data are moving from the traditional private data centers to public clouds; private Data Center(s) and Applications are still critical.

This session will provide architectural guidance to help customers optimize and understand traffic flows, operational efficiencies and visibility in a Multi-Cloud world.

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Goals of this session:

- Provide you an understanding of the following and provide use-cases:
  - Understanding of the current Cloud Networking deployment options
  - Explain current challenges and use-cases
  - Provide In-Region, Intra-Region and Inter-Cloud Connectivity Options Visibility
  - Articulate a consistent and uniform Cloud networking / segmentation / security solution
  - Visibility across entire solution

So many solutions, so many options – want to provide discussion, what I have seen and conversations with customers and the engagements with Engineering.

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Agenda

- Current Challenges, Issues, Administration and Options
- Multi-Cloud Networking: Cisco Cloud Network Controller
  - Single region connectivity
  - Multi-region connectivity
  - Multi-Cloud connectivity
  - Private Data Center connectivity
- Branch to Cloud
- Cisco Cloud Network Controller Configuration
- New capabilities / features
- Visibility
- Summary

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Taxonomy

- Hybrid-Cloud: Public-Cloud and Private-Cloud
- Multi-Cloud: Hybrid-Cloud + 2 or more CSP(s)
- East / West Traffic Flows within (intra) across Cloud Regions/Branches
- North / South Traffic Flows across (inter) Clouds and on-prem Data Center as well as user to app flows
- I will be using AWS terminology but applies to other Cloud Providers (CSP):
  - IGW: Internet Gateway
  - DX-Gateway: Direct Connect Gateway
  - TGW: Transit Gateway
  - vPC: Virtual Private Cloud

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Cloud Terminology Matrix

For Your Reference

Area	AWS service	Azure service	GCP Service
Cloud virtual networking	Virtual Private Cloud (VPC)	Virtual Network (VNet)	Virtual Private Cloud (VPC)
NAT gateways	NAT Gateways	Virtual Network NAT	Cloud NAT
Cross-premises connectivity	VPN Gateway	VPN Gateway	Cloud VPN Gateway
DNS management	Route 53	DNS	Cloud DNS
DNS-based routing	Route 53	Traffic Manager	Cloud DNS
Dedicated network	Direct Connect	ExpressRoute	Cloud Interconnect
Load balancing	Network Load Balancer	Load Balancer	Network Load Balancing
Application-level load balancing	Application Load Balancer	Application Gateway	Global Load Balancing
Route table	Custom Route Tables	User Defined Routes	Routes
Private link	PrivateLink	Azure Private Link	Private Service Connect
Private PaaS connectivity	VPC endpoints	Private Endpoint	Private Service Connect
Virtual network peering	VPC Peering Transit Gateway	VNet Peering	VPC Network Peering
Content delivery networks	Cloud Front	Azure CDN	Cloud CDN
Network Monitoring	VPC Flow Logs	Azure Network Watcher	Network Intelligence Center

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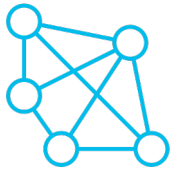
Current Challenges, Issues, Administration and Options

Challenges to solve



Network connectivity

Operations and visibility

Services integration

Segmentation and security

Need For Homogenous Experience Across Heterogenous Cloud Environments

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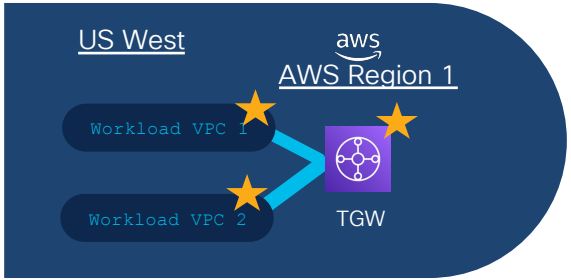
Creating two VPC(s) in one Region



1
- Create VPC 1
- Create IP CIDR blocks

2
- Create VPC 2
- Create IP CIDR blocks

3
- Create TGW in Region 1

4
- Set up VPC to TGW attachment
- Create and associate routing table for VRFs VPC 1 and VPC2 in TGW
- Create all the relevant routes for VRFs in each of the component routing tables
- VPC routing table, TGW VPC attachment

★ Administrative touch points, routing controls and visibility

```
"TransitGatewayId": "tgw-0262a0e521EXAMPLE”
"TransitGatewayArn": "arn:aws:ec2:us-east-
2:111122223333:transit-gateway/tgw-0262a0e521EXAMPLE",
"AssociationDefaultRouteTableId": "tgw-rtb-018774adf3EXAMPLE”
"PropagationDefaultRouteTableId": "tgw-rtb-018774adf3EXAMPLE"
```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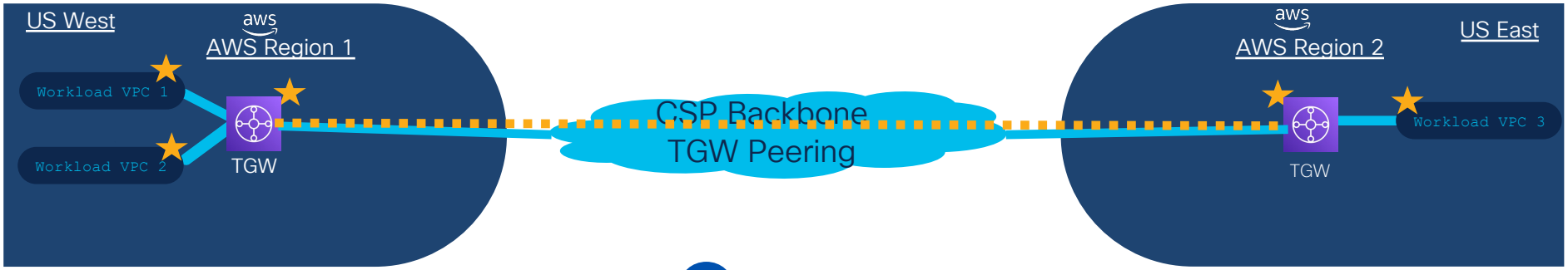
Adding a third VPC in a Second Region



1 - Create VPC 3 in region 2
- Create IP CIDR blocks

2 - Create TGW in Region 2

3 - Set up VPC to TGW attachment

4 - Tell VPC 3 about VPC 1 and VPC 2
- Creates and associates routing table for VRFs VPC 3 in the relevant TGWs
- Set up all the relevant routes for VRFs in each of the component routing tables
- VPC routing table, TGW VPC attachment

5 - Go to VPC 1 and VPC 2 and tell about VPC 3

6 - Set up TGW to TGW peering across regions
- VPC routing table, TGW VPC attachment, TGW peering attachment & routing tables

★ Administrative touch points, routing controls and visibility

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Cloud Native Routing

- **Intent:** Reach 10.1.1.0/24 over all possible paths (ECMP) and Path Failure(s)
- Think of each Cloud as a distributed router
  - How do we know about path failures?
  - How do we have a backup path?
  - ECMP?

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Inter-Region Connectivity Options

Connectivity Options

1) Leverage a WAN carrier
2) Leverage Colo (Equinix Fabric) + MACsec
3) Leverage Cloud Native TGW peering
4) Middle Mile
5) AWS Cloud WAN
6) Azure Virtual WAN

Customers are looking to build and create an environment they can switch out of easy (options) based on cost / pricing / charges.

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Cloud Connectivity between same CSP

CSP Backbone – Different Regions

- No Routing protocol
- Leverage CSP Backbone
  - Each region is few hundred miles away. If Internet has latency of 500ms between the region; AWS backbone will offer less than 255ms
- No ECMP Path
- No Feedback mechanism for path-failures
- Misconfigurations

★ Administrative touch points, routing controls and visibility

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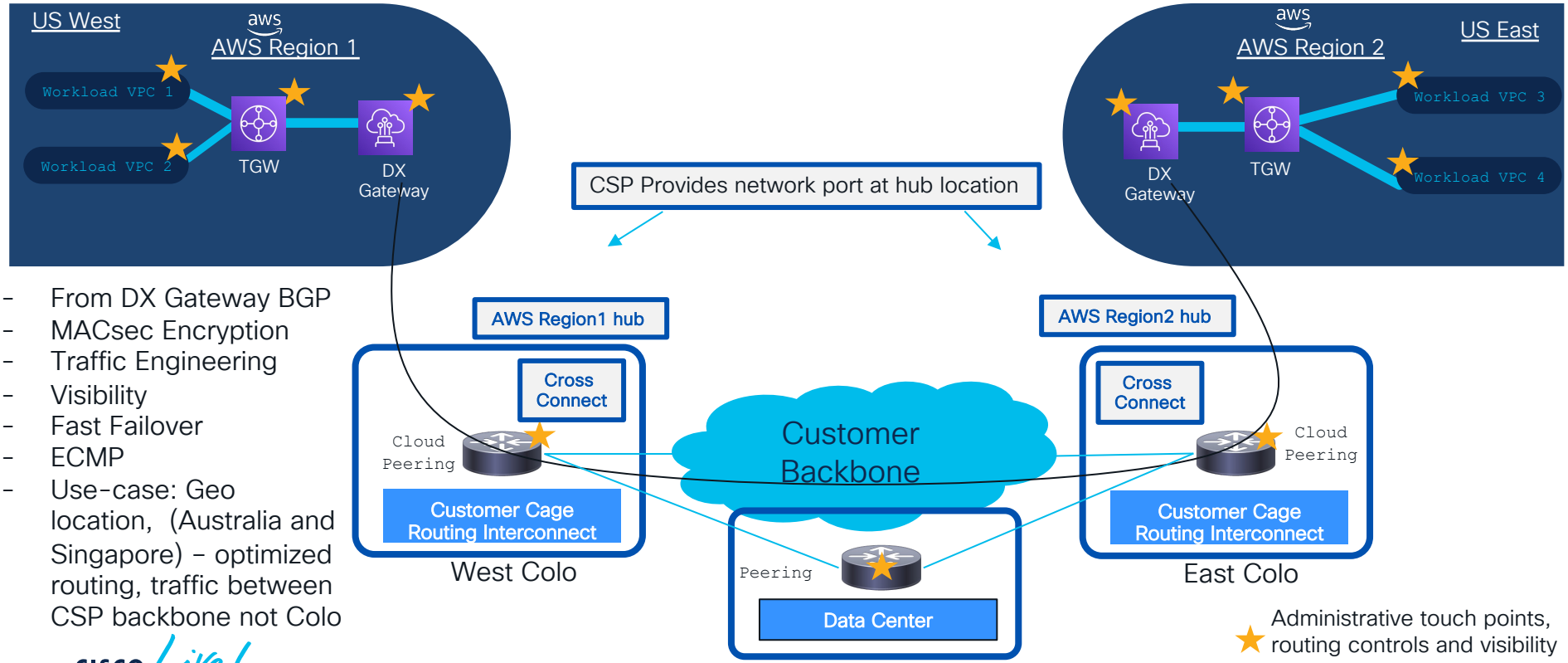
Cloud Connectivity between same CSP

Customer Backbone/Private Peering – Different Regions



- From DX Gateway BGP
- MACsec Encryption
- Traffic Engineering
- Visibility
- Fast Failover
- ECMP
- Use-case: Geo location, (Australia and Singapore) – optimized routing, traffic between CSP backbone not Colo

★ Administrative touch points, routing controls and visibility

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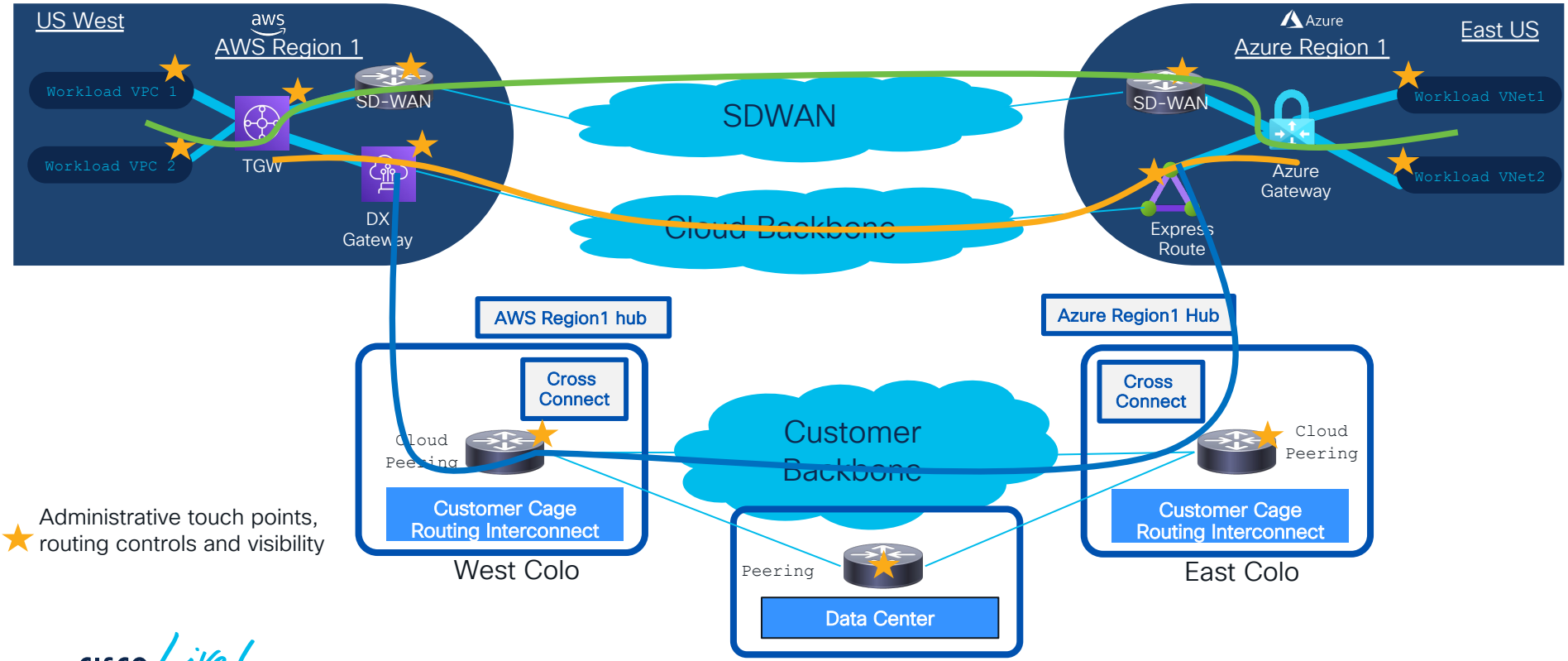
Multi-Cloud Connectivity and Routing

Multiple Ingress/Egress



★ Administrative touch points, routing controls and visibility

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Resulting in...

- Three different paths between Region 1 and Region 2
  - SD-WAN/Internet
  - CSP Backbone
  - Private-peering
- Which path with the traffic flow?
- Is ECMP possible?
- Multiple administrative touchpoints
- Failover?
- Path Failure detection and re-routing to a new / backup path?
- What about visibility?

