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The bridge to possible

Untangle Enterprise Direct Cloud Connectivity

with Powerful Catalyst 8500 Series Edge Platforms

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@sumantmali

BRKENT-2809

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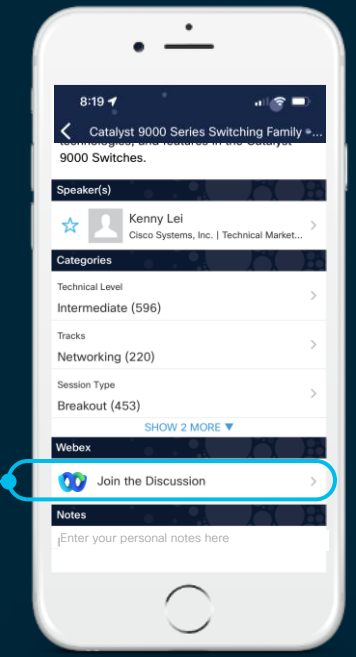
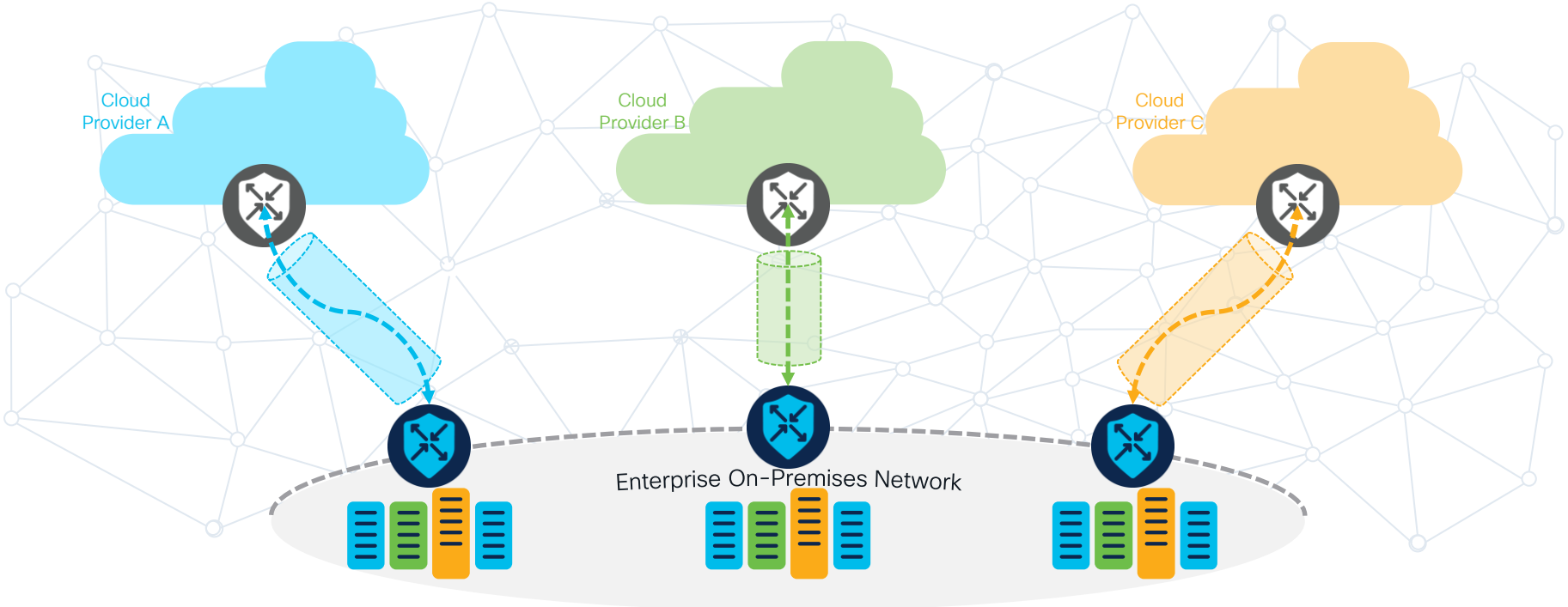


https://ciscolive.ciscoevents.com/ciscolivebot/#BRKENT-2809

Agenda

- Why Cloud Direct Connect?
- Azure ExpressRoute
- AWS Direct Connect
- GCP Cloud Interconnect
- Catalyst 8500 Platform Overview
- References

Why Cloud Direct Connect?

