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#CiscoLiveAPJC

ACI – The Foundation of an Internal Private Cloud

(aka “not just another network…”)

BRKDCN-2984

Steve Sharman – Solutions Engineer
BRKDCN-2984

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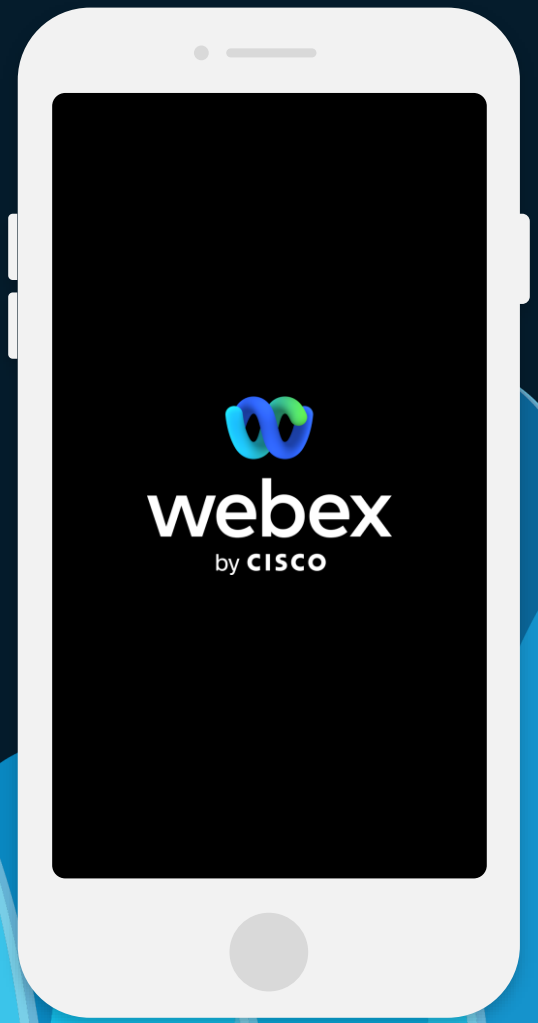

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At little bit of background to this session...

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Agenda

- Setting the scene
- Converting your fabric into Application Centric “mode”
- Working with ESGs
- Understanding ACI Security
- External Connectivity
- Increasing Security
- Automation Blueprints

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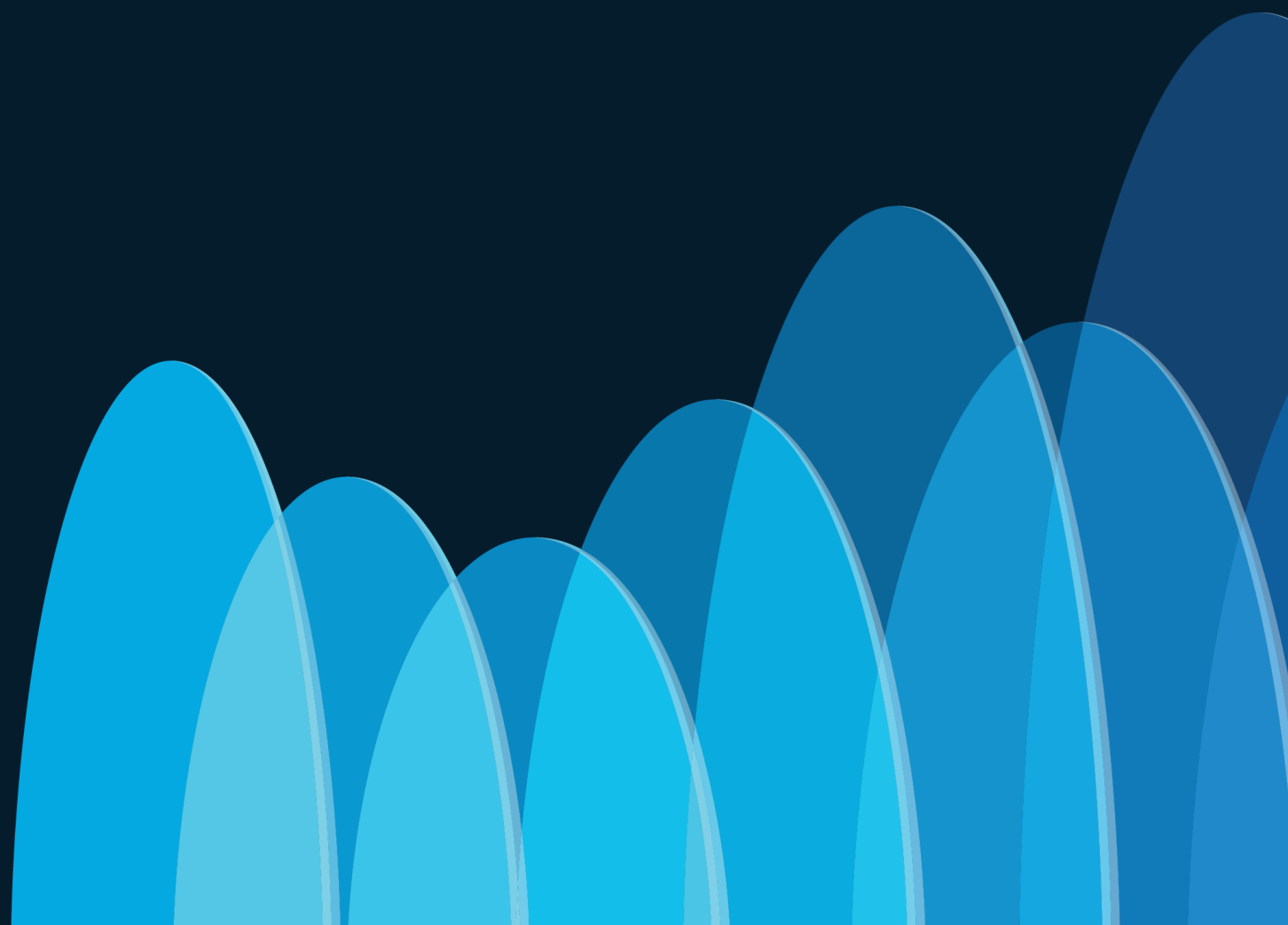
Before we get started...