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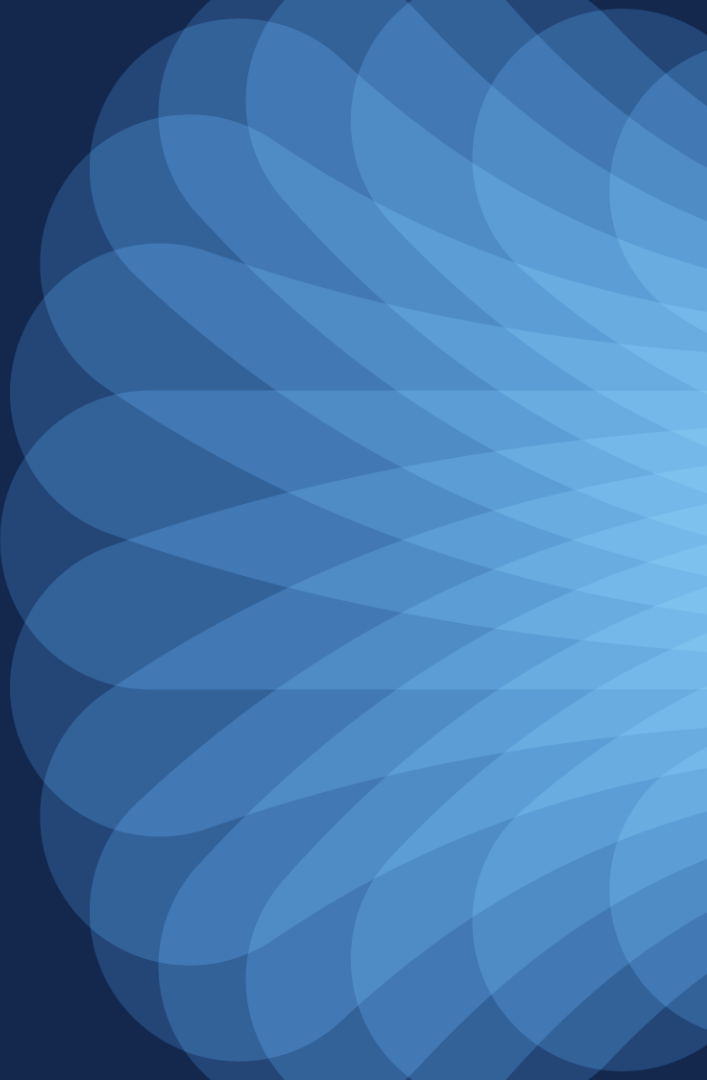
Multi-Cloud Networking: Cisco Cloud Network Controller



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Cisco Cloud Network Controller

De-Coupled:
Security Policy and Network Connectivity

Specify Security Policy
Using Contracts

Network Connectivity
Enabled Per VRF, Route Maps

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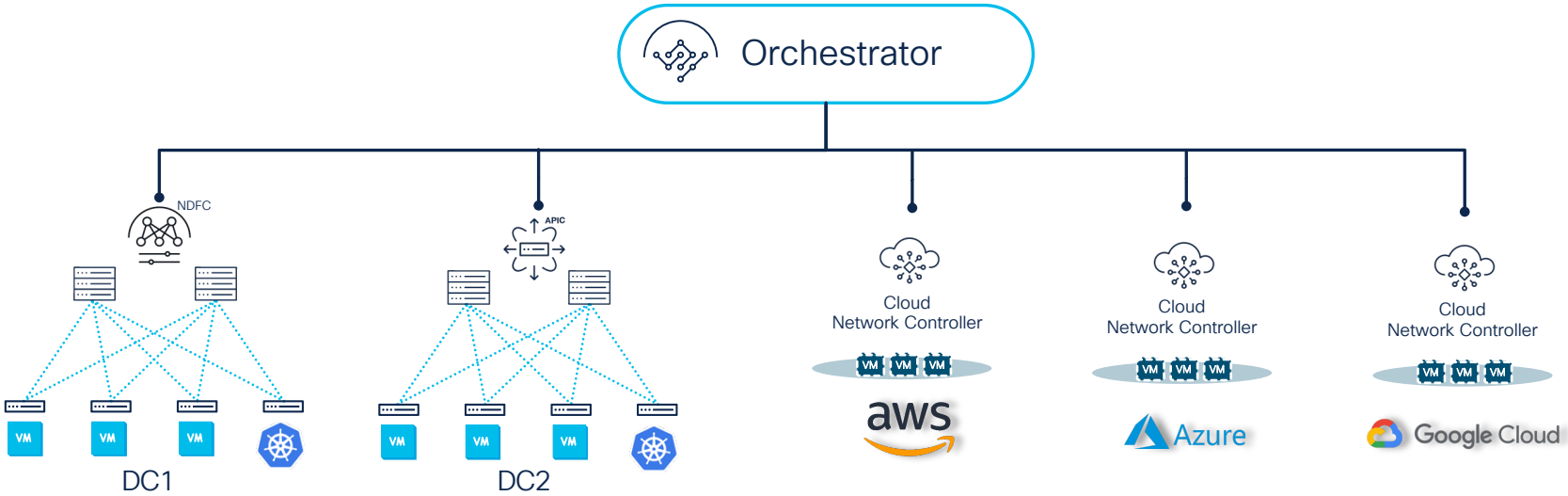
Multi-cloud Networking

Automate connectivity & segmentation, with full visibility across hybrid cloud



Automated connectivity and routing

Consistent security and segmentation

Single Point of Orchestration Visibility & Troubleshooting

Automated insertion of L4-7 services

Cisco Hybrid Multi-Cloud Networking Design Guide

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Solution Building Blocks

Cloud Network Controller

Region Management
Network and App Policy
Cloud Resources: Inventory, Visibility, Topology View

Catalyst 8000v
Or Cloud Native Router

Intra-Cloud Connectivity
Inter-Cloud Connectivity
External Network Connectivity
BGP Routing (IPv4, EVPN*)

Nexus Dashboard Orchestrator

Secure Cloud Inter-Connect
Multi-Tenancy
Networking & Segmentation
L4-L7 Service Insertion

*Cat8kv only

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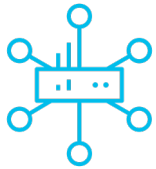
Multi-Cloud: Flexible Deployment Models

Cloud only

- Intra-cloud single region
- Intra-cloud multi-region
- Inter-clouds

Hybrid with on-premises ACI

Hybrid with on-premises NDFC



Connect to external networks

- SD-WAN router
- Branch router
- Data Center edge router

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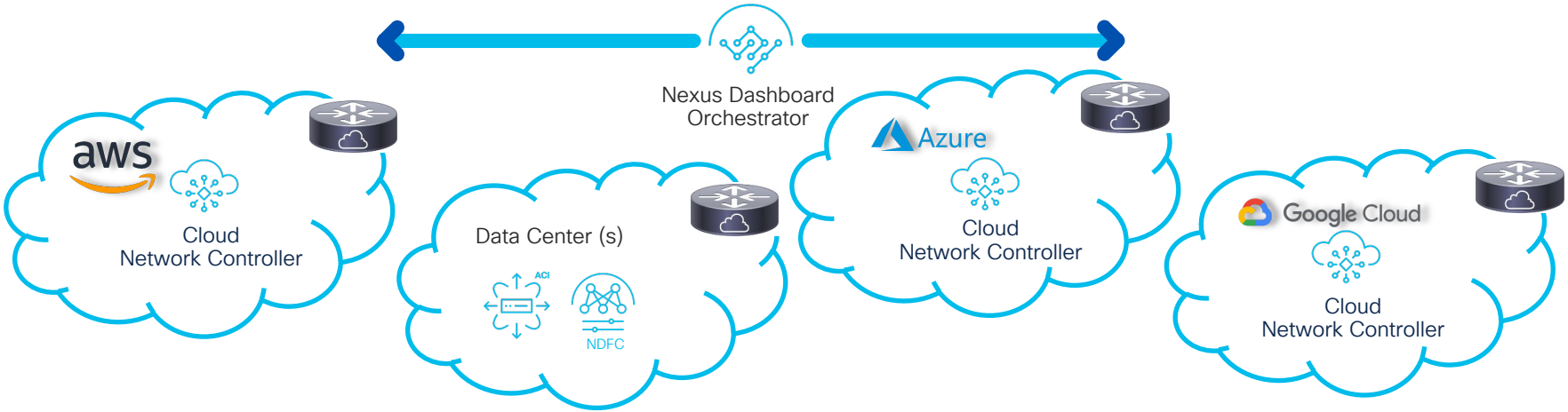
Distributed Cloud Networking

Cloud Network Controller / One per CSP



- The Cloud Network Controller per CSP is the Supervisor Module
  - Intent is stored in the Cloud Network Controller
- Each Cloud is a distributed router
- Leverage SLA probes to monitor Cloud Objects / Path Selection

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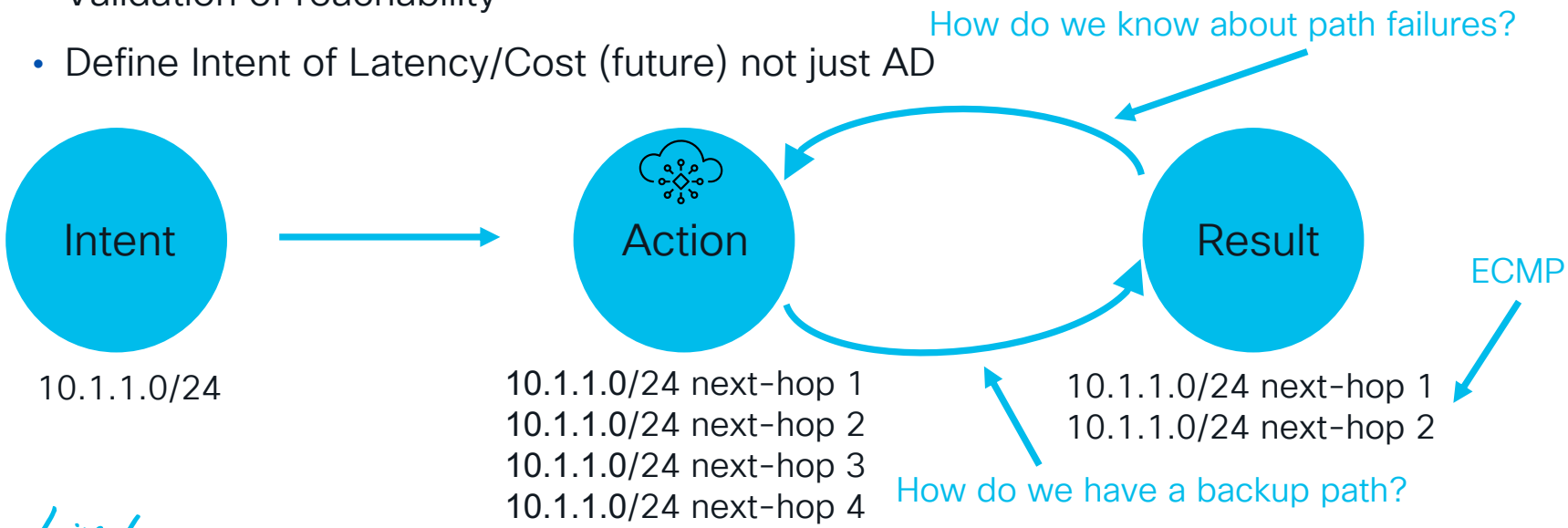
Cloud Networking with Cloud Network Controller

- **Intent:** Reach 10.1.1.0/24 over all possible paths (ECMP) and Path Failure(s)
- Administrator expresses the Routing Intent (NetOps / Cloud NetOps)
- Validation of reachability
- Define Intent of Latency/Cost (future) not just AD



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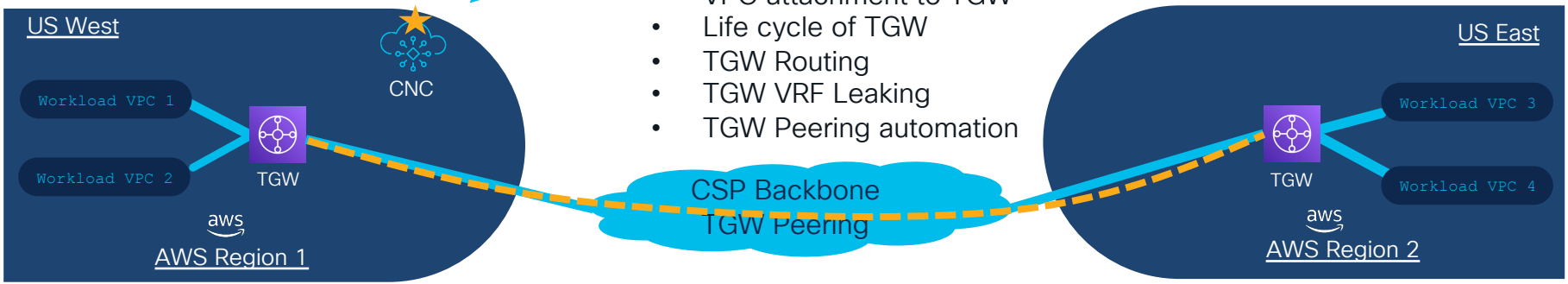
Connectivity between same CSP: Different Regions

Native TGW Peering

NetOps Operator: David

Intent:

- Create two regions
- Four VPC(s)
- Subnets per VPC / CIDR(s)
- VRF per VPC
- VPC attachment to TGW
- Life cycle of TGW
- TGW Routing
- TGW VRF Leaking
- TGW Peering automation



★ Administrative touch points, routing controls and visibility

- Keeps up with any further changes automatically
- Additions/Deletions of Subnets, CIDRs, VPCs, Regions.
- Updates to the network policy
- Selective Route Exchange between different routing domains VRF (i.e.: Shared Services)

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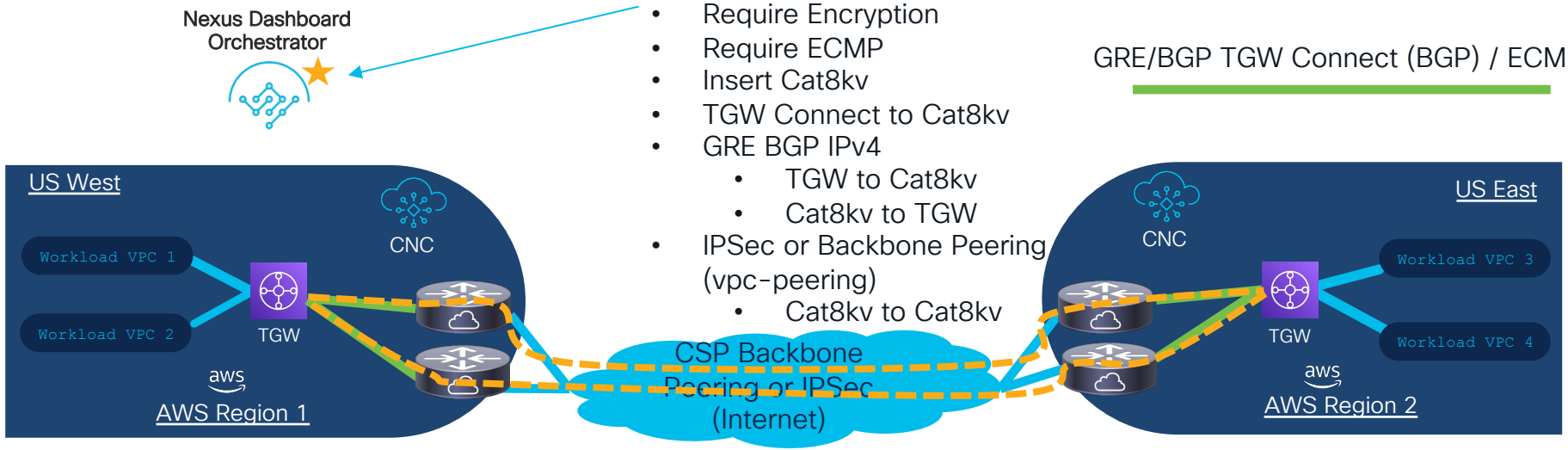
Connectivity between same CSP: Different Regions

IPSec or Backbone Peering

NetOps Operator: David

Intent:

- Require Encryption
- Require ECMP
- Insert Cat8kv
- TGW Connect to Cat8kv
- GRE BGP IPv4
  - TGW to Cat8kv
  - Cat8kv to TGW
- IPSec or Backbone Peering (vpc-peering)
  - Cat8kv to Cat8kv