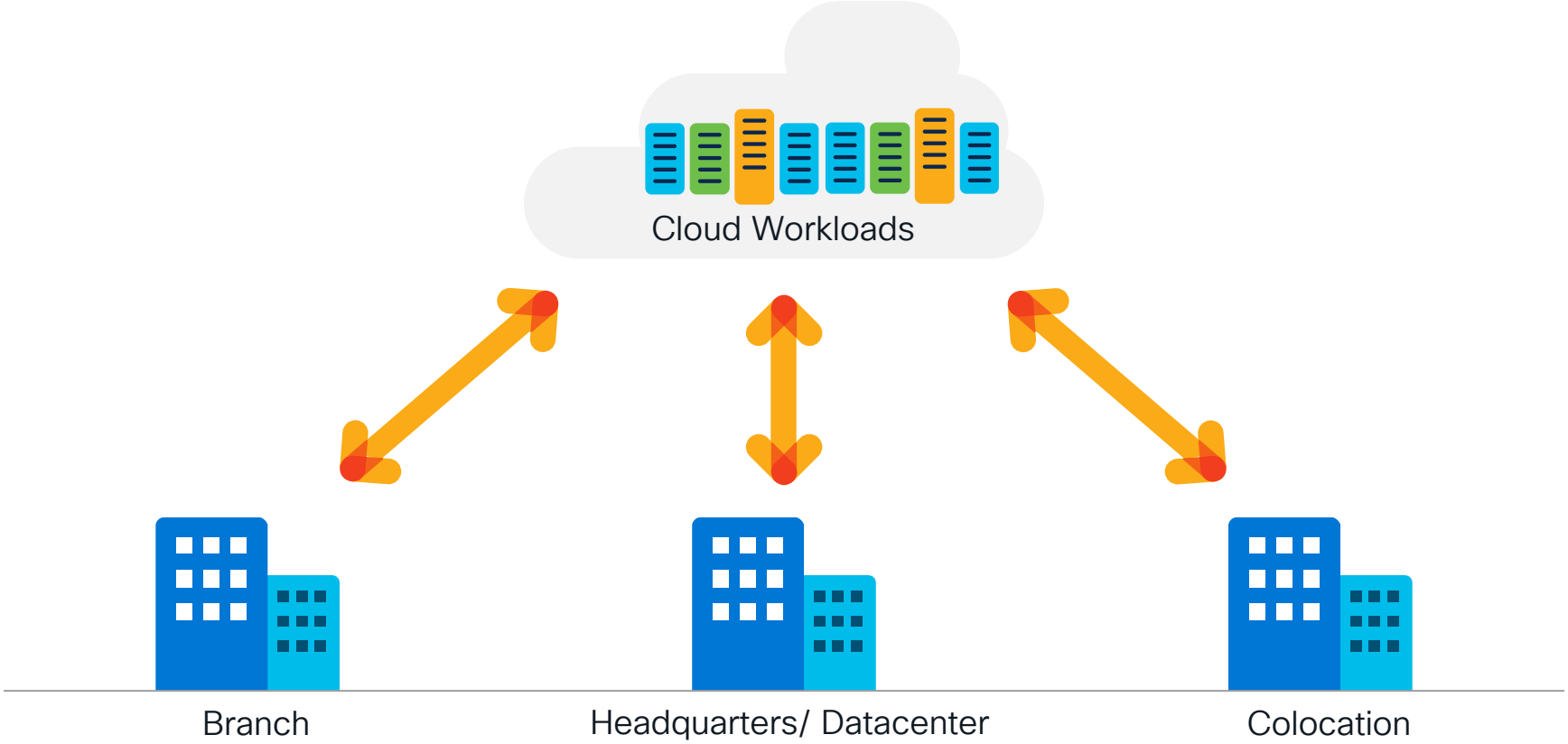


Risks with Public Internet

ISP Costs vs Performance

Variable Network Experience

On-premise Network and Cloud Workloads

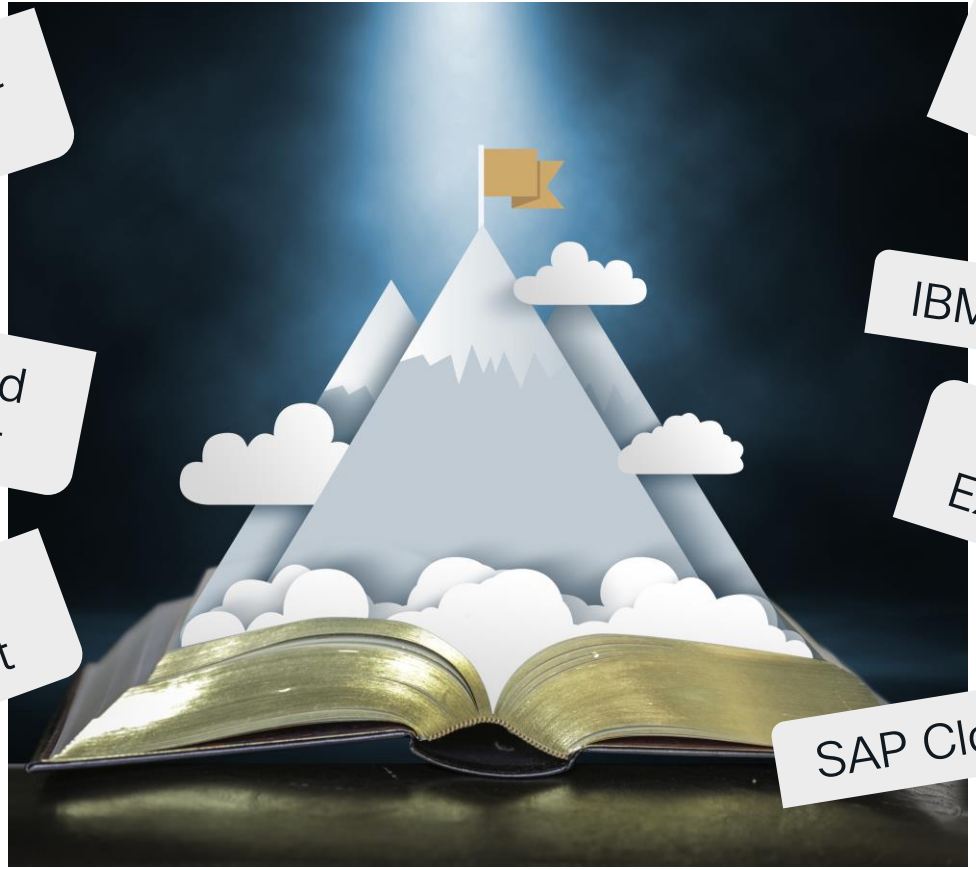


Cloud Direct Connectivity Providers

AWS Direct Connect

Google Cloud Interconnect

Oracle Cloud FastConnect



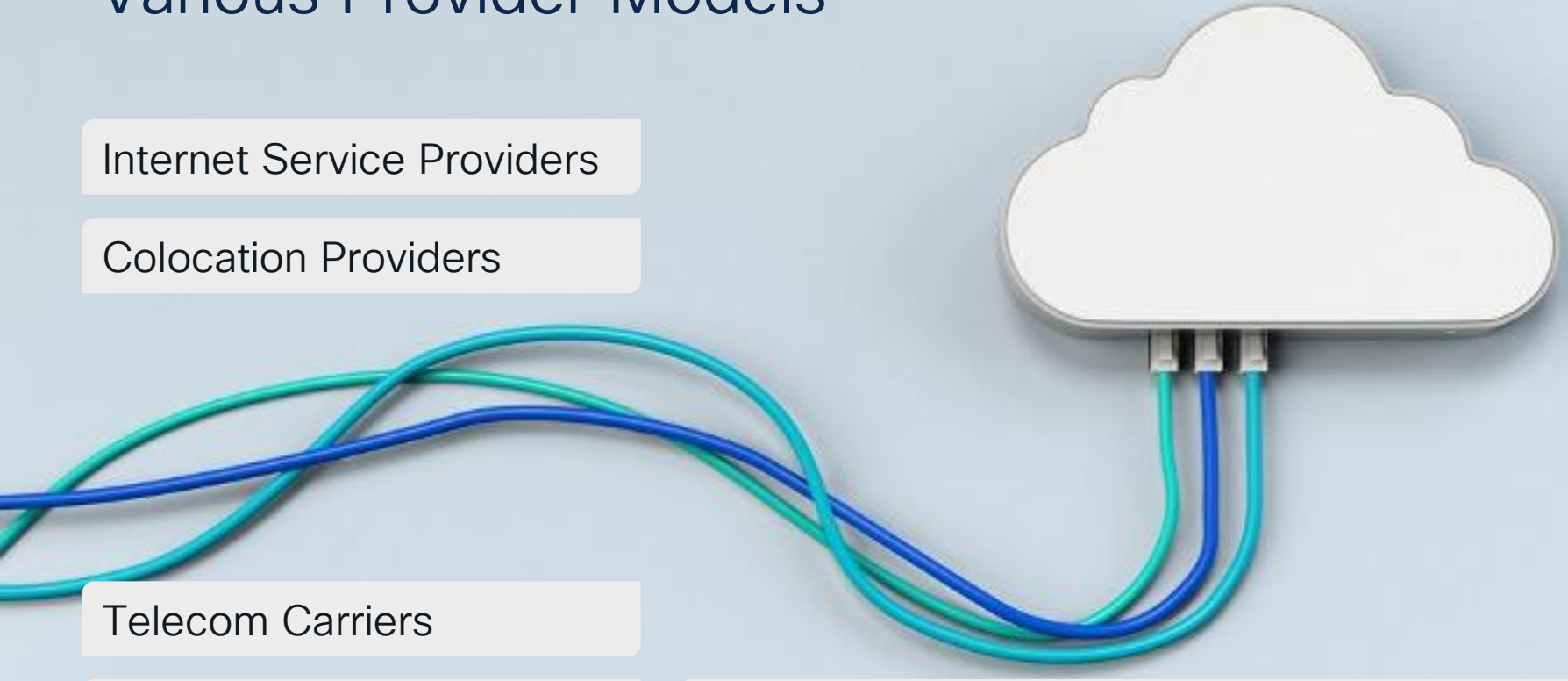
Microsoft Azure ExpressRoute

IBM Cloud Direct Link

Salesforce Express Connect

SAP Cloud Peering

Various Provider Models