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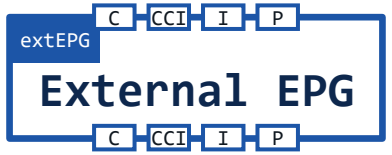
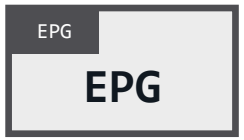
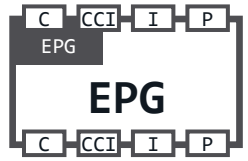
Icons







*arrows indicate expected direction of connection i.e. from consumer to provider

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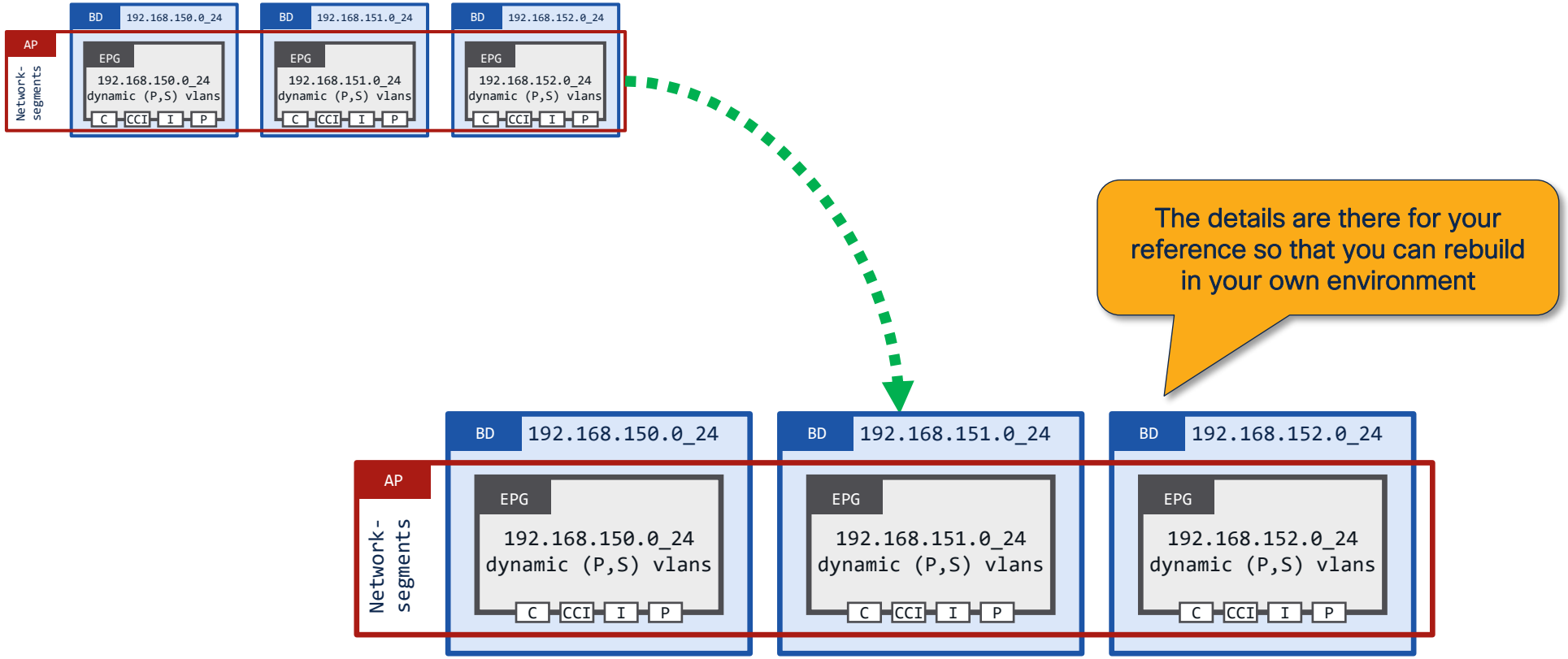
You are going to see lots (and lots) of diagrams...