★ Administrative touch points, routing controls and visibility

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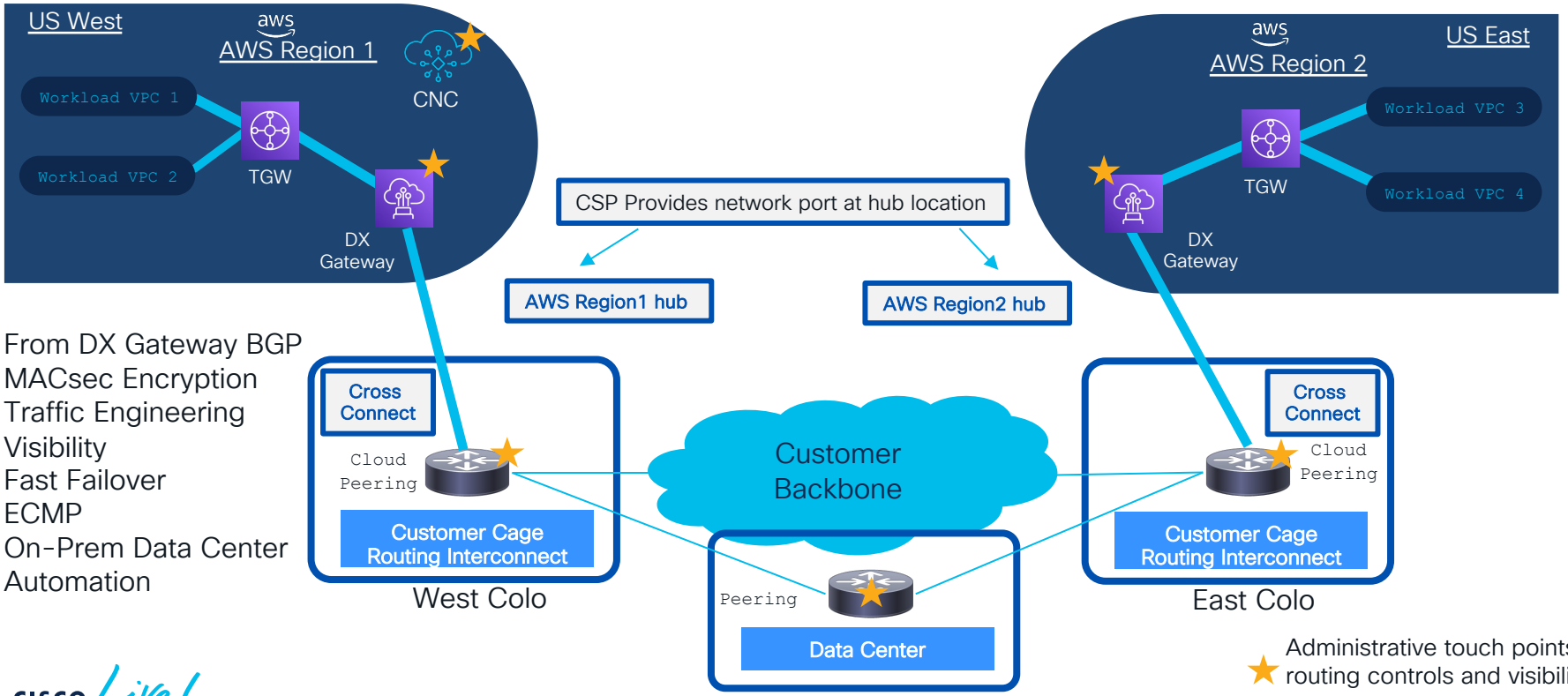
Connectivity between same CSP: Different Regions

Private Peering



- From DX Gateway BGP
- MACsec Encryption
- Traffic Engineering
- Visibility
- Fast Failover
- ECMP
- On-Prem Data Center Automation

★ Administrative touch points, routing controls and visibility

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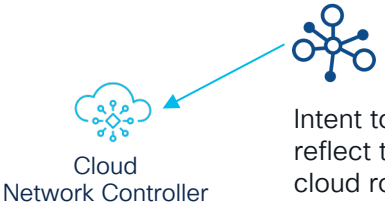
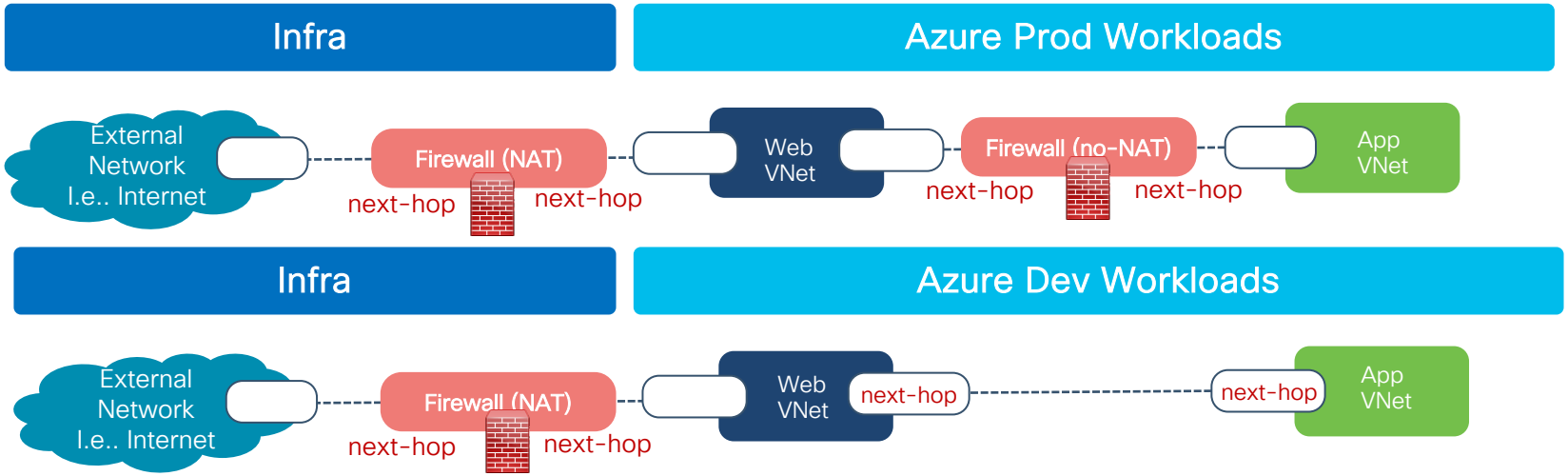
L4-L7 Service Insertion

Azure Example



NetOps Operator: David

Intent to Cloud Network Controller; that change will reflect to route filtering on the Cat8kv or natively on cloud routing depending on your connectivity model.



- **Workload(s):**
  - Prod Workloads use firewall as next-hop
  - Dev Workloads Azure "selective" use firewall services/inspection
- **External-Network:**
  - Based on routing policy, i.e. route community
  - route-map and BGP community configuration automatically (route-filtering)

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When do you require Cloud Orchestrator?

For Your Reference

Orchestrator	aws	Azure	Google Cloud	On-Prem Data Center
aws				
Azure				
Google Cloud				
On-Prem Data Center				

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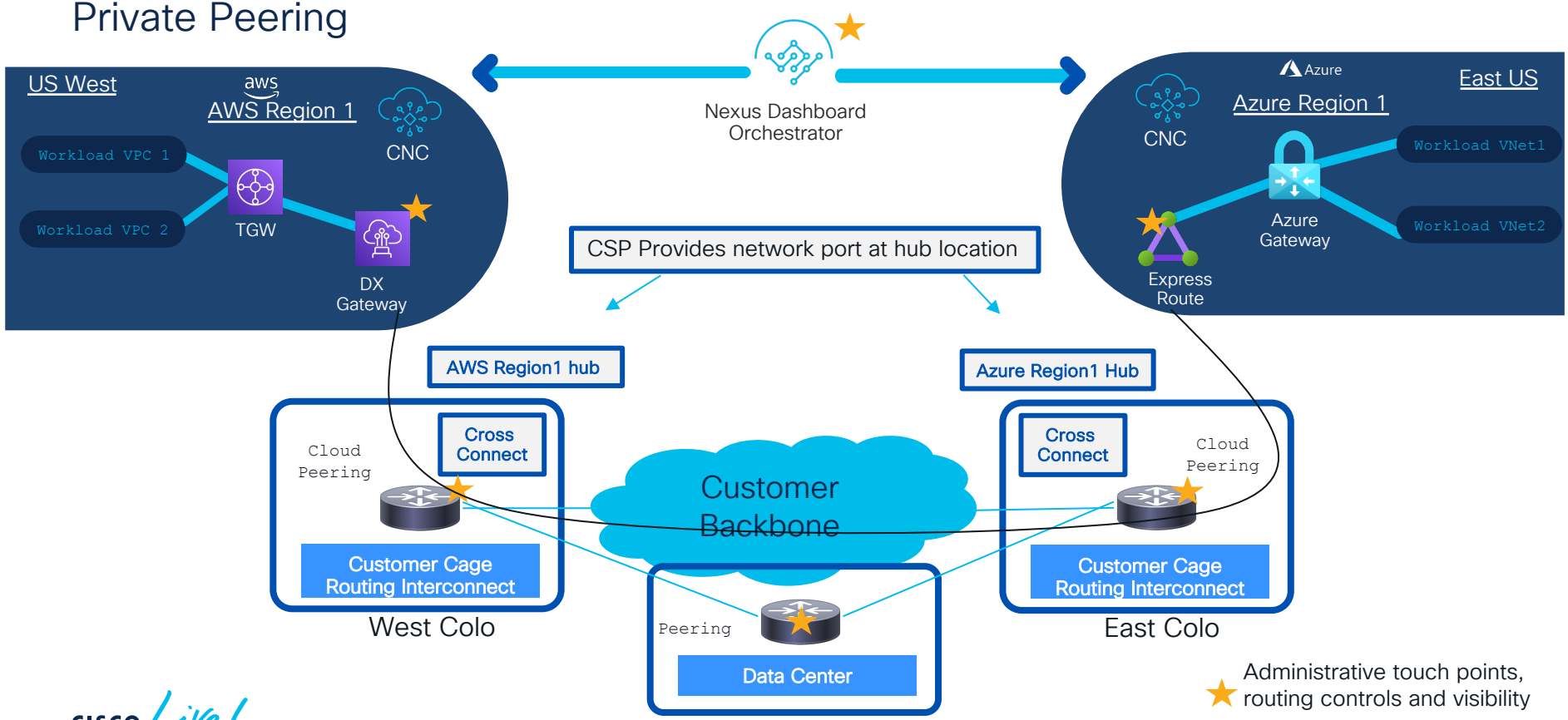
Multi-Cloud Connectivity between different CSPs

Private Peering



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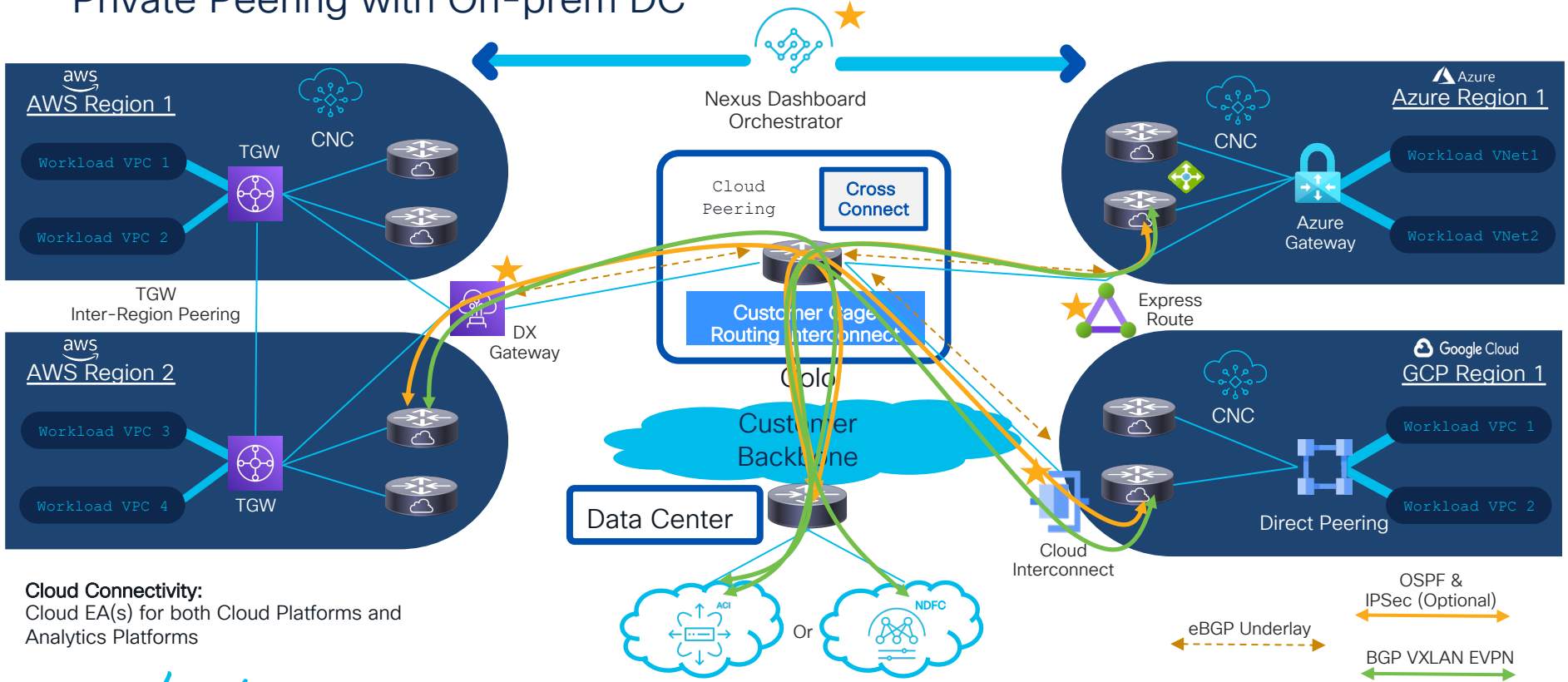
Multi-Cloud Connectivity between different CSPs

Private Peering with On-prem DC



Cloud Connectivity:
Cloud EA(s) for both Cloud Platforms and Analytics Platforms

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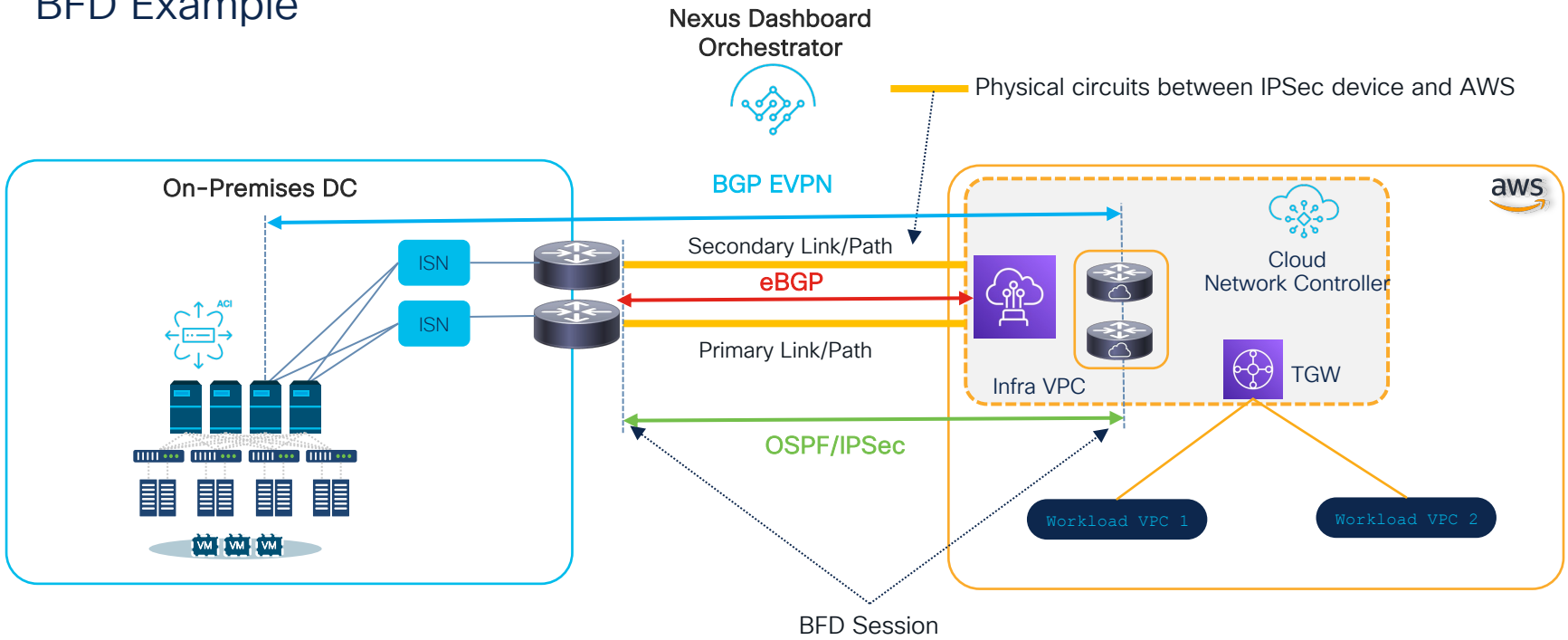
Hybrid Connectivity with AWS Direct Connect

BFD Example



[Improving Convergence Between On-Premises ACI Sites and Cloud Sites]