Internet Service Providers

Colocation Providers

Telecom Carriers

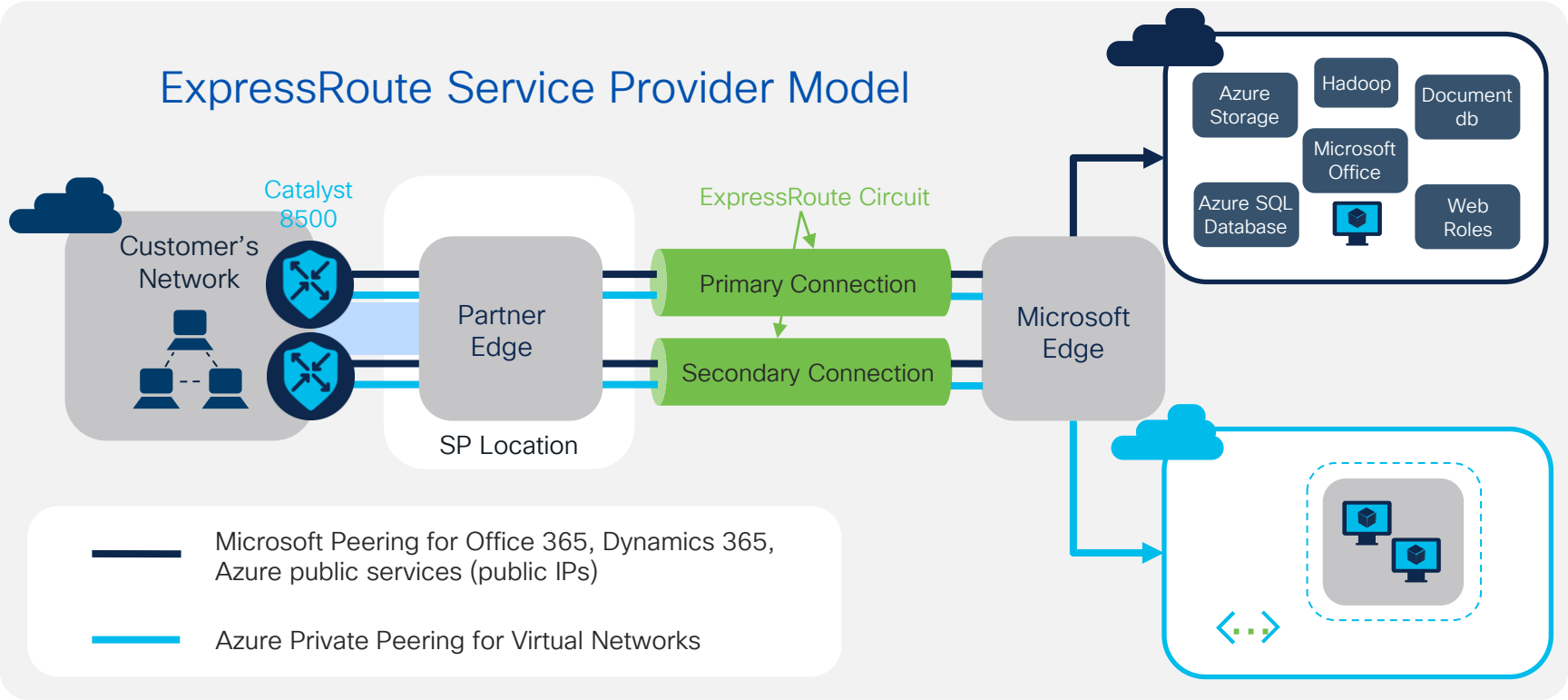
Network Providers

Cloud Connectivity, Interconnection Providers

Azure ExpressRoute with C8500 Platforms

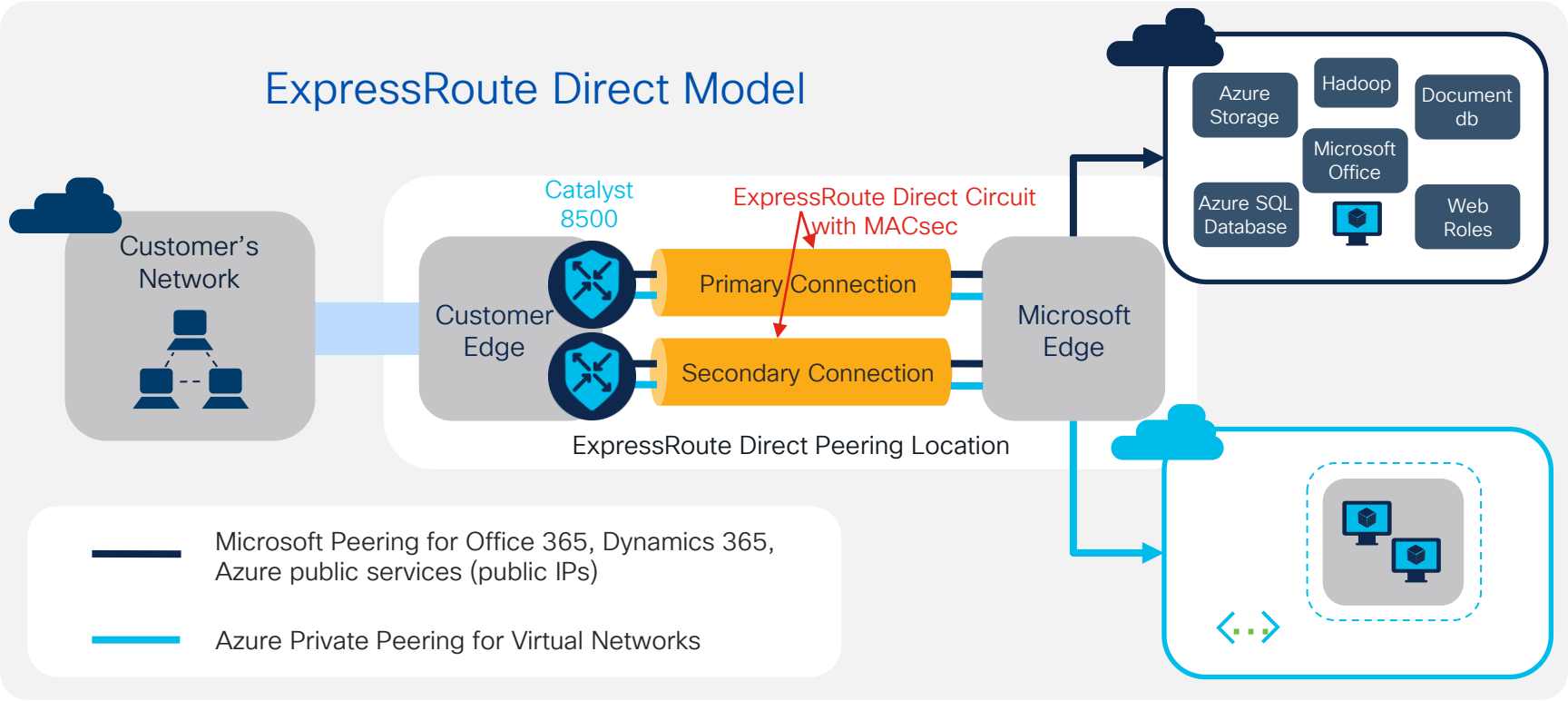
Azure ExpressRoute

Catalyst 8500 as ER Customer Edge

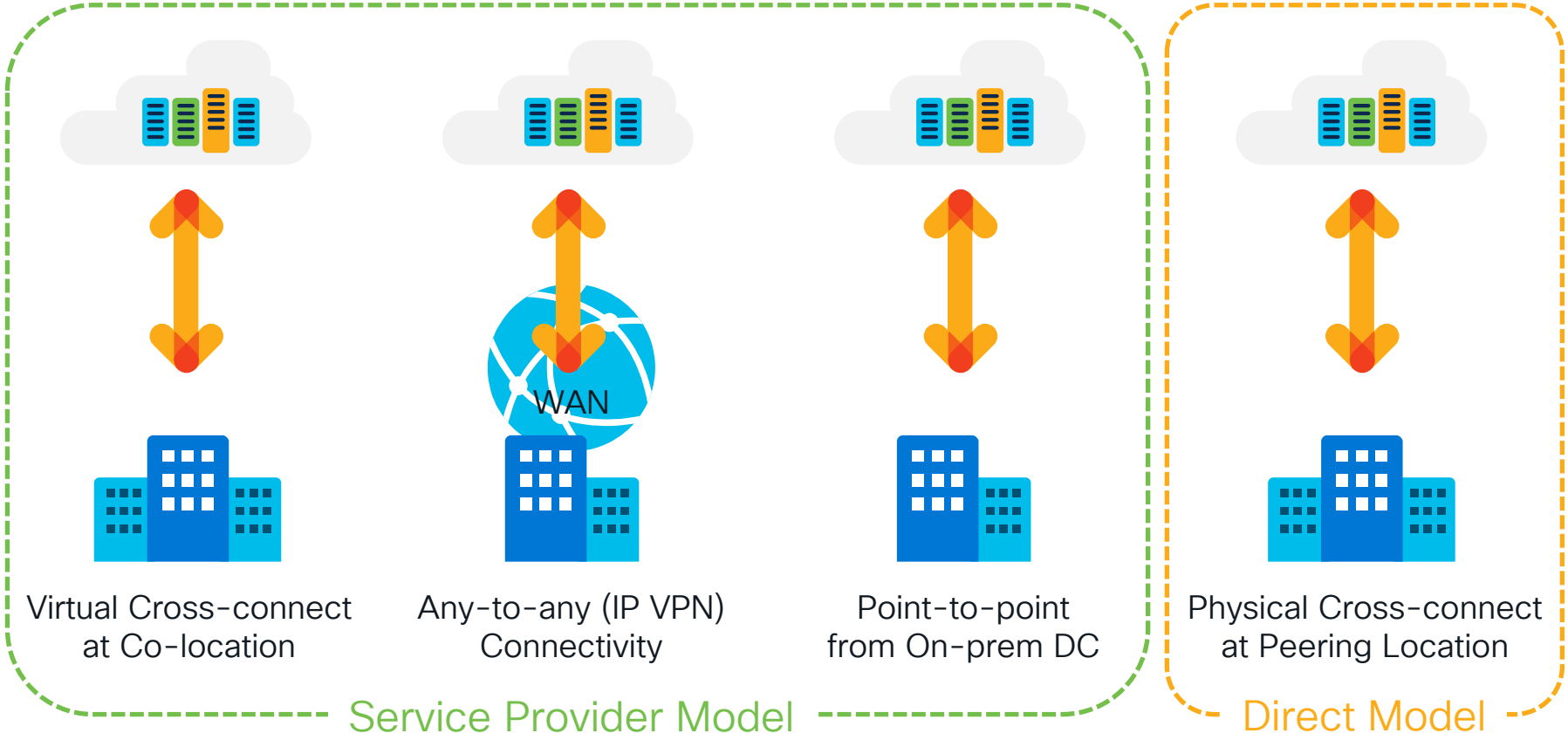


Azure ExpressRoute Direct + MACsec

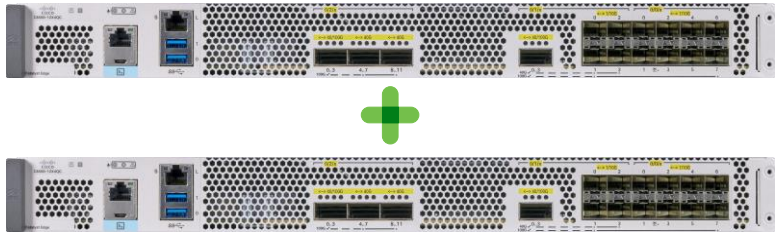
Catalyst 8500 as ER Direct Customer Edge