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Setting the scene...

Designing your Tenants...

Switching to Application Centric mode...

Working with ESGs...

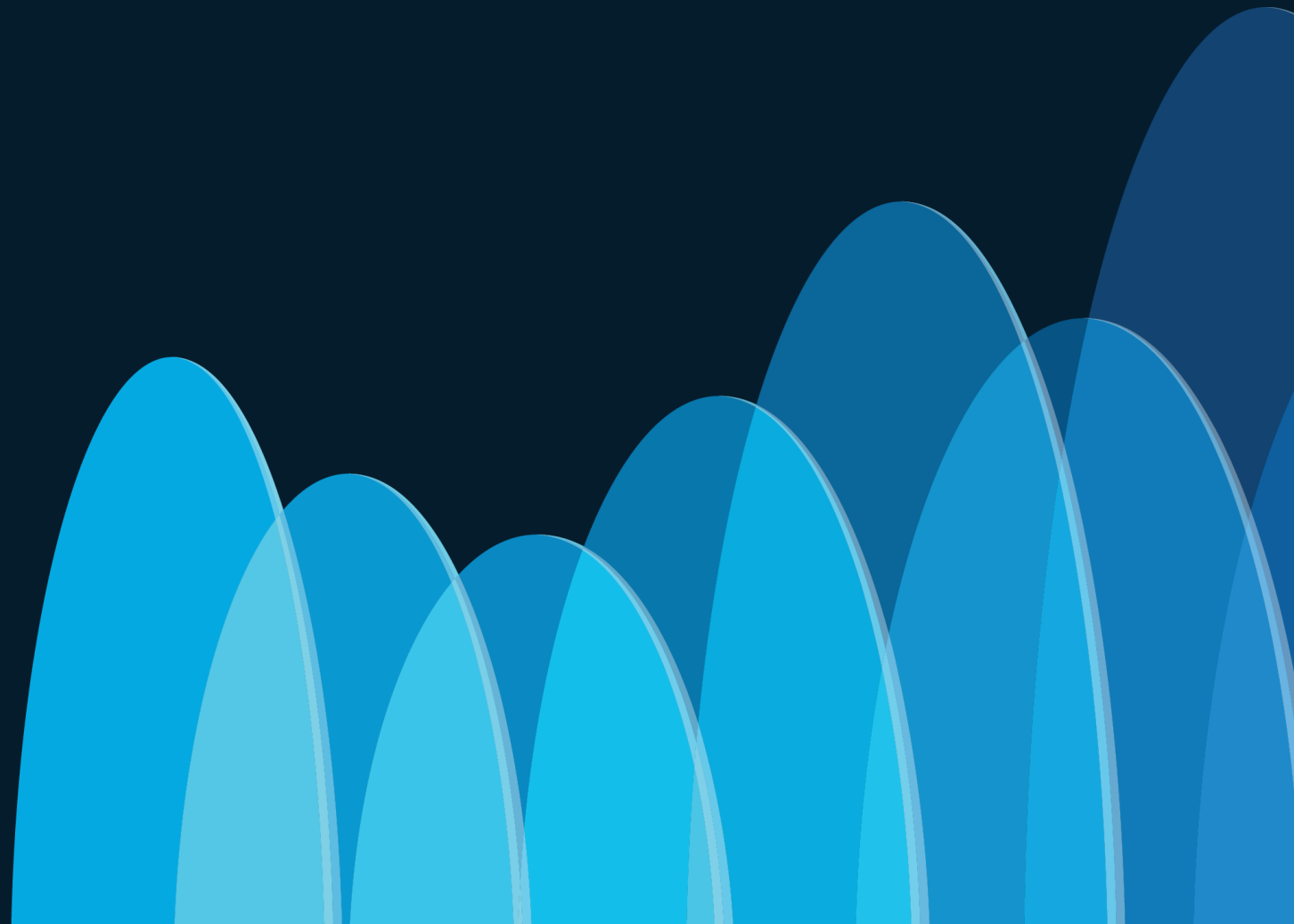
Understanding ACI security...