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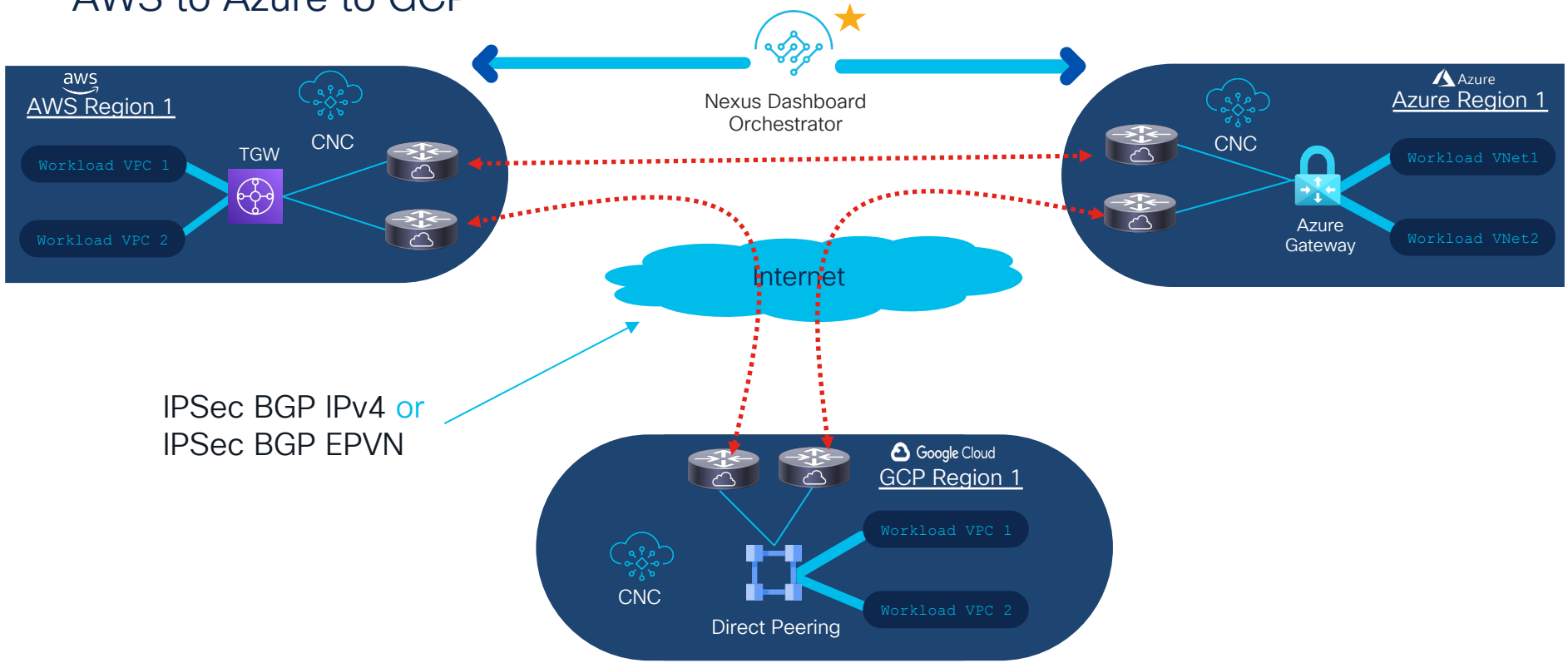
Multi-Cloud Networking
AWS to Azure to GCP



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What About Brownfield?

- Connectivity to Azure brownfield VNets
- Connectivity to AWS brownfield VPCs
- Workload VPC / VNet
- VPC / VNet Route Table

- Attachment to new TGWs
- Import of existing VPC/Subnet
- VPCs/Subnets associated to the VRF Routing Domains

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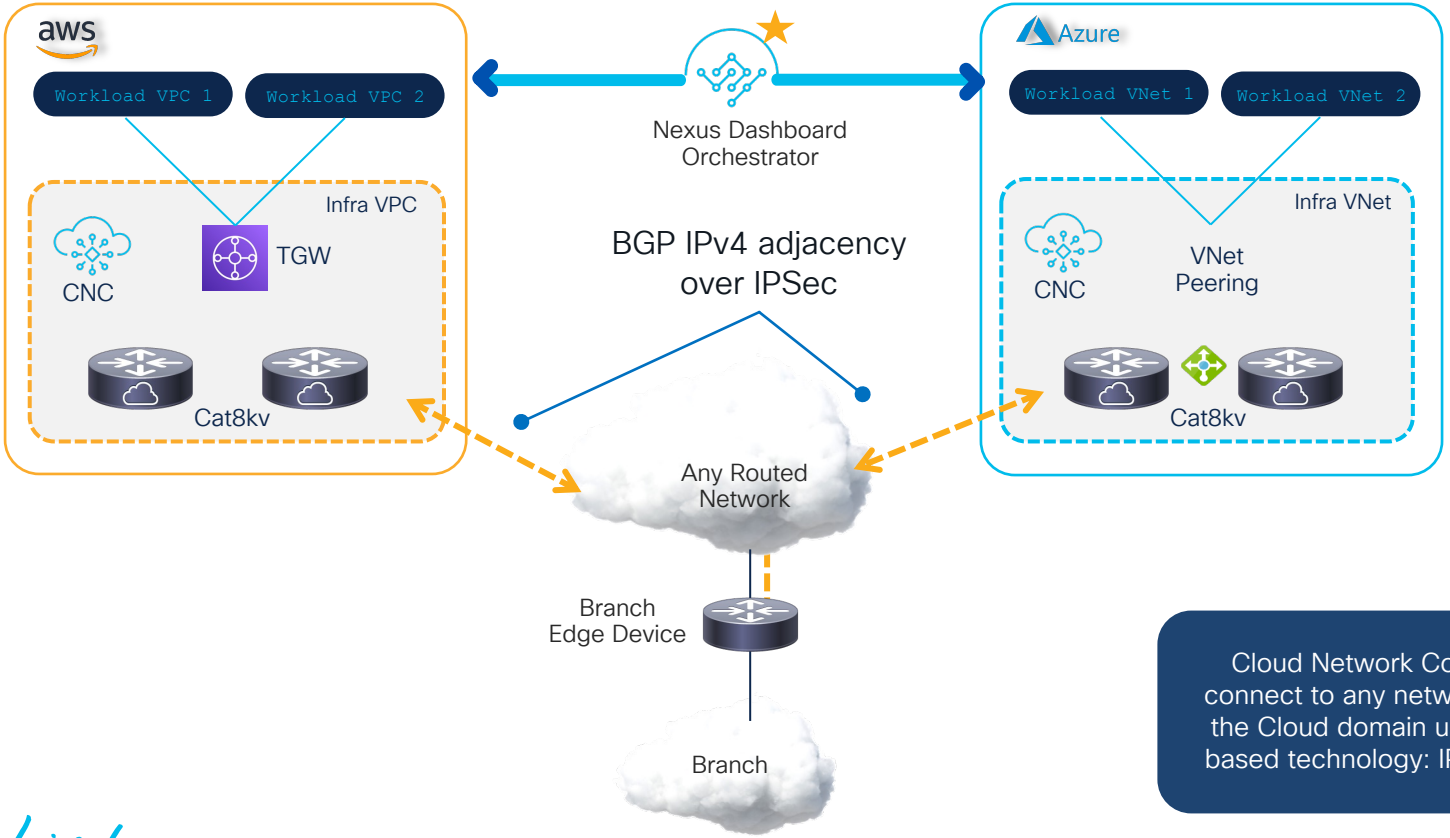
Branch to Cloud

Branch to Cloud Connectivity: Using Cat8kv



Cloud Network Controller can connect to any network outside of the Cloud domain using standard based technology: IPsec and BGP

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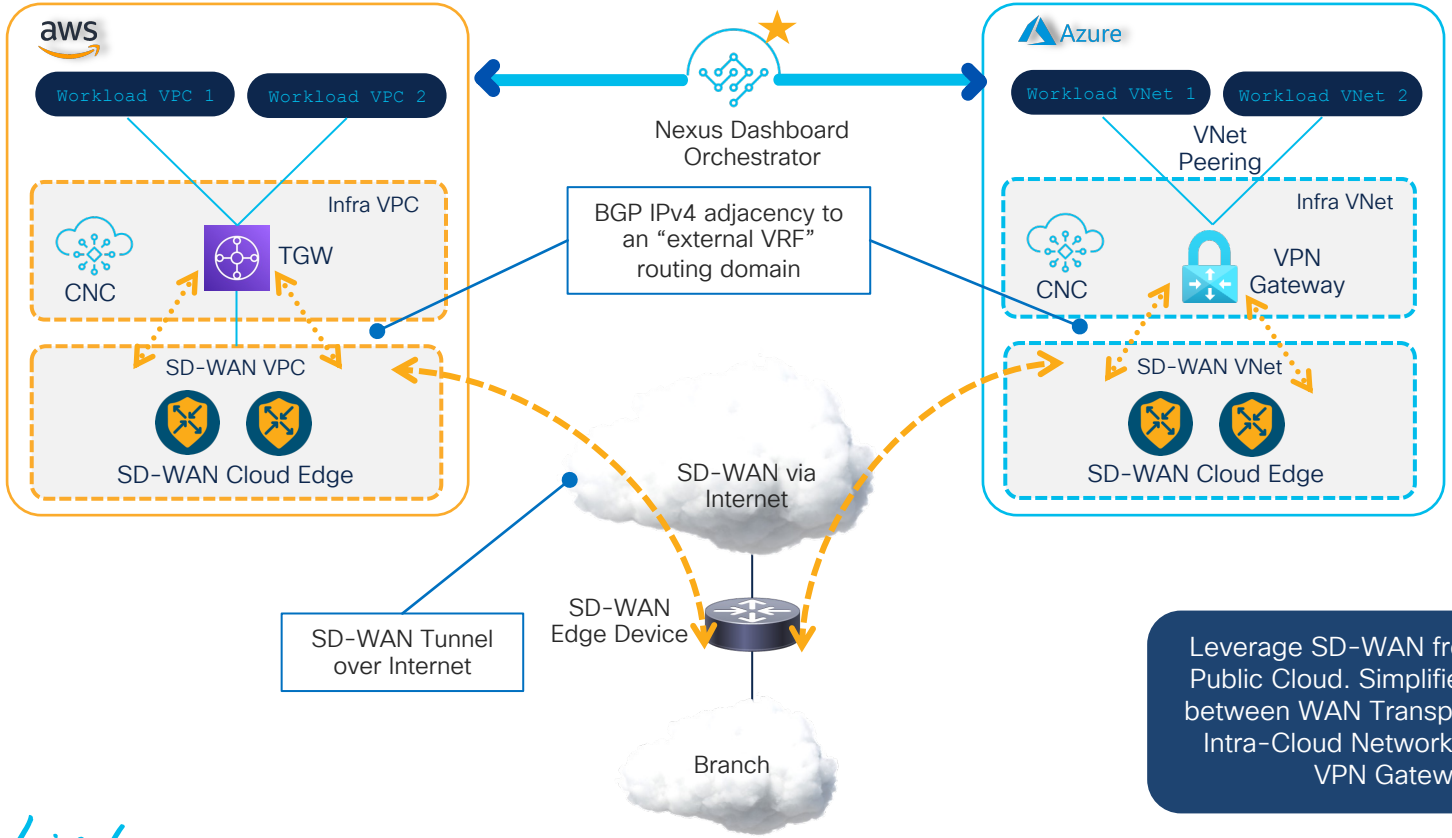
Branch to Cloud Connectivity: Using SD-WAN



Leverage SD-WAN from Branch to Public Cloud. Simplified integration between WAN Transport and native Intra-Cloud Networking (TGW or VPN Gateway)

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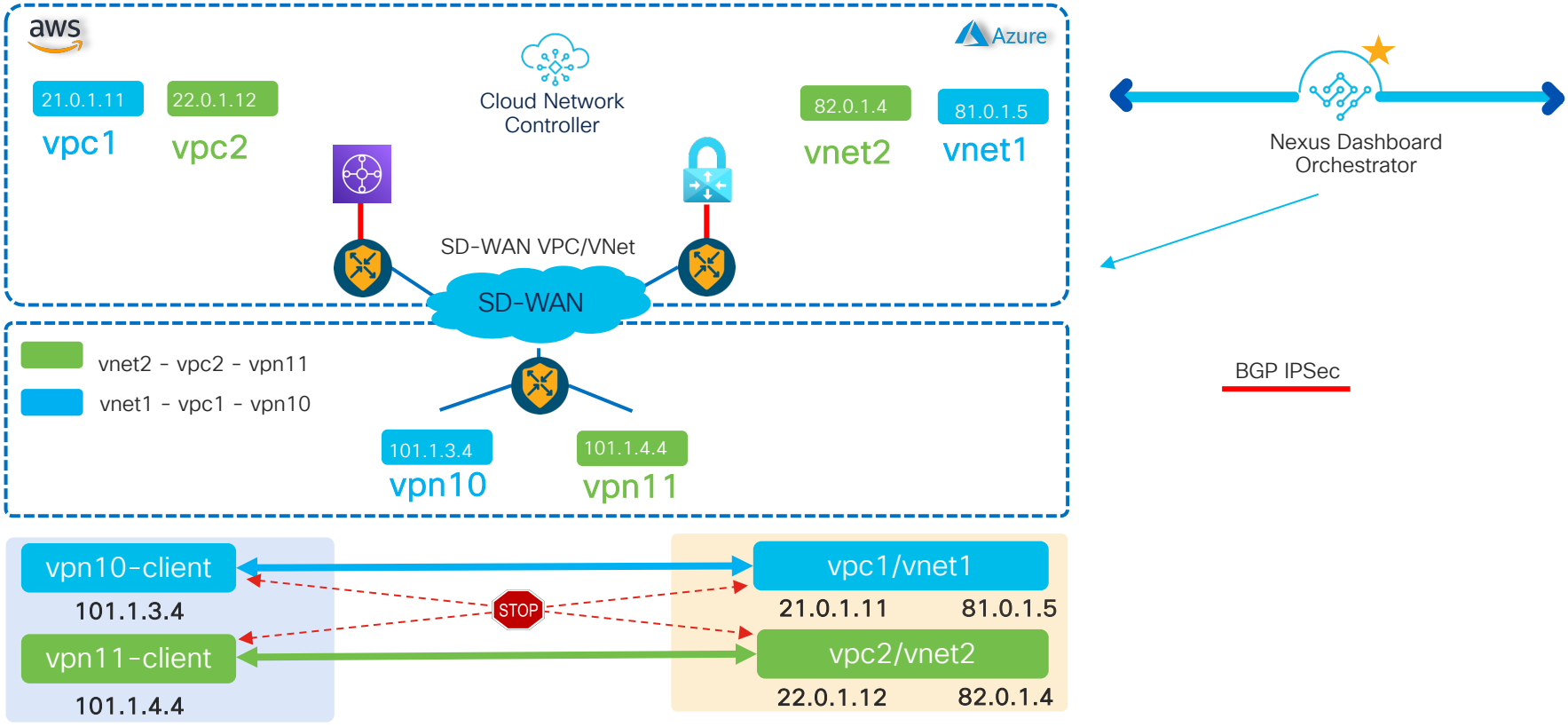
Interworking with SD-WAN



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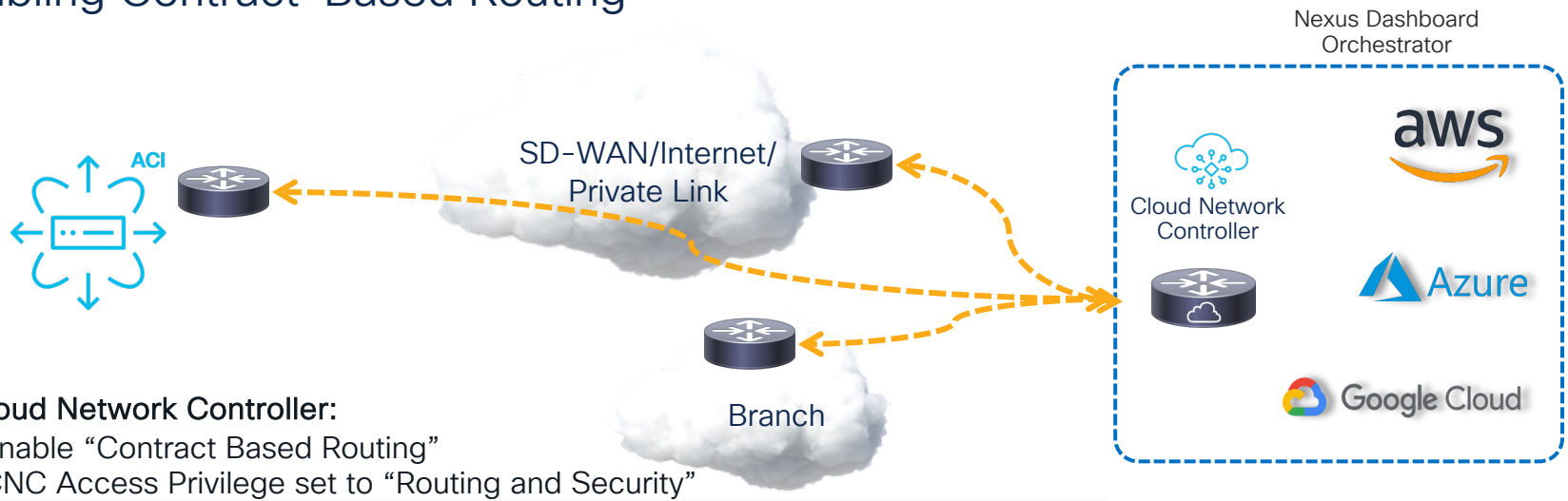
Contract-Based Routing or Routing Only with VRF leaking