ExpressRoute Connectivity Models

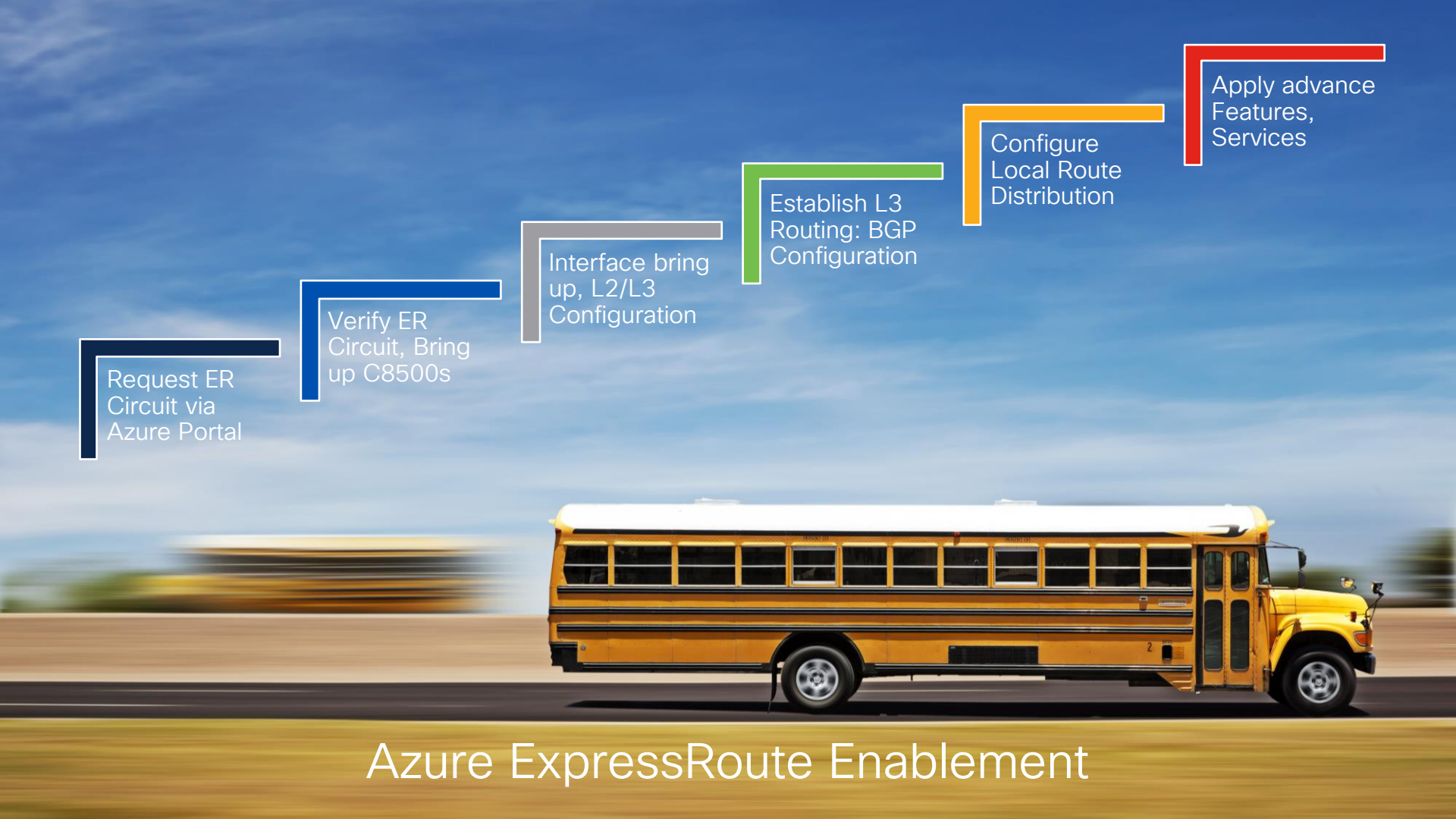


Two Router vs One Router Deployment



- Azure always offers two BGP Neighbors for each peering connection
- Active/Active redundancy for direct cloud connect

- Single point failure with absence of redundant direct connect path
- Provider Model might have various options


Request ER Circuit via Azure Portal
Verify ER Circuit, Bring up C8500s
Interface bring up, L2/L3 Configuration
Establish L3 Routing: BGP Configuration
Configure Local Route Distribution
Apply advance Features, Services
Azure ExpressRoute Enablement

Verify Circuit Status– ER Direct Model

Home > Resource groups > SEA-Cust30 >

SEA-Cust30-ER

ExpressRoute circuit

Search (Cmd+/)

Delete | Refresh

- Overview
- Activity log
- Access control (IAM)
- Tags
- Diagnose and solve problems

Settings

- Configuration
- Connections
- Authorizations
- Peerings
- Properties
- Locks

Monitoring

- Alerts
- Metrics
- Diagnostic settings
- Logs

Essentials — View Cost | JSON View

Resource group (change)
SEA-Cust30

ExpressRoute Direct Resource
SEA-100Gb-VendorTest

Circuit status
Enabled

Peering location
Equinix-Seattle-SE2

Location
West US 2

Bandwidth
1 Gbps

Subscription (change)
ExpressRoute-Lab

Service key
65b785ea-4c22-44d0-bf80-0dced4ab6940

Subscription ID
4bffbb15-d414-4874-a2e4-c548c6d45e2a

Tags (change)
Click here to add tags

Peerings

Type	Status	Primary subnet	Secondary subnet	Last modified by
Azure private	Provisioned	Two subnets configured	Two subnets configured	Customer
	Enabled	192.168.30.16/30	192.168.30.20/30	
	Enabled	fd:1:1:30FF::/126	fd:1:1:30FF::4/126	
Azure public	Not provisioned	-	-	-
Microsoft	Provisioned	One subnet configured	One subnet configured	Customer
	Enabled	198.137.97.24/30	198.137.97.28/30	

Verify Circuit Status– ER Provider Model

Home > Resource groups > ASH-Cust13 >

ASH-Cust13-ER
ExpressRoute circuit

Search (Ctrl+/)

- Overview
- Activity log
- Access control (IAM)
- Tags
- Diagnose and solve problems

Settings

- Configuration
- Connections
- Authorizations
- Peerings
- Properties
- Locks

Monitoring

- Alerts
- Metrics
- Diagnostic settings
- Logs

Delete | Refresh | Restore

Essentials | View Cost | JSON View

Resource group (change)	: ASH-Cust13	Provider	: Equinix
Circuit status	: Enabled	Provider status	: Provisioned
Location (change)	: East US	Peering location	: Washington DC
Subscription (change)	: ExpressRoute-Lab	Bandwidth	: 50 Mbps
Subscription ID	: 4bffbb15-d414-4874-a2e4-c548c6d45e2a	Service key	: dc694d2a-c4e2-498c-9000-036e69de949a
Tags (change) :			

Peerings

Type	Status	Primary subnet	Secondary subnet	Last modified by
Azure private (1) - Provisioned				
	Enabled	192.168.13.16/30	192.168.13.20/30	Customer
Azure public (0) - Not provisioned				
Microsoft (0) - Not provisioned				

Two Router Peering Configuration Example

Feature	R1				R2			
Interfaces	Hu0/2/0		Hu0/1/0		Hu0/2/0		Hu0/1/0	
Interface description	Connection to ER Primary		Connection to customer corporate network		Connection to ER Secondary		Connection to customer corporate network	
Sub-interfaces	0/2/0.301	0/2/0.300	0/1/0.301	0/1/0.300	0/2/0.301	0/2/0.300	0/1/0.301	0/1/0.300
Sub-interface description	Primary Microsoft Peering	Primary Private Peering	DMZ VLAN	Corporate VLAN	Secondary Microsoft Peering	Secondary Private Peering	DMZ VLAN	Corporate VLAN
Encapsulation	dot1Q 100 second-dot1q 301 or dot1Q 301	dot1Q 100 second-dot1q 300 or dot1Q 300	dot1Q 301	dot1Q 300	dot1Q 100 second-dot1q 301 or dot1Q 301	dot1Q 100 second-dot1q 300 or dot1Q 300	dot1Q 301	dot1Q 300
VRFs*	301	300	301	300	301	300	301	300
IP Addresses	198.137.97.25/30	192.168.30.17/30	10.1.30.1/30	10.1.30.5/30	198.137.97.29/30	192.168.30.21/30	10.1.30.9/30	10.1.30.13/30

Customer Corporate Interface Configuration

Connectivity to On-premises Network

```
interface HundredGigE0/1/0
 description Customer Corporate Network Connection
 no ip address
!
interface HundredGigE0/1/0.300
 description Customer Corporate VLAN for Private Peering
 encapsulation dot1Q 300
 vrf forwarding 300
 ip address 10.1.30.1 255.255.255.252
!
interface HundredGigE0/1/0.301
 description Customer DMZ VLAN for Microsoft Peering
 encapsulation dot1Q 301
 vrf forwarding 301
 ip address 10.1.30.5 255.255.255.252
!
```

802.1Q VLAN ID Interface Configuration

Connectivity towards ExpressRoute

```
interface HundredGigE0/2/0
 description Customer ExpressRoute Primary Connection
 no ip address
!
interface HundredGigE0/2/0.300
 description Customer Private Peering to Azure
 encapsulation dot1Q 300
 vrf forwarding 300
 ip address 192.168.30.17 255.255.255.252
 ipv6 address FD:1:1:30FF::1/126
!
interface HundredGigE0/2/0.301
 description Customer Microsoft Peering to Azure
 encapsulation dot1Q 301
 vrf forwarding 301
 ip address 198.137.97.25 255.255.255.252
!
```

Example shows only primary router configuration, similar type of config will be applicable on secondary router

ExpressRoute peering configured with dot1Q vlan sub interfaces, the dot1Q vlan tag identifies peering service