External Connectivity...

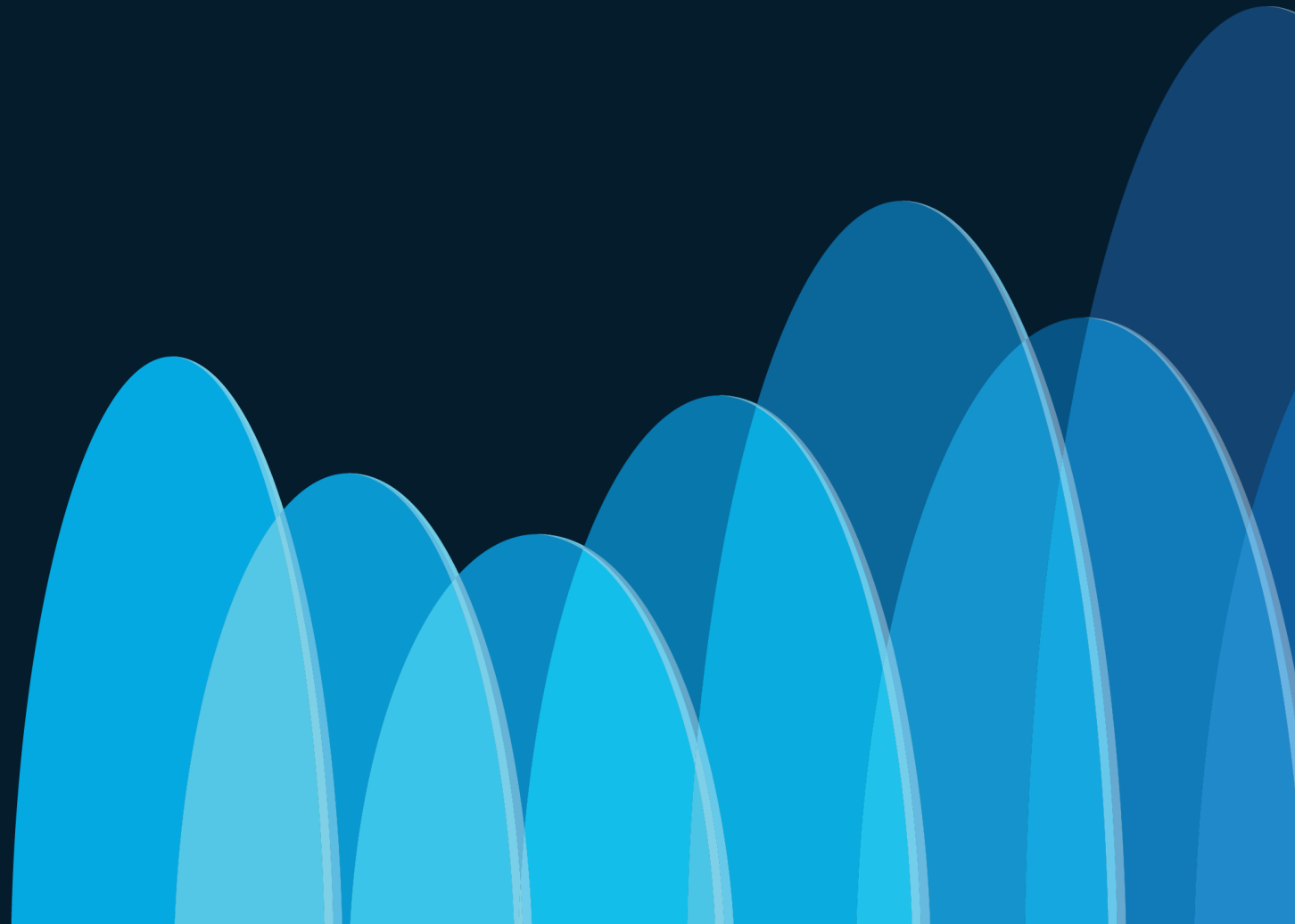
Increasing Security...