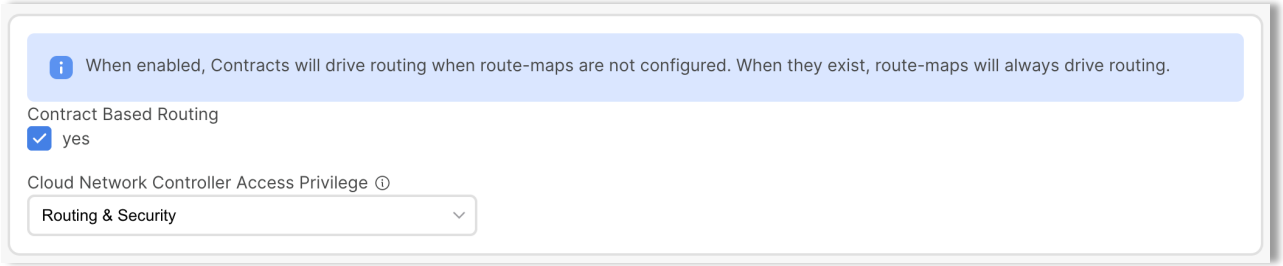
Cloud Network Controller Implementation / Configuration

Enabling Contract-Based Routing



On Cloud Network Controller:

1) Enable “Contract Based Routing”
2) CNC Access Privilege set to “Routing and Security”



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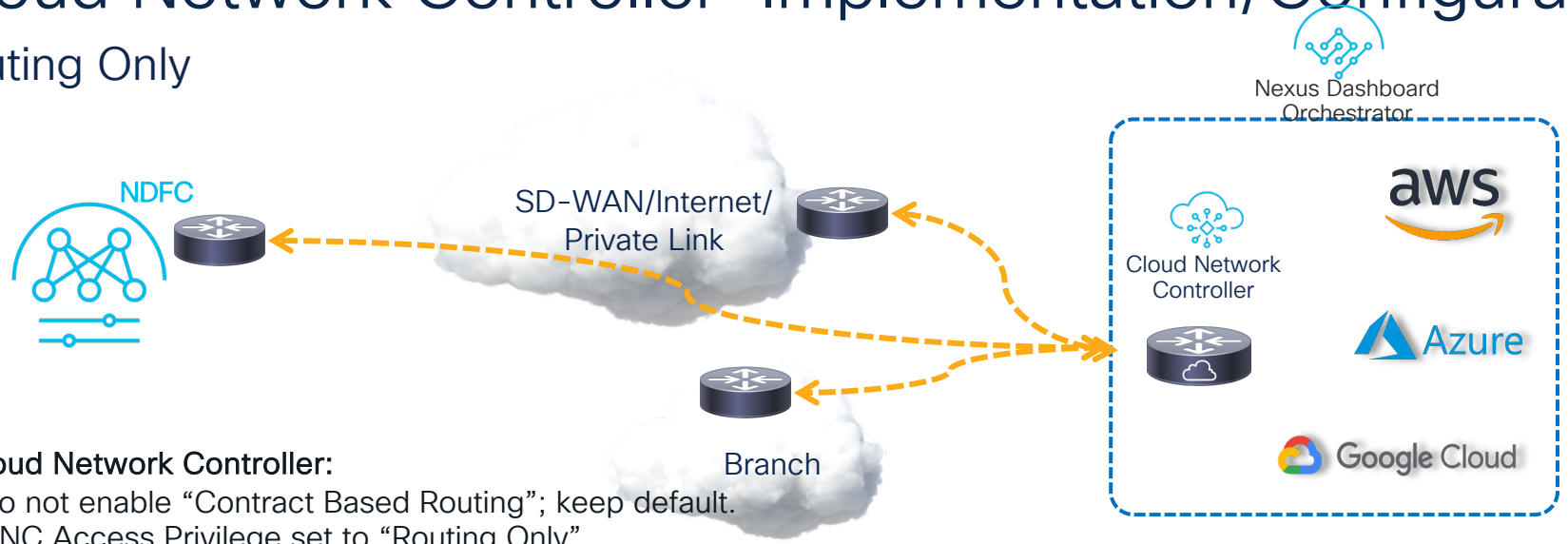
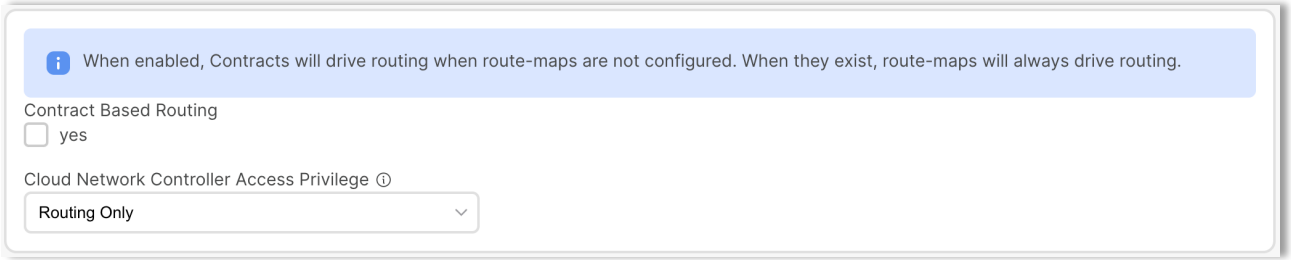
Cloud Network Controller Implementation/Configuratio

Routing Only



On Cloud Network Controller:

1) Do not enable “Contract Based Routing”; keep default.
2) CNC Access Privilege set to “Routing Only”



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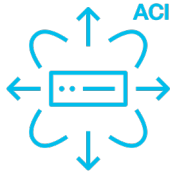
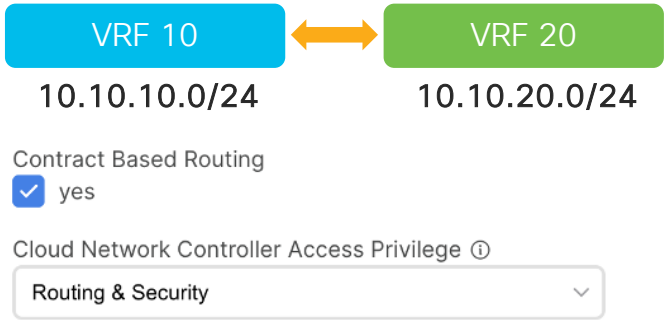
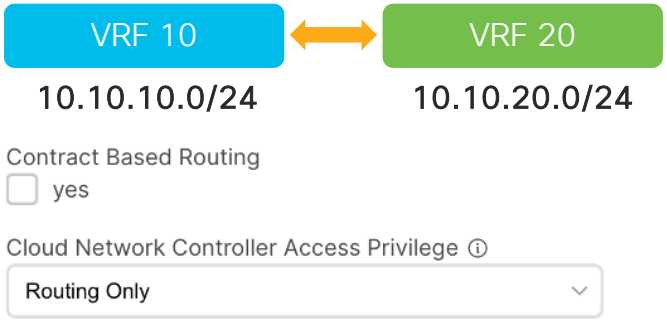
VRF Leak Example





Contract is needed; enable contract-based routing. The contract will do the leaking implicitly.



VRF leaking is still done by networking team but explicitly from CNC GUI; no contract needed/supported. Leaking can be done by FW/Routing Protocol.

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CCNC 26.0.2
New Features

CCNC 26.0.2 New Features

- Multiple VPCs/VNets in a single VRF in a region AWS/Azure
- Per Subnet Route Table – Azure. (AWS next release)
- Multi-Account per tenant for AWS/Azure

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Multiple VPCs/VNets in a single VRF for AWS and Azure in a region

Feature overview

- Prior to CCNC 26.0.2 release, ability have multiple VPCs/VNets map to one VRF in different cloud regions.
- Customers are asking for a smaller number of VRFs for a large number of VPCs/VNets in a single cloud region.
- From CCNC 26.0.2 release, allows customers to create multiple VPCs/VNets in same cloud region associated to one VRF.
- This feature is also supported from NDO 4.2.2e
- The benefits of this new feature:
  - Reduce VRF management complex
  - Flexibility in building routing domain with a group of VPCs/VNets

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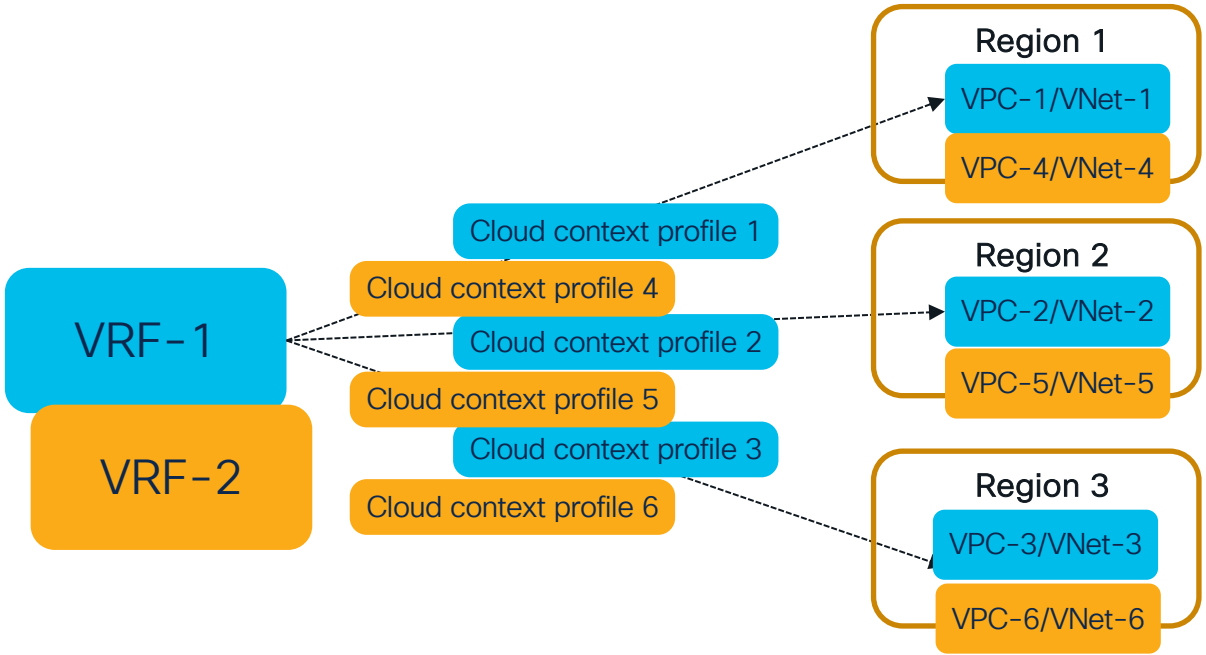
Prior to CCNC release 26.0.2

One VRF maps to multiple VPCs/VNets in different cloud regions.



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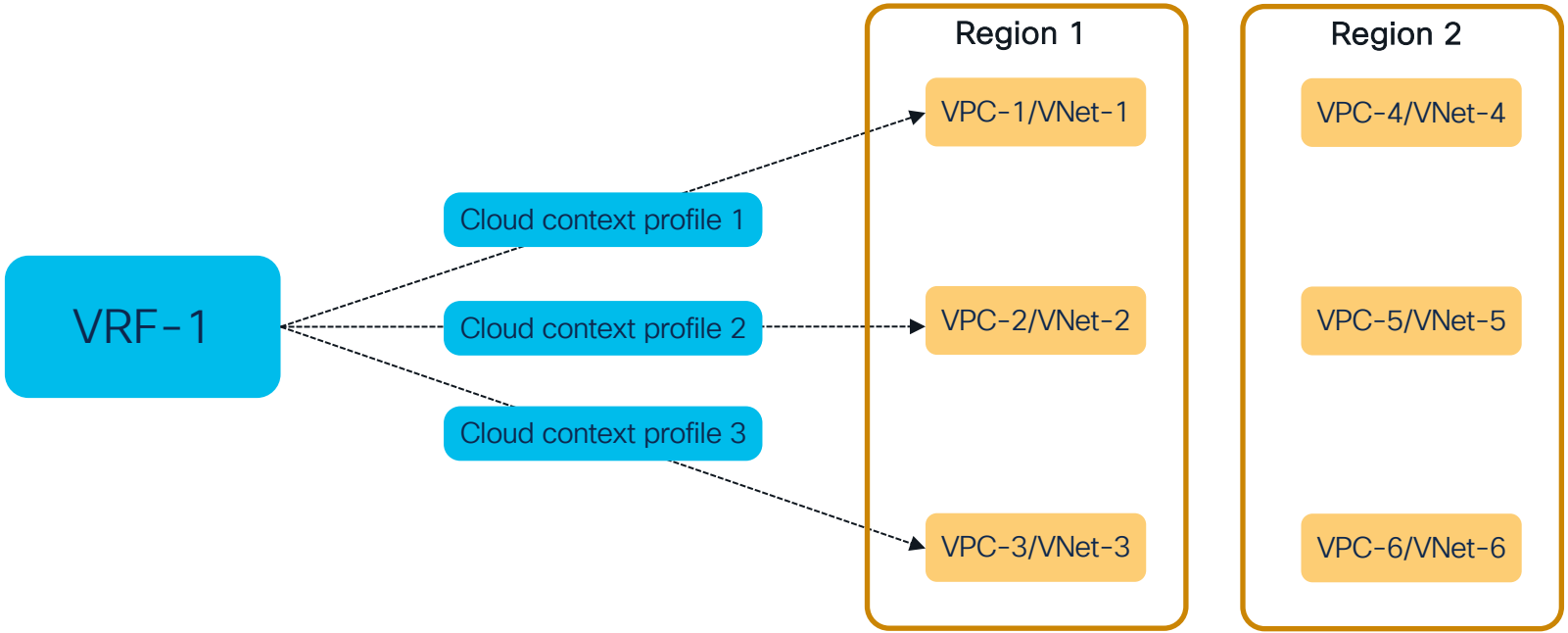
From CCNC release 26.0.2

One VRF maps to multiple VPCs/VNets in “Region 1” and “Region 2”



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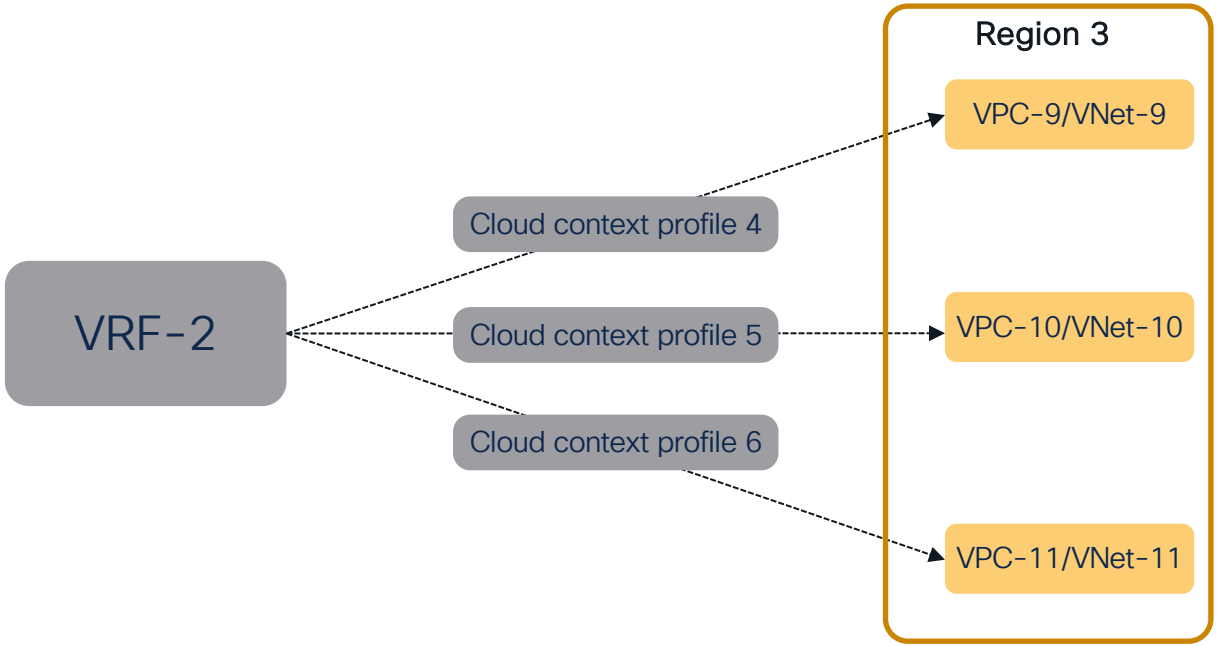
From CCNC release 26.0.2