802.1Q-in-Q VLAN ID Interface Configuration

Connectivity towards ExpressRoute

```
interface HundredGigE0/2/0
 description Customer ExpressRoute Primary Connection
 no ip address
 dot1q tunneling ethertype 0x9100
!
interface HundredGigE0/2/0.300
 description Customer Private Peering to Azure
 encapsulation dot1Q 100 second-dot1q 300
 vrf forwarding 300
 ip address 192.168.30.17 255.255.255.252
 ipv6 address FD:1:1:30FF::1/126
!
interface HundredGigE0/2/0.301
 description Customer Microsoft Peering to Azure
 encapsulation dot1Q 100 second-dot1q 301
 vrf forwarding 301
 ip address 198.137.97.25 255.255.255.252
```

Default ethertype is 0x8100, can be changed to 0x88A8|0x9100|0x9200 to meet the connectivity provider's requirement

ExpressRoute peering configured with Q-in-Q vlan sub interfaces, outer vlan tag identifies the Customer and inner vlan tag identifies peering service

Setup eBGP Sessions

Establish Layer 3 Connectivity

```
router bgp 65021
 bgp router-id 198.137.97.25
 bgp log-neighbor-changes
 !
 address-family ipv4 vrf 300
  neighbor 192.168.30.18 remote-as 12076
  neighbor 192.168.30.18 activate
  neighbor 192.168.30.18 next-hop-self
  neighbor 192.168.30.18 soft-reconfiguration inbound
  neighbor 192.168.30.18 route-map only-advertise-private out
 exit-address-family
 !
 address-family ipv6 vrf 300
  neighbor FD:1:1:30FF::2 remote-as 12076
  neighbor FD:1:1:30FF::2 activate
  neighbor FD:1:1:30FF::2 next-hop-self
  neighbor FD:1:1:30FF::2 soft-reconfiguration inbound
 exit-address-family
 !
```

eBGP configuration for routing connectivity between Customer edge router and Azure end point. IPv4 and IPv6 neighborships. Similar config for other vrf 301 is required.

Advertise Prefixes over BGP session to Azure

Reference slide

```
router bgp 65021
!
 address-family ipv4 vrf 300
  network 10.1.30.4 mask 255.255.255.252
  redistribute connected
  redistribute static
 !
 address-family ipv6 vrf 300
  network 2001:5B0:4406:30::/64
 !
 address-family ipv4 vrf 301
  network 10.1.30.0 mask 255.255.255.252
  redistribute connected
  redistribute static
 !
 address-family ipv6 vrf 301
  network 2001:5B0:4406:31::/64
!
```

Block unwanted Prefixes

Reference slide

```
router bgp 65021
!
address-family ipv4 vrf 301
 neighbor 198.137.97.26 prefix-list block-list out
!
ip prefix-list block-list deny 10.0.0.0/8 le 32
ip prefix-list block-list deny 127.0.0.0/8 le 32
ip prefix-list block-list deny 172.16.0.0/12 le 32
ip prefix-list block-list deny 192.168.0.0/16 le 32
ip prefix-list block-list deny 224.0.0.0/3 le 32
ip prefix-list block-list permit 0.0.0.0/0 le 32
```

Route Table Summary – Private Peering

Realtime view of Routing Entries from Microsoft endpoint

Home > Resource groups > SEA-Cust30 > SEA-Cust30-ER >

Route table summary (Primary)

AzurePrivatePeering - SEA-Cust30-ER

Download

Primary Secondary

Neighbor	Version	Up/down	AS property	State/PfxRcd
10.17.30.140+49955	4	0	65515	1
10.17.30.141+49901	4	0	65515	1
192.168.30.17+52761	4	7	65020	2
fd:1:1:30ff::1+42188	4	0	65020	1

Route Table Summary – Microsoft Peering

Realtime view of Routing Entries from Microsoft endpoint

Home > Resource groups > SEA-Cust30 > SEA-Cust30-ER >

Route table summary (Primary)

MicrosoftPeering - SEA-Cust30-ER

Download

Primary Secondary

Neighbor	Version	Up/down	AS property	State/PfxRcd
198.137.97.25+179	4	7	65020	2

MACsec Enablement for ExpressRoute Direct

```
mka policy xpn-p1
 macsec-cipher-suite gcm-aes-xpn-256
!
key chain azure-macsec macsec
 key 1
   cryptographic-algorithm aes-256-cmac
  key-string
1234567890abcdef1234567890abcdef1234567890abcdef1234567890abcdef
!

interface HundredGigE0/2/0
 no ip address
 mka policy xpn-p1
 mka pre-shared-key key-chain azure-macsec
 macsec disable-sci
 macsec
!
```

Configure MKA Policy with desired XPN cipher and associated key-string, this key-string would also be enabled on Azure portal

SCI can be disabled based on remote end configuration, apply MACsec key, policy configuration on main interface

Note: Azure ER circuit recently started supporting both XPN and non-XPN AES algorithm. The support for SCI disablement on C8500L-8S4X is on roadmap. Azure recently started supporting SCI and non-SCI options for ER direct.

MACsec Enablement for ExpressRoute Direct

Home > Resource groups > SEA-Cust30 > SEA-Cust30-ER >

SEA-100Gb-VendorTest

ExpressRoute Direct

Search (Cmd+/)

- Overview
- Activity log
- Access control (IAM)
- Tags
- Diagnose and solve problems

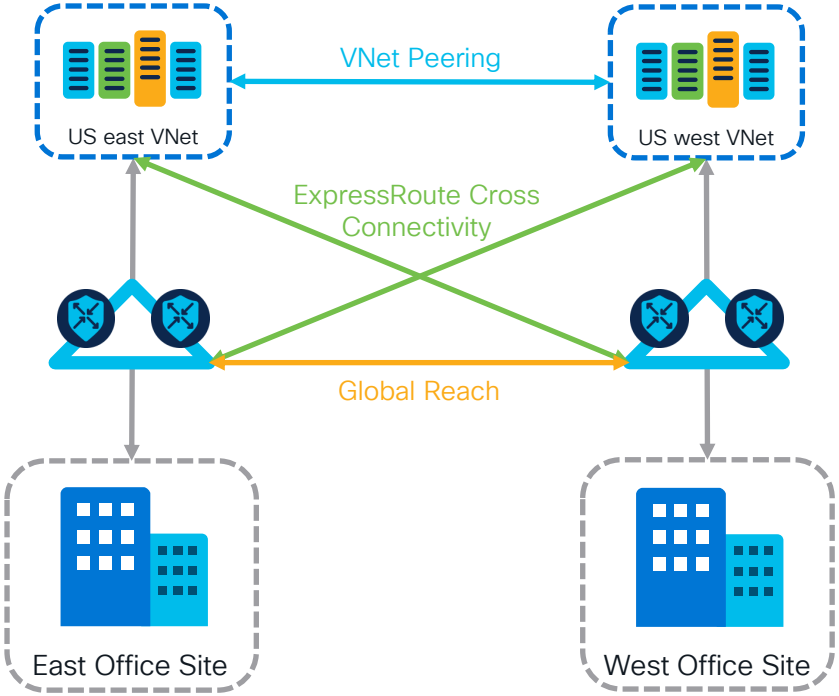
Delete | Refresh | Generate Letter of Authorization

Essentials — View Cost | JSON View

Links

Name	Admin State	MacSec	Router Name	Interface Name
link1	Enabled	Enabled	exr01.wst	et-1/1/6
link2	Disabled	Enabled	exr02.wst	et-1/1/6

Network Level Connectivity Choices



1. Connect Virtual Networks together

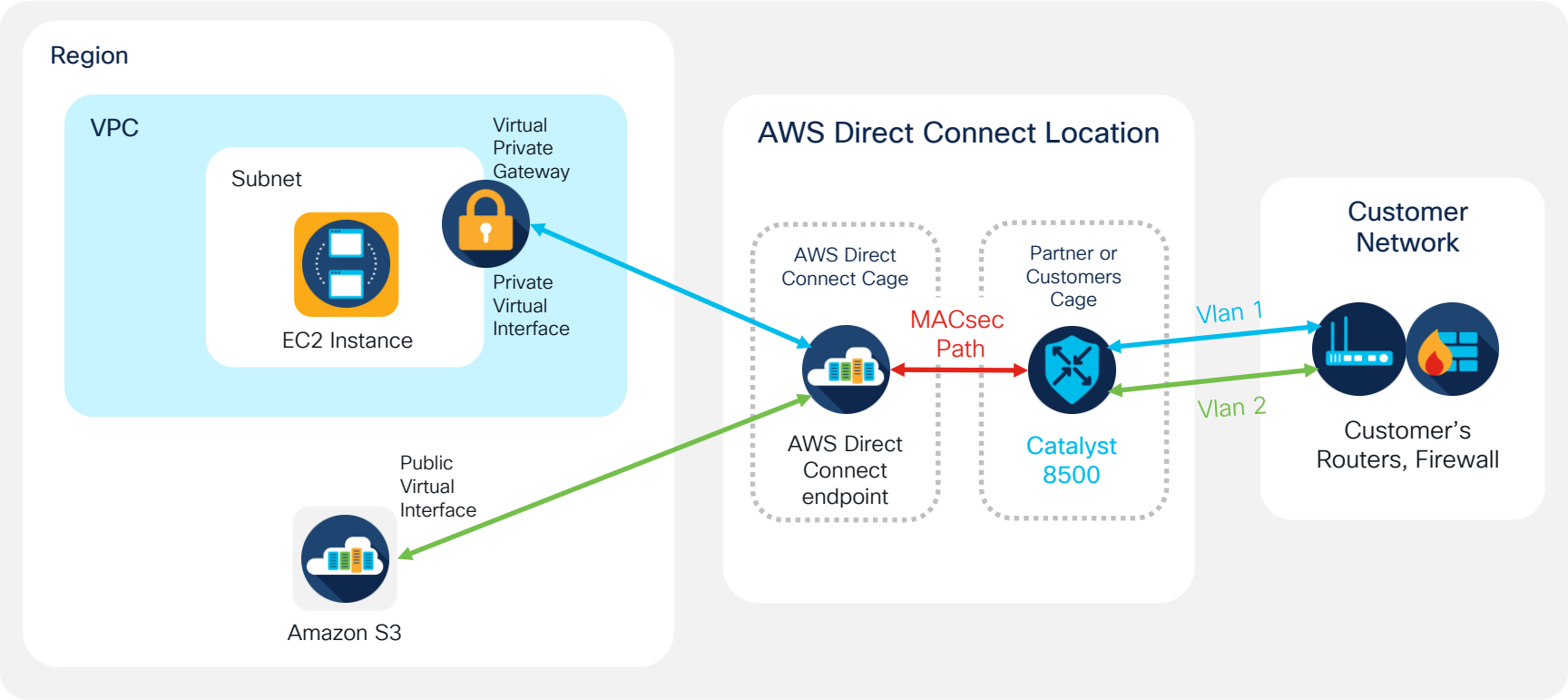
2. Cross connect Virtual Networks with remote sites

3. Cross connect sites using Global Reach

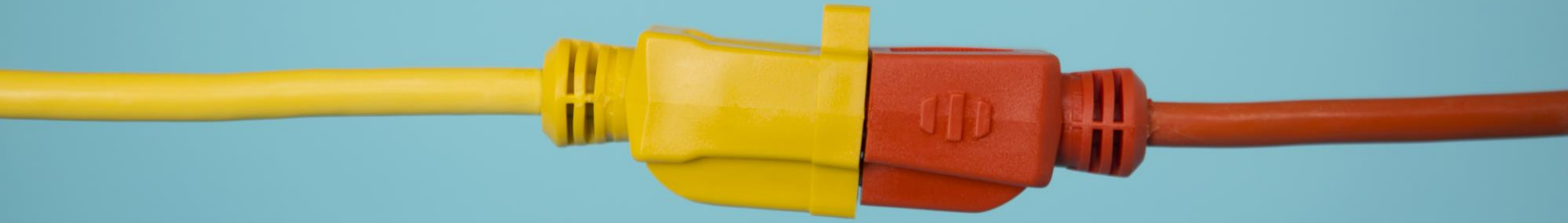
AWS Direct Connect

AWS Direct Connect + MACsec

Catalyst 8500 as AWS DX Customer Edge



Physical Connectivity → Configure Port-Channel → Member link Configuration → Enable MACsec → Verify Connectivity



AWS Direct Connect Enablement

Port-Channel Configuration

```
interface Port-channel5
 mtu 9216
 vrf forwarding cust-c
 no ip address
end
!
interface Port-channel5.105
 encapsulation dot1Q 105
 vrf forwarding cust-c
 ip address 192.168.105.2 255.255.255.0
end
```

Direct connect Connectivity VRF

Direct connect Connectivity Vlan ID

Note: Remote side AWS end-point configuration is done via AWS Direct Connect enablement tools. The AWS use-case configuration is verified for C8500 interoperability in Internal CPOC lab.

AWS MACsec Considerations

Parameter	Description
CKN length	This is a 64-hexadecimal character (0–9, A–E) string. Use the full length to maximize cross-platform compatibility.
CAK length	This is a 64-hexadecimal character (0–9, A–E) string. Use the full length to maximize cross-platform compatibility.
Cryptographic algorithm	AES_256_CMAC
SAK Cipher Suite	• For 100 Gbps connections: GCM_AES_XPN_256 • For 10 Gbps connections: GCM_AES_XPN_256 or GCM_AES_256
Key Cipher Suite	16
Confidentiality Offset	0
ICV Indicator	No
SAK Rekey Time	PN Rollover>

Key and MKA Policy Configuration

```
key chain KEY_1 macsec
 description MACsec Link to AWS
 key 01
   cryptographic-algorithm aes-256-cmac
  key-string
0123456789012345678901234567890123456789012345678901234567890123
   lifetime 00:00:00 Jan 1 2022 infinite
!
mka policy aws-test
 key-server priority 10
 macsec-cipher-suite gcm-aes-xpn-256
 sak-rekey interval 3600
 ssci-based-on-sci
!
```

MACsec 64 hexadecimal key configuration

MKA Policy with XPN Cipher configuration, key-server priority should be non-zero

Important config to interop using XPN cipher with N9K remote end MACsec SCI capabilities

Interface Configuration

```
interface HundredGigE0/1/0
 mtu 9216
 no ip address
 ip mtu 9184
 negotiation auto
 mka policy aws-test
 mka pre-shared-key key-chain KEY_1
 macsec access-control should-secure
 macsec replay-protection window-size 512
 macsec
 channel-group 5
end
```

Attach MACsec Policy and Key Configuration

Expected Window size based on remote end configuration

Configure port-channel Member for Po5

100G MACsec DX Verification

Reference slide

```
C8500-12X4QC-2#show mka sessions interface Hu0/1/0


Summary of All Currently Active MKA Sessions on Interface HundredGigE0/1/0...


===========================================================================================
Interface       Local-TxSCI          Policy-Name       Inherited         Key-Server
Port-ID         Peer-RxSCI           MACsec-Peers      Status            CKN
===========================================================================================
Hu0/1/0         f04a.022a.dec4/0018 aws-test          NO                NO
24              a0b4.39b6.e684/0001 1                 Secured           01



C8500-12X4QC-2#
```

MACsec session should be in Secured state

Correct Key (CKN) and MACsec Policy should be applied as per config.

100G MACsec DX Verification

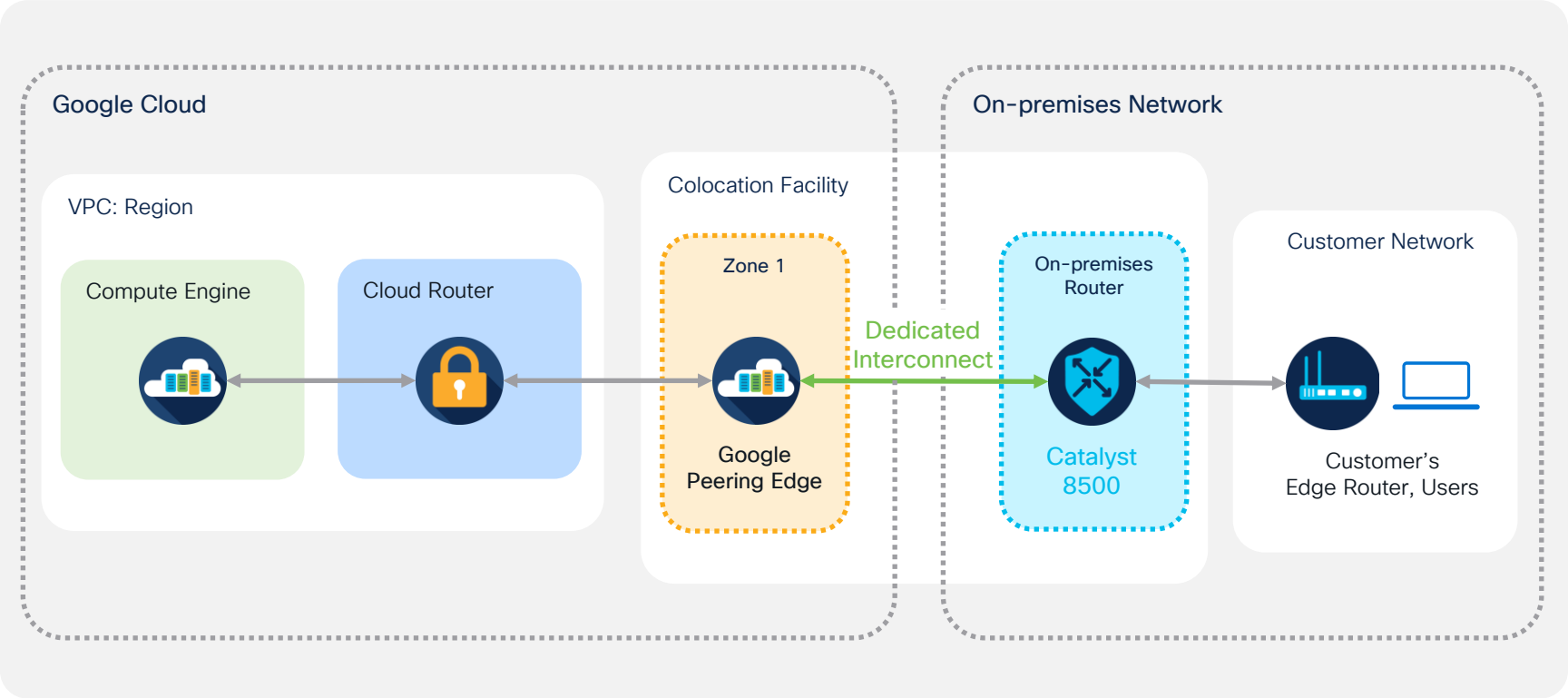
Reference slide

```
C8500-12X4QC-2#sh macsec status interface Hu0/1/0
 Capabilities:
  Ciphers Supported:        GCM-AES-128 GCM-AES-256 GCM-AES-XPN-128 GCM-AES-XPN-256
  Cipher:                   GCM-AES-XPN-256
  Confidentiality Offset:   0
  Replay Window:            512
  Delay Protect Enable:     FALSE
  Access Control:           should-secure
  Include-SCI:              TRUE


 Transmit SC:
  SCI:                      F04A022ADEC40018
  Transmitting:             TRUE
 Transmit SA:
  Next PN:                  2
  Delay Protect AN/nextPN:  NA/0


 Receive SC:
  SCI:                      A0B439B6E6840001
  Receiving:                TRUE
 Receive SA:
  Next PN:                  18
  AN:                       0
  Delay Protect AN/LPN:     0/0
C8500-12X4QC-2#
```