One VRF maps to multiple VPCs/VNets in “Region 3”



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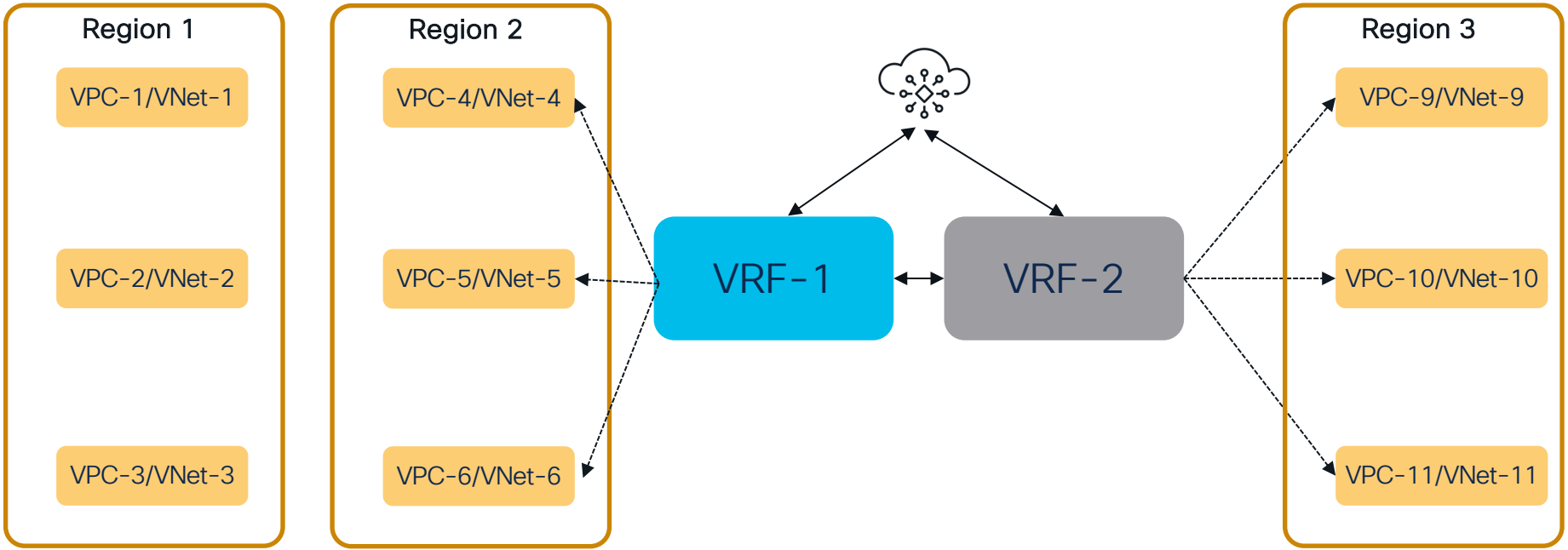
CCNC Routing Automation

NDO/CNC Allows ”VRF-1” and ”VRF-2” Communicate



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Per Subnet Route Table Azure

(AWS next release)

Feature Overview

- Per Subnet Route Table allows us to create a VNet with multiple subnets, where each subnet can map to its own Route Table, or we can group some subnets to map to the same Route Table.
- The benefit of this solution is allowing different routing treatments for different VNet's subnets. It also paves the way for other useful features in the future. For example, the insertion of a Firewall between 2 subnets.

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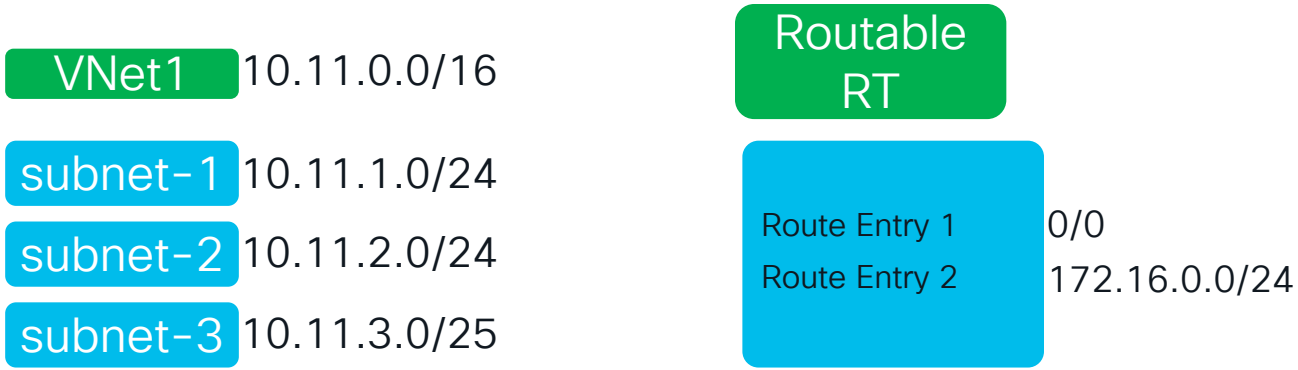
Previously, all subnets were associated to one route table



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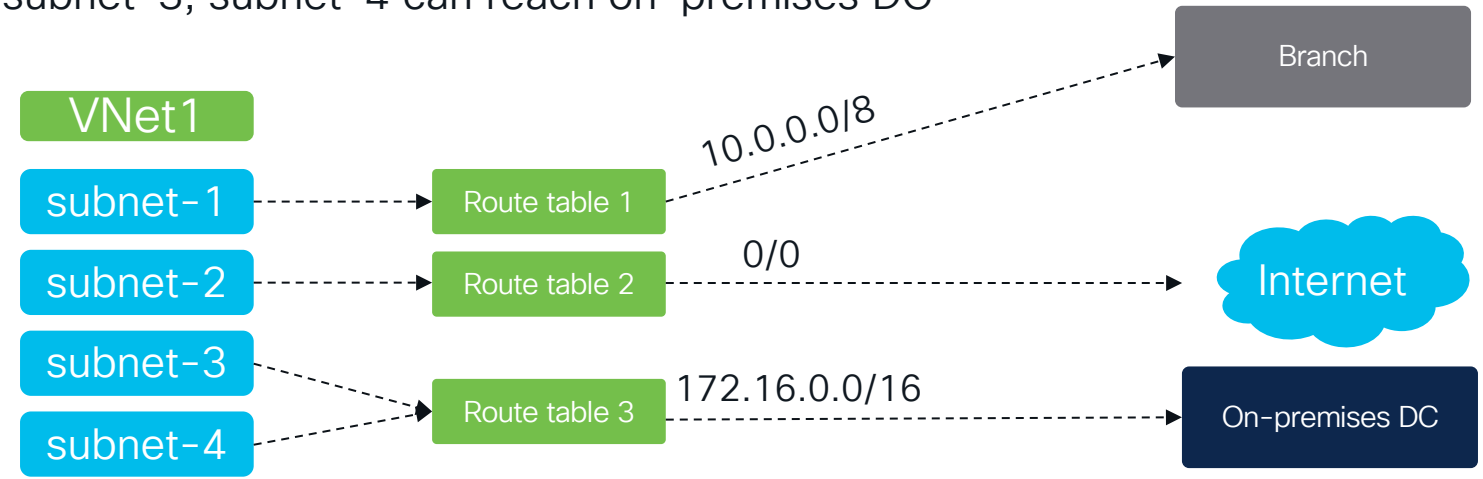
Per Subnet Route Table: Flexibility
Azure UDR

In the below example:

1) Subnets belong to the same VNet1
2) Different routing policy based its own route table
3) Subnet-1 cannot go to Internet; just Branch
4) Subnet-2 can reach Internet directly
5) Only subnet-3, subnet-4 can reach on-premises DC



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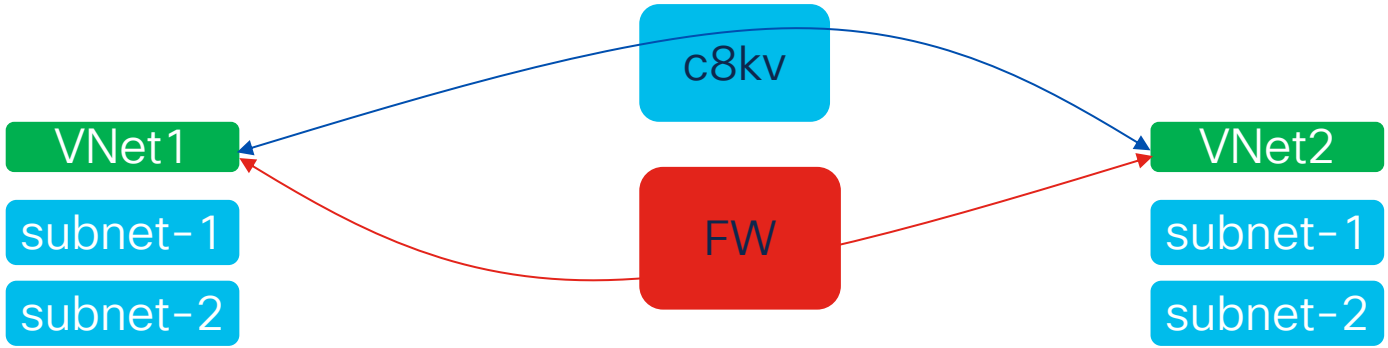
Per Subnet Route Table (Per Subnet UDR)

- Subnet-1 to Subnet-2 must go through a Firewall

- You need to have different route tables; otherwise, subnet-1 would just talk to subnet-2 w/o Firewall

- Granularity at the subnet level



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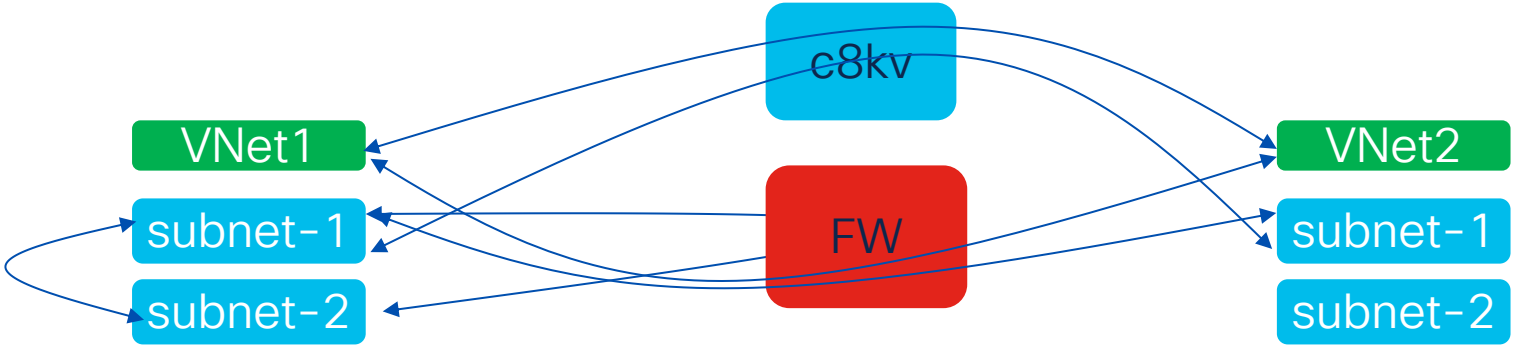
Per Subnet Route Table (Per Subnet UDR)

VNet1 -> VNet2:
1) c8Kv
2) FW

Within VNet1 subnet1 -> subnet 2:
1) cloud native

VNet1 subnet1-> VNet2 subnet1
1) c8KV
2) FW



within VNet1 Subnet1 – subnet 2:
1) FW

Vnet1 -> VNet2:
1) cloud native

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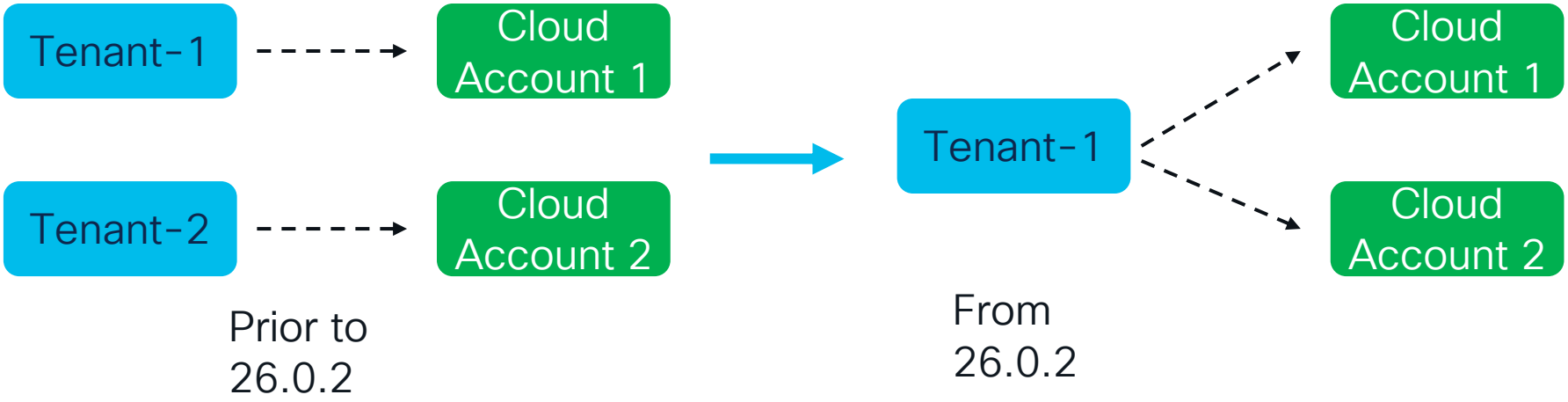
Multi-Account for AWS/Azure

Multi-Account

Prior to CCNC 26.0.2 release, each tenant would require one cloud account. Cloud account refers to AWS account ID or Azure subscription or GCP project.

This mapping model does not always match customers' cloud environments. Usually, customers use a tenant (Cloud terminology) with multiple Cloud accounts. For example, a Marketing tenant (under Azure directory on Azure) with multiple Azure subscriptions.

From CCNC 26.0.2 release, it is possible to create one tenant and associate it to multiple cloud accounts.