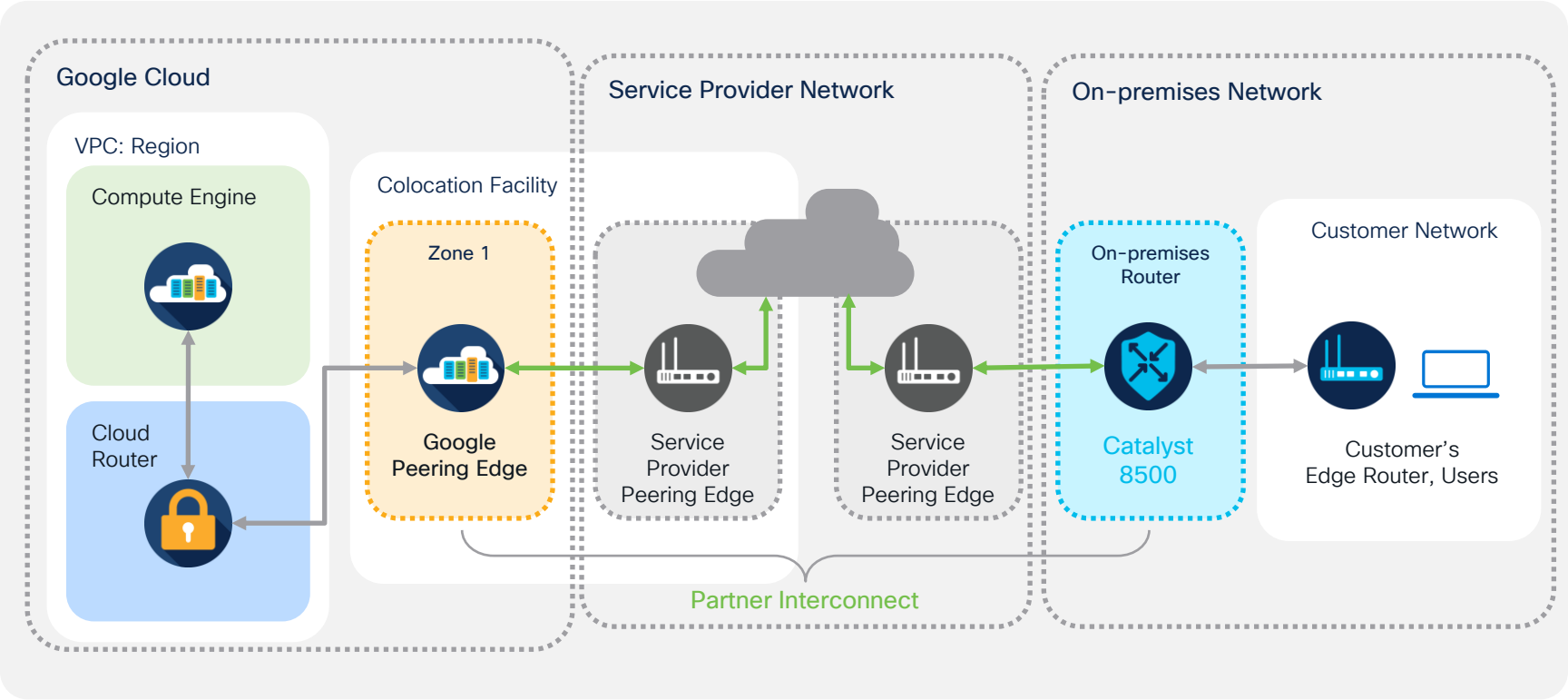
Correct cipher should be applied as per config.

Google Cloud Interconnect

Google Cloud Dedicated Interconnect



Google Cloud Partner Interconnect



Port-channel, interface configuration

```
interface Po2
  description Layer3 peering with GC dedicated interconnect
  no shut
!
interface Po2.101
  description attachment_vlan101
  encapsulation dot1Q 101
  ip address 169.254.10.2 255.255.255.248
  ip mtu 1440
!
!
interface Hu0/0/0
  description Customer dedicated interconnect primary connection
  channel-group 2 mode active
  no shut
```

Port-channel and VLAN based enablement for cloud L3 connectivity, IP address shared by GCP

LACP needs to be enabled

BGP Routing configuration

```
ip prefix-list TO_GCP seq 1 permit 192.168.12.0/24
!
route-map TO_GCP_OUTBOUND permit 10
  match ip address prefix-list TO_GCP
!
!
router bgp 64500
  bgp graceful-restart restart-time 60
   neighbor 169.254.10.1 description peering_to_cloud_router
   neighbor 169.254.10.1 remote-as 65200
   neighbor 169.254.10.1 ebgp-multihop 4
   neighbor 169.254.10.1 timers 20 60
   neighbor 169.254.10.1 update-source Po2.101
   neighbor 169.254.10.1 route-map TO_GCP_OUTBOUND out
```

Layer 3 only model enables BGP peering with Google Cloud Router. Route-map can be defined for better IP route advertisements

Note: For partner Interconnect model, BGP terminates on Partner router. Configure the on-premises router based on Service Provider guidance.

Catalyst 8500 Platform Overview.

Catalyst 8500, Platform Overview.

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Cisco Catalyst 8500 Series Edge Platforms

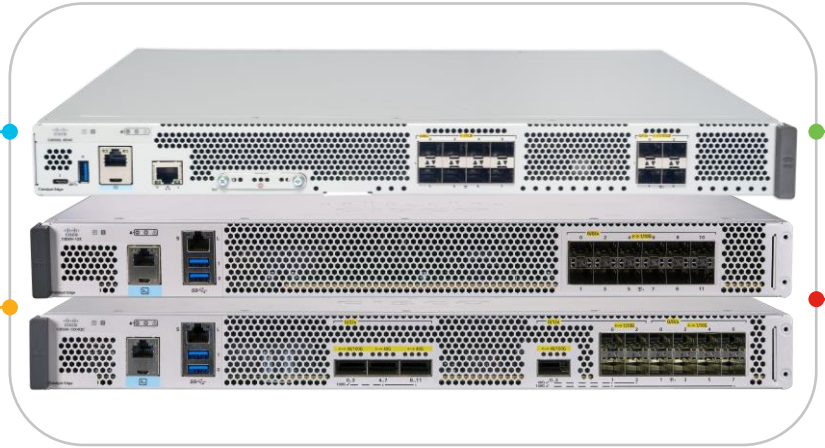
Highly Capable 1RU Enterprise Routing Platforms

Integrated Rich Services

NBAR2, NAT, Firewall, QoS, etc.
High Scale Service Edge Platforms

Edge Intelligence

Compute
Container based Apps



Scale

Up to 8000 SD-WAN Tunnels
High Speed 100 / 40 GE Ports
High Density 10 / 1 GE Ports

Multi-layer Security

High Throughput IPsec
Line Rate MACsec
Trustworthy Solutions
Umbrella SIG

Built-in Port Flexibility

Highlights

- Flow based Datapath
- WAN MACsec
- Third Generation QFP
- Up to 200Gbps CEF
- 5G Ready

Manageability

- vManage
- DNA Center
- Open APIs
- Analytics

Third Generation QFP Architecture

Multi-threaded Parallel Processing

- 28 clusters of 8 PPEs each
- 224 PPEs, 4 threads each → 896 threads

Hardware Accelerated Crypto

- 16 Crypto Engines with dedicated resources
- Flow queues for complex stateful features

Layer-2 Aggregation

- 240Gbps of aggregation
- Per Port Classification and Accounting

QFP 3.0

Catalyst 8500 Series Edge Platforms

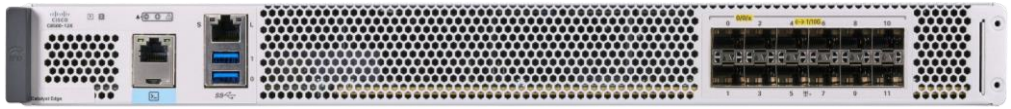
100G, 40G
'C' 'Q'