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Visibility

Visibility Capabilities

Cloud
Network Controller

Nexus Dashboard
Orchestrator

- **Nexus Dashboard Orchestrator and CNC:**
  - Inventory
  - Topology (Underlay / Overlay)
  - Statistics and Bandwidth
  - L4-L7 Statistics
  - Troubleshooting tools
  - Raise faults (API failures, delays, resource constraints, state changes)
  - Provides visibility to cloud resources and the correlation with the configuration.
  - Drift Detection – Reconcile with cloud state across reboots, software upgrades
  - Event Analytics Tab in CNC (Account permissions, Licensing subscription, protocols down)
  - IP Connectivity Analysis
  - Site Details

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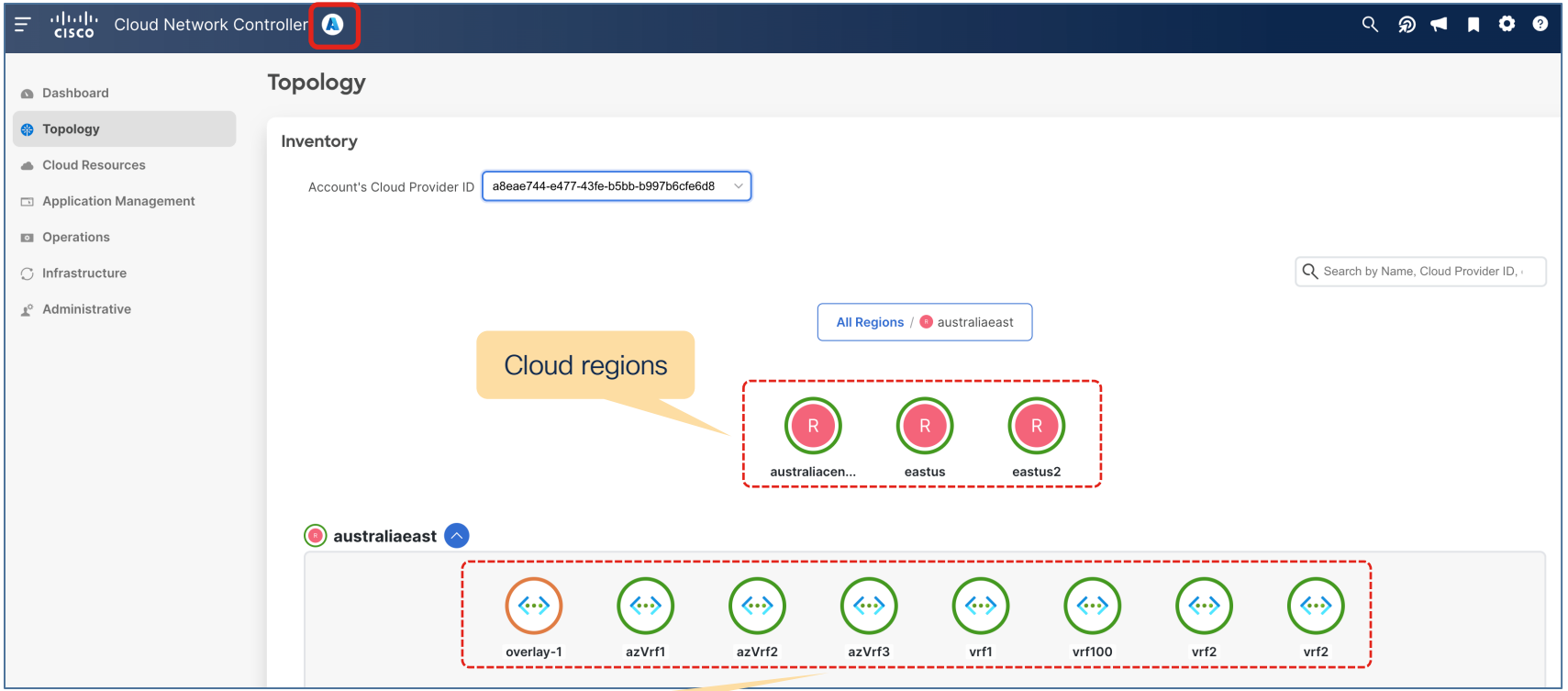
This view is on CCNC on Azure



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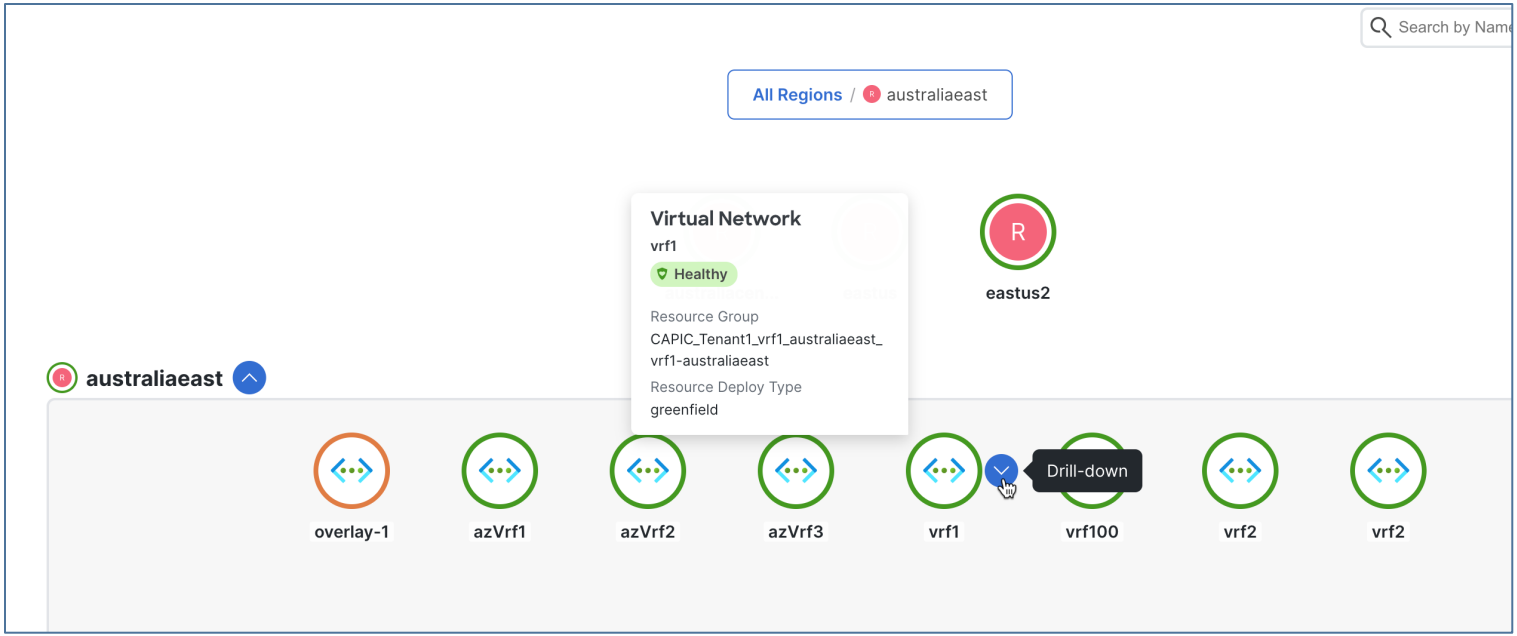
Virtual Networks



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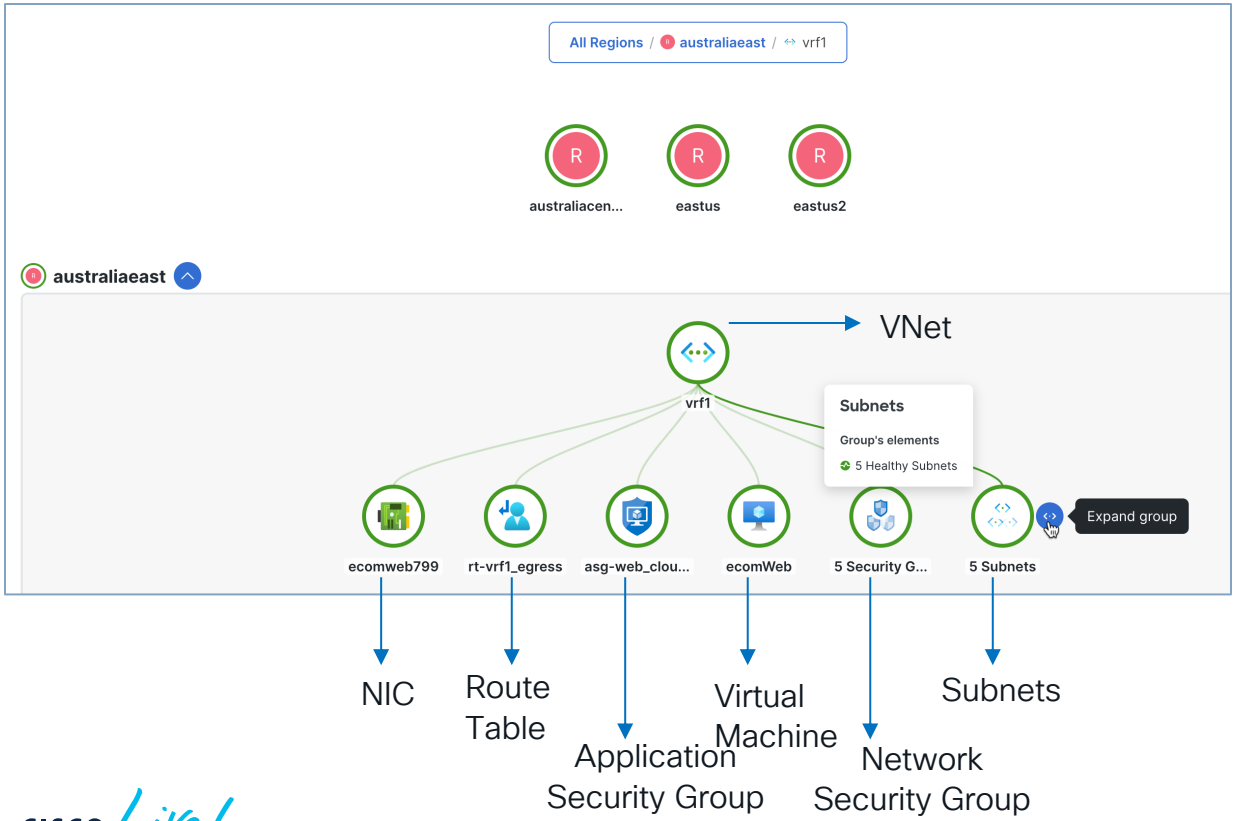
Subnets



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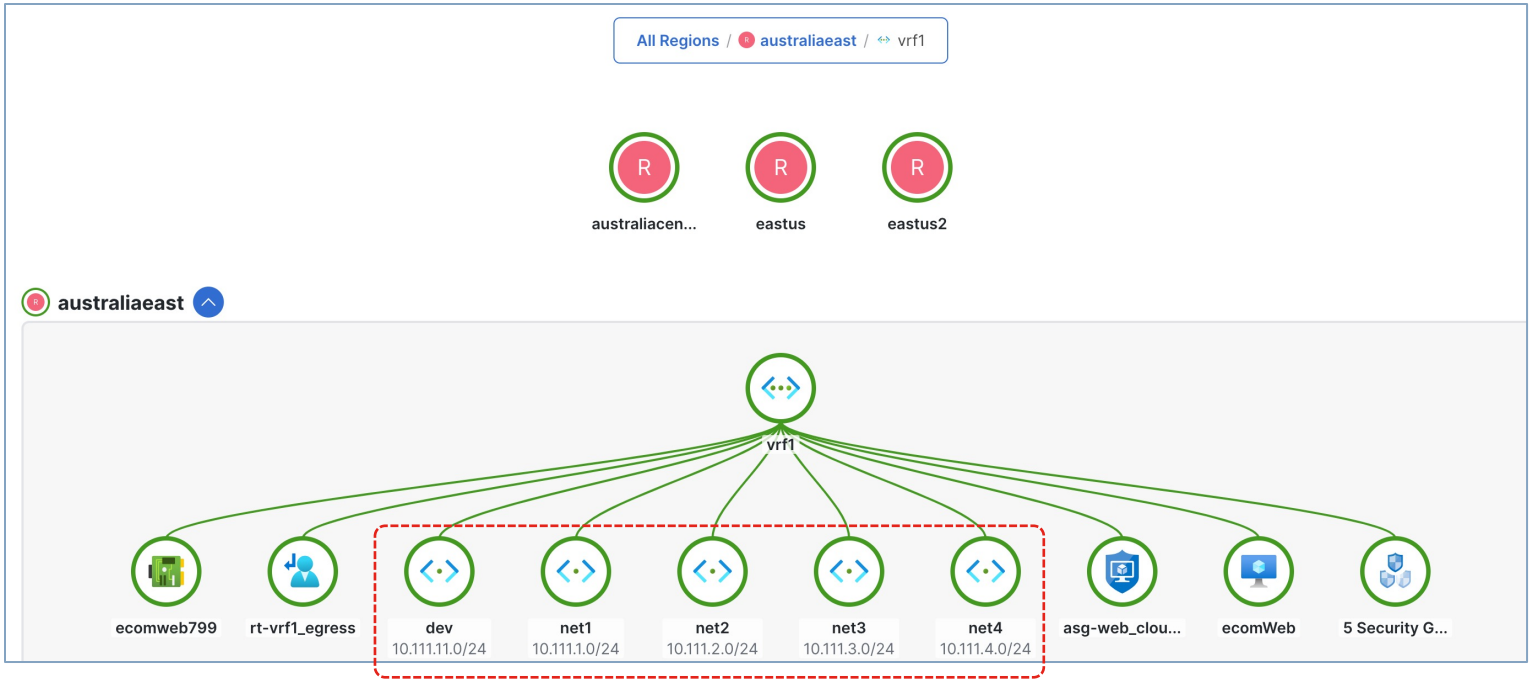
VNet detail



Subnets

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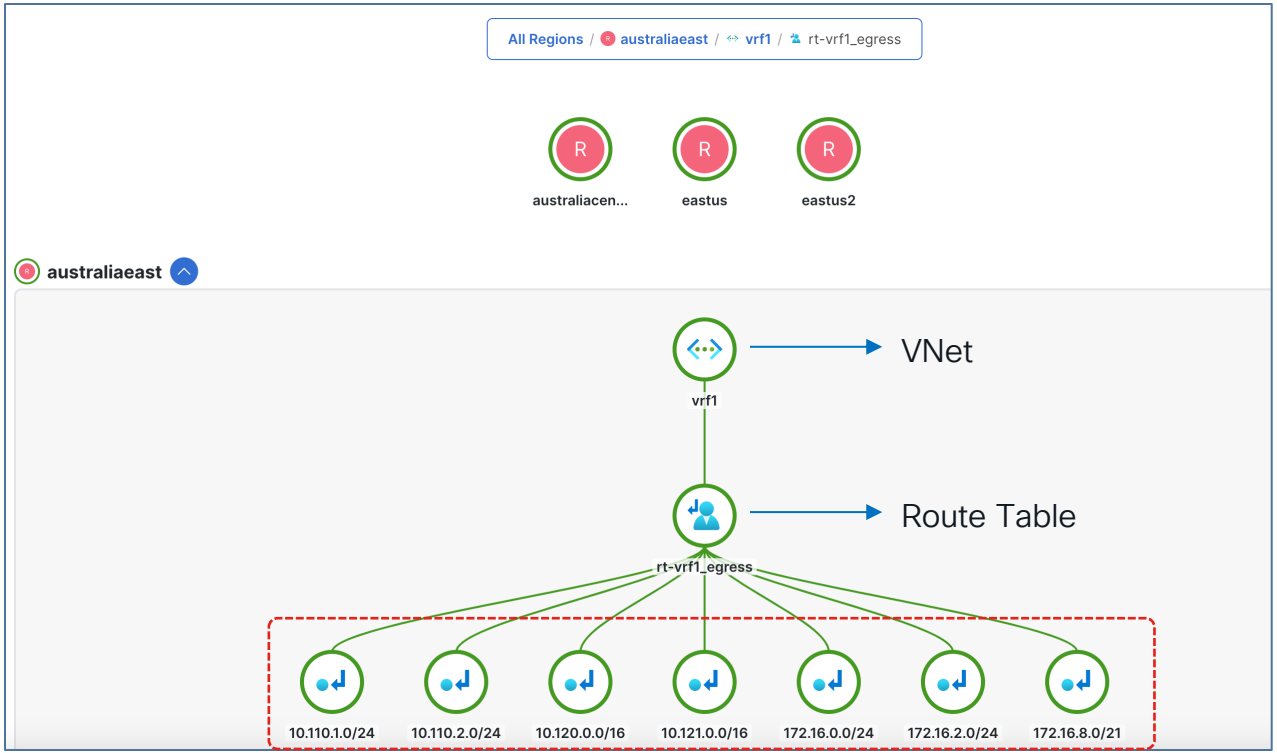
Route table detail



Route Table entries

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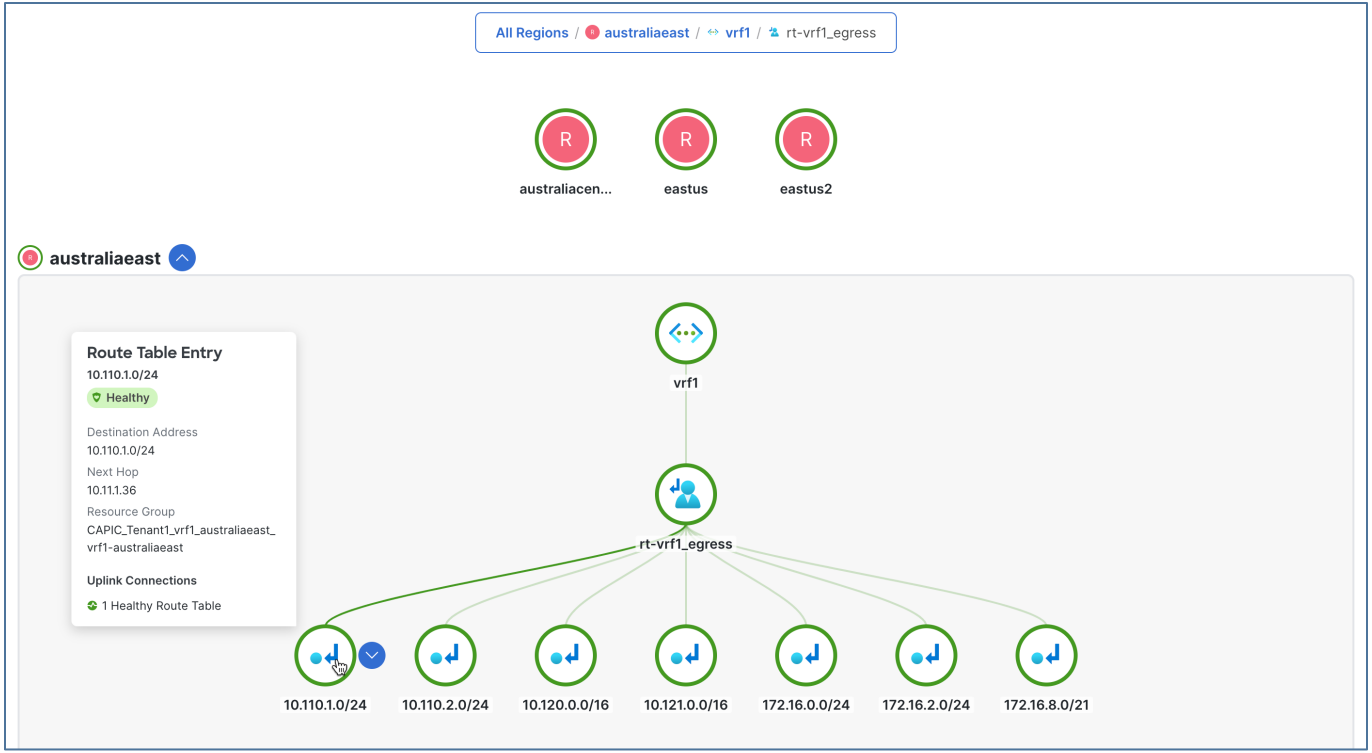
Route table entry detail



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Search

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Visibility: AWS Inter Region

Thousand Eyes: Dallas, TX to Ashburn, VA

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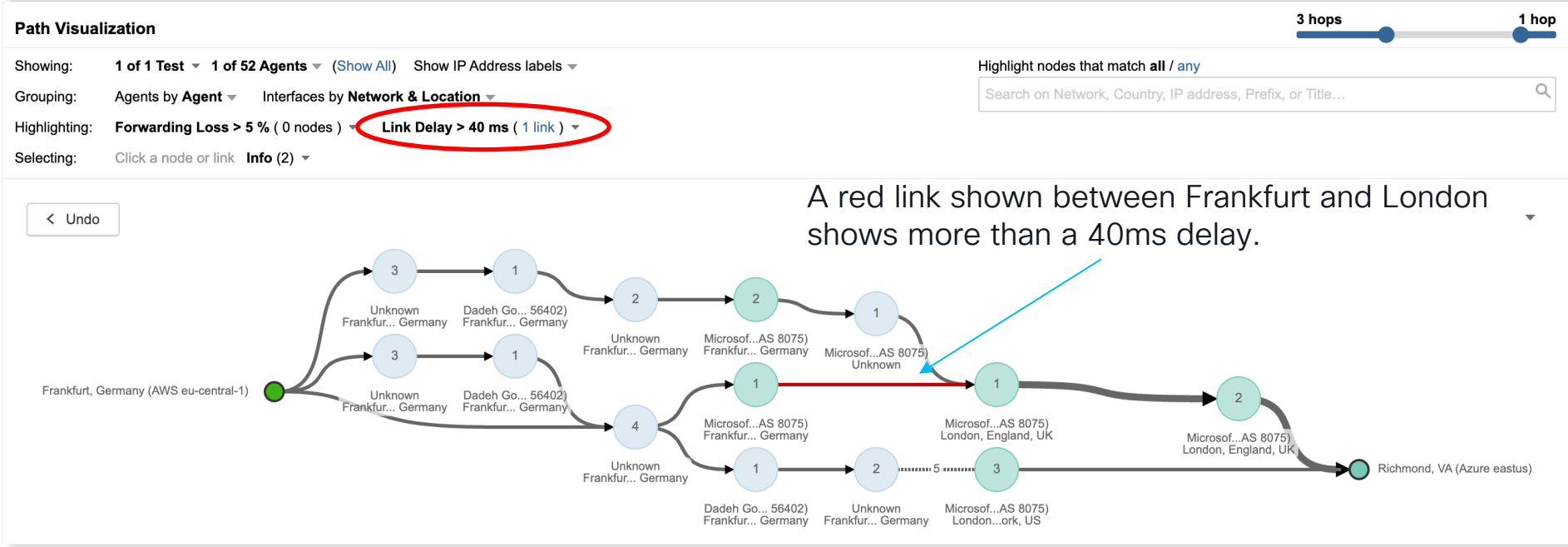
Visibility: AWS/Azure Inter Cloud

Thousand Eyes – Frankfurt, Germany AWS to Richmond, VA US Azure



- Provider-to-provider path analysis w/ direct peering relationships.
- Traffic from AWS through an intermediate provider but still gets on the Azure backbone before leaving Frankfurt

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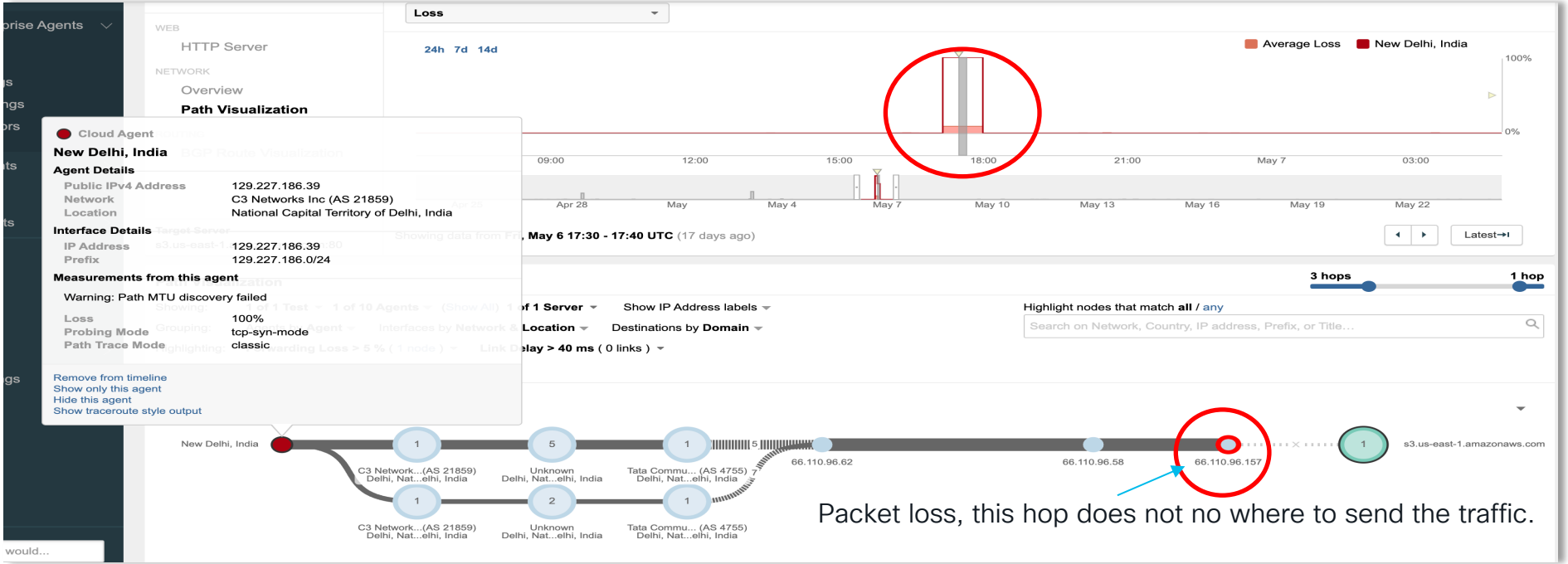
Visibility: AWS/Azure Inter Cloud

Thousand Eyes – End user perspective from New Delhi to S3 Service



Depicted above is the loss of service, source of loss and time of outage.

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Finally, what About Infrastructure as Code?

https://registry.terraform.io/namespaces/CiscoDevNet

https://galaxy.ansible.com/cisco

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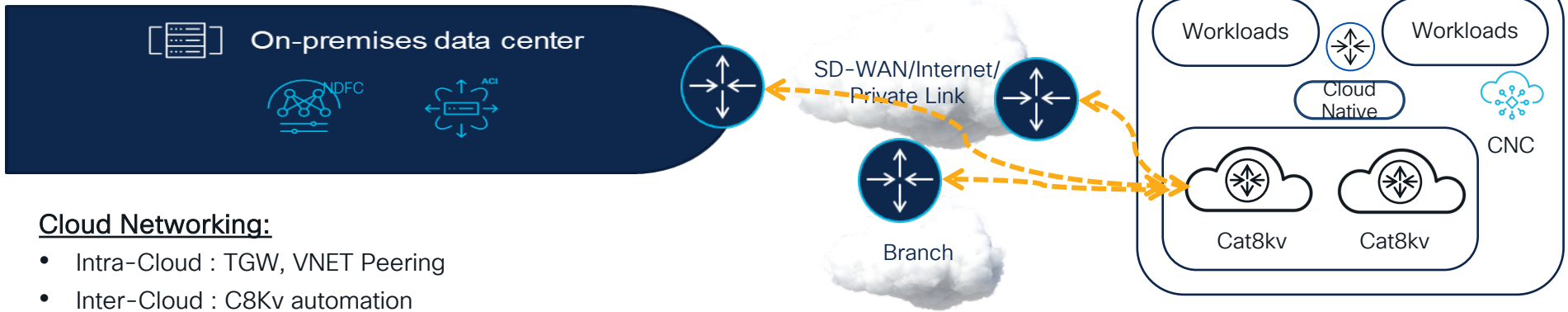
Summary
Cloud Network Controller



Cloud Networking:
- Intra-Cloud : TGW, VNET Peering
- Inter-Cloud : C8Kv automation
- Connectivity: IPSEC, Direct Connect, Express Rt
- End Point Discovery

Visibility:
- View and connect to brownfield VPC networks
- Inventory and topology view

L4-L7 Services:
- Automate service insertion and service chaining (Load balancers, Firewalls, ...)

Segmentation:
- Extend segments from On-Premises to cloud
- Extend segments from cloud to cloud
- Security Group rule management

Public Cloud:
- AWS, Azure, Google Cloud

Open APIs:
- Enable automation using Terraform and Ansible

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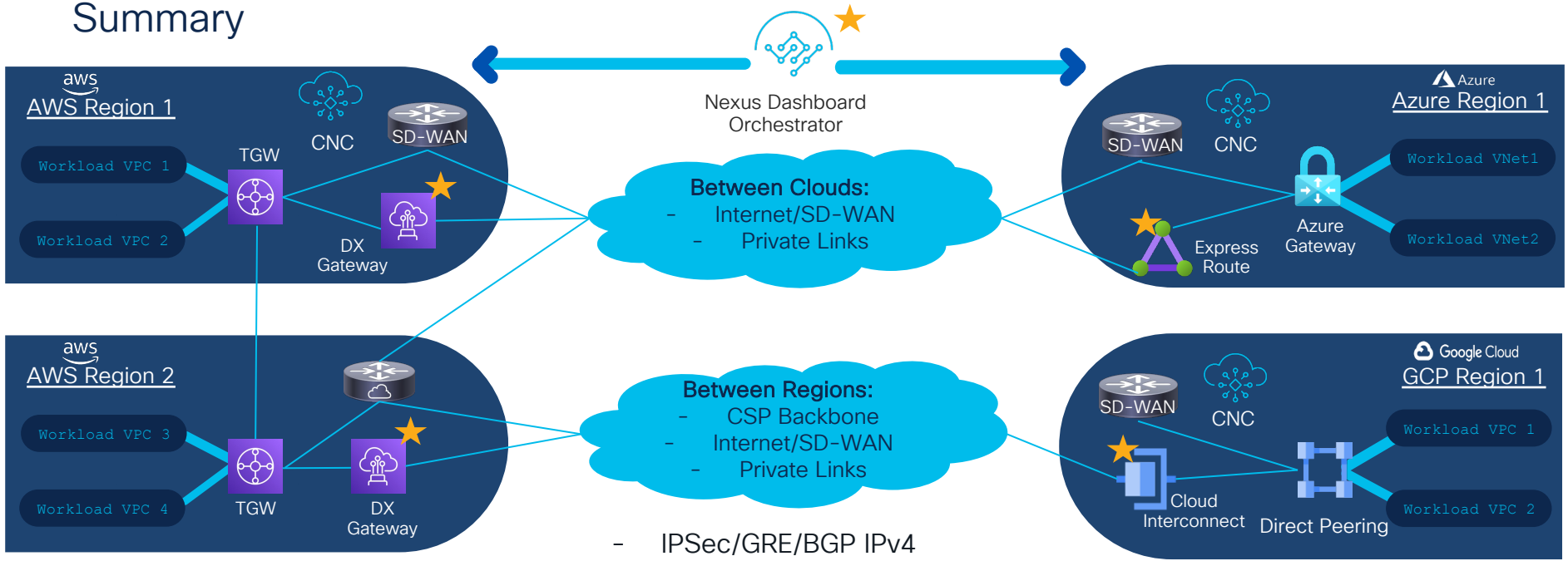
Multi-Cloud Options with Cloud Network Controller

Summary



- IPSec/GRE/BGP IPv4
- BGP VXLAN EVPN (ACI/NDFC)
- SD-WAN GRE/OMP
- Branch non-SD-WAN
- Cloud Native

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Additional Information

- Equinix and Cisco are Enabling Cybersecurity on a Global Scale

https://blog.equinix.com/blog/2022/06/06/equinix-and-cisco-are-enabling-cybersecurity-on-a-global-scale/

- Cisco Hybrid Multi-Cloud Networking Design Guide

https://www.cisco.com/c/en/us/td/docs/dcn/whitepapers/cisco-cloud-aci-hybrid-multicloud-design-guide.html

- Network Service Mesh: Linking multi-cloud workloads

https://www.networkworld.com/article/3662750/network-service-mesh-linking-multicloud-workloads.html

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Friday	**10:30am – 1:30pm**

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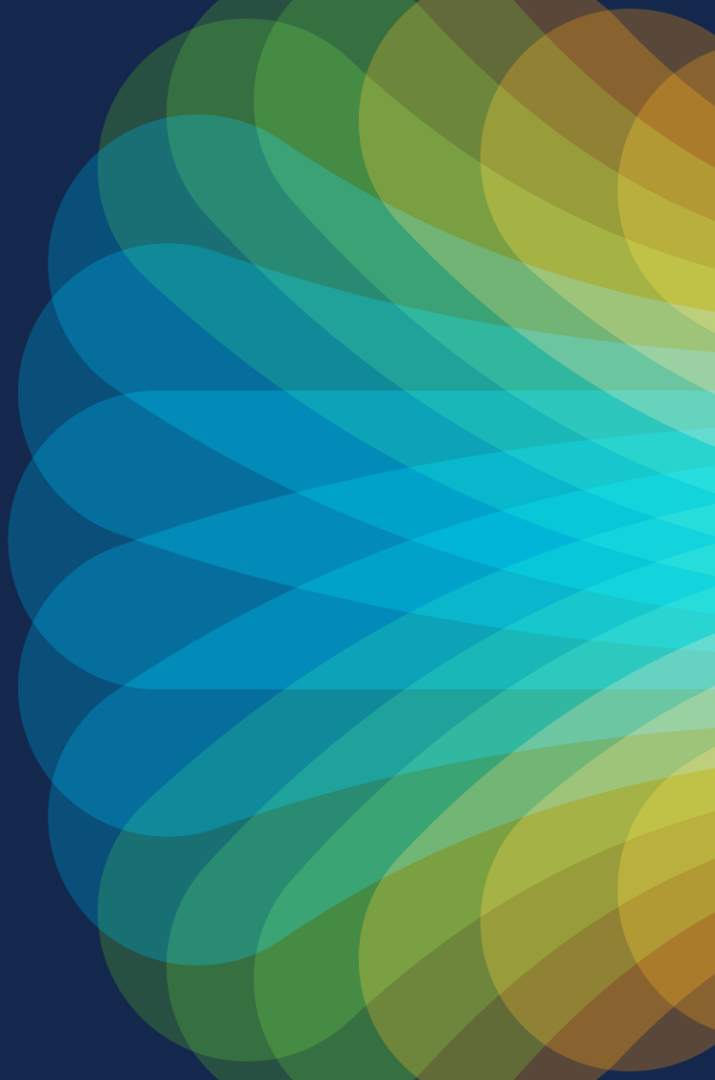
The bridge to possible

Thank you



Let's go