C8500-12X4QC

2 QSFP28, 2 QSFP
12 SFP+

10G, 1G
'X'

C8500-12X



12 SFP+

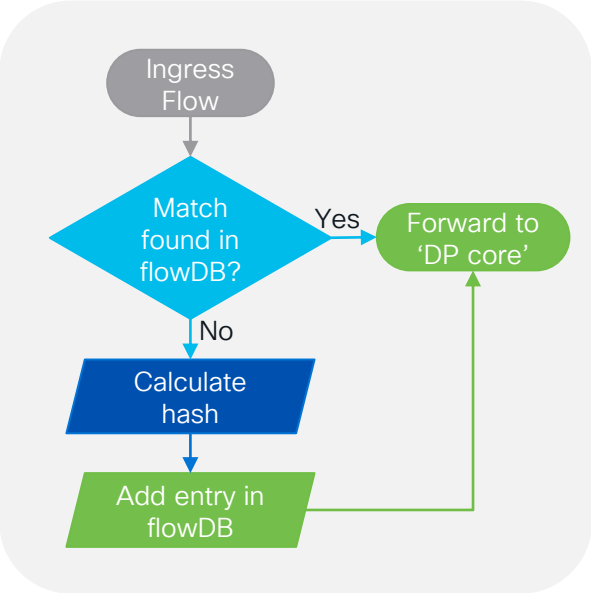
Up to 200 Gbps CEF,
High Performance IPsec

3rd Generation QFP,
Hardware Accelerated Services

User Centric Design,
RFID, Label Tray, FRUs

Advanced Flow-based Forwarding

Re-imagined x86 Forwarding Architecture

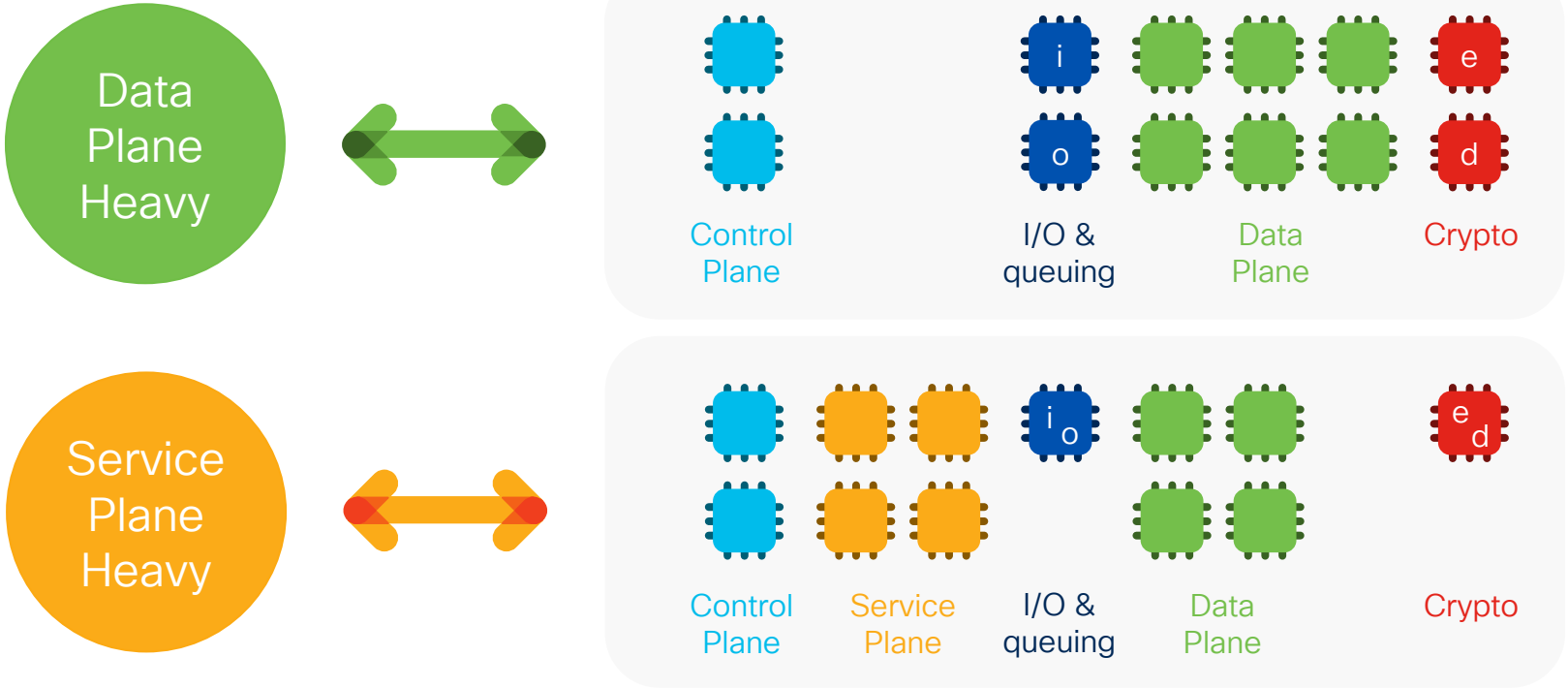


DPDK
DATA PLANE DEVELOPMENT KIT

Quick Assist Technology

Protocol	Tuple hashing elements
TCP/UDP	srcIP, dstIP, protocol, srcPort, dstPort, vrfID
ESP	srcIP, dstIP, protocol, vrfID
All other Protocols	srcIP, dstIP, protocol, vrfID

Data Plane vs Service Plane Heavy



CLI configuration and reboot required to change modes. Roadmap for future software to not require reboot.

Catalyst 8500L Series Edge Platforms

x86

10G, 1G
'X' 'S'

C8500L-8S4X

8 SFP, 4 SFP+

Up to 20 Gbps CEF,
High Performance IPsec

Advanced Flow Based
Forwarding Algorithms

User Centric Design,
RFID, Label Tray, FRUs

MACsec Cipher Support

C8500-12X4QC, C8500-12X, C8500L-8S4X Platforms

Reference slide

Port Speed	Supported cipher-suite
10 Gbps	gcm-aes-128, gcm-aes-256, gcm-aes-xpn-128*, gcm-aes-xpn-256*
100 Gbps	gcm-aes-128, gcm-aes-256, gcm-aes-xpn-128, gcm-aes-xpn-256

**C8500-12X4QC and C8500-12X platforms support 10G XPN ciphers from Release 17.6 onward*
**C8500L-8S4X platform supports 10G XPN ciphers from Release 17.9 onward*

Catalyst 8500 for Cloud Gateways, Colocation

Large capacity in small form factor

Cloud MSP: Edge, CPE

Rich Features

Multi-tenant, VRF Aware

VxLAN

Route Scale

Convergence Services

IPsec, NAT, Firewall

B2B Redundancy

Colo, Cloud Gateway

Highly Scalable

8000 VRFs

4M IPv4, IPv6 Routes

16M NAT, 32M CGN

6M Firewall Sessions

Up to 8000 IPsec Tunnels

WAN MACsec on all ports

Port Flexibility: 100/40/10/1G

Small 1 RU form factor

Platinum Power Efficiency

Cisco Catalyst 8500 Series Edge Platforms

Best Platforms for Cloud-scale Enterprise Networks

01 Powerful Data Plane

02 Highly Scalable Control Plane

03 High Speed Multi-Cloud Access

04 Accelerated SD-WAN Services

"C8500 Platforms offer best in class hardware with rich software features for high performance use-cases!"

QFP

x86

Powerful Data Plane
QFP 3.0, x86 FBD*

Hardware Accelerated Services

High Speed DIA, DCA 100/40/10/1GE Ports

High Scale SD-WAN IPsec Tunnels

*FBD: Flow Based Distribution

References

References

Reference slide

- Catalyst 8500 and Azure ExpressRoute Joint Validated Design Guide: https://www.cisco.com/c/en/us/solutions/collateral/enterprise-networks/sd-wan/cisco-catalyst-8500-microsoft-azure.html
- Azure ExpressRoute: https://docs.microsoft.com/en-us/azure/expressroute/
- AWS Direct Connect: https://docs.aws.amazon.com/directconnect/latest/UserGuide/create-vif.html#vif-router-config
- Google Cloud Interconnect: https://cloud.google.com/network-connectivity/docs/interconnect/concepts/dedicated-overview

More Details on Catalyst 8500

Reference slide

- Datasheet: https://www.cisco.com/c/en/us/products/collateral/routers/catalyst-8500-series-edge-platforms/datasheet-c78-744089.html
- Frequently Asked Questions: https://www.cisco.com/c/en/us/products/collateral/routers/catalyst-8500-series-edge-platforms/q-and-a-c67-744086.html
- Ordering Guide: https://www.cisco.com/c/en/us/products/collateral/routers/catalyst-8500-series-edge-platforms/guide-c07-744092.html
- Architecture Whitepaper: https://www.cisco.com/c/en/us/products/collateral/routers/catalyst-8500-series-edge-platforms/white-paper-c11-2395855.html

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