Automation Blueprints...

Wrapping up...

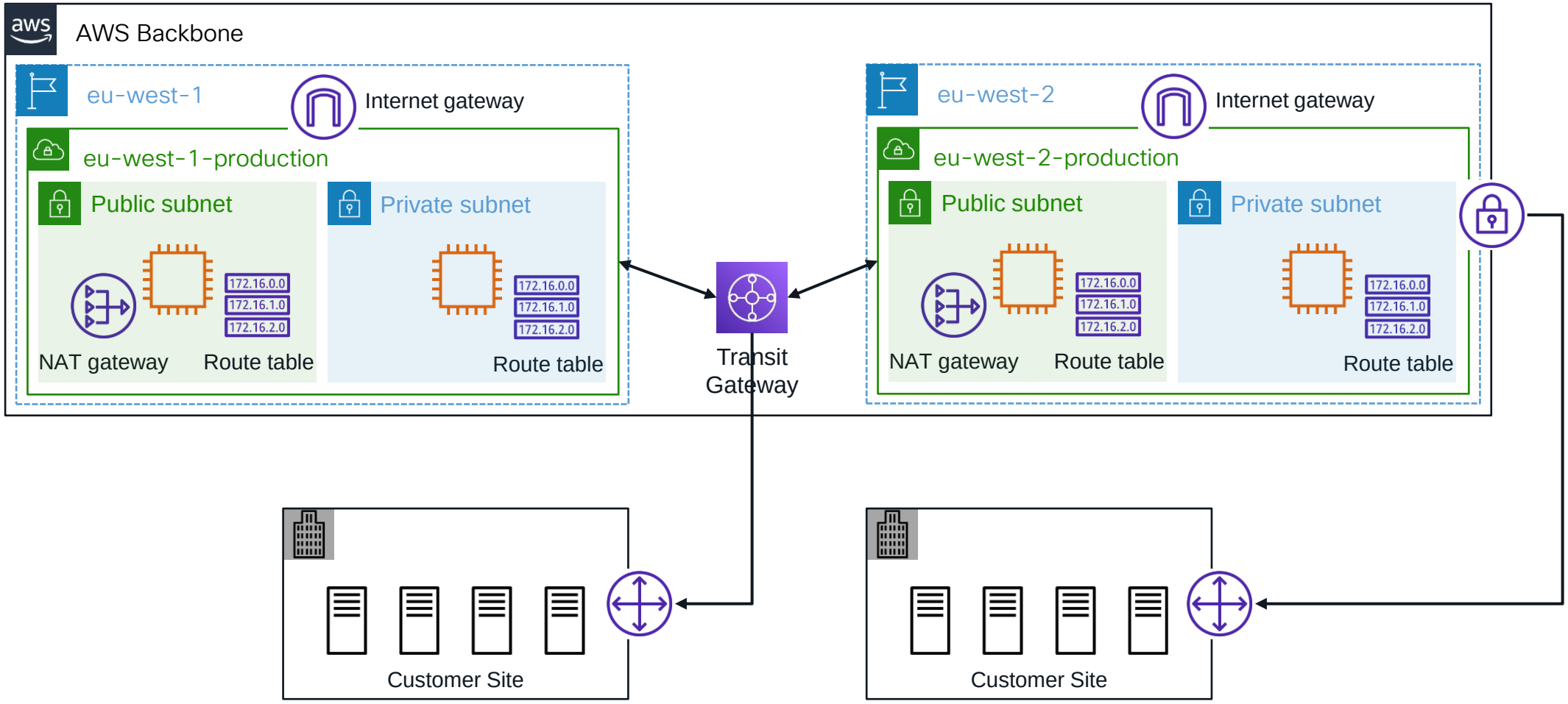


Public Cloud infrastructure...



AWS reference architecture

https://docs.aws.amazon.com/vpc/latest/userguide/extend-intro.html



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Network Connectivity and Security are mandatory in the cloud...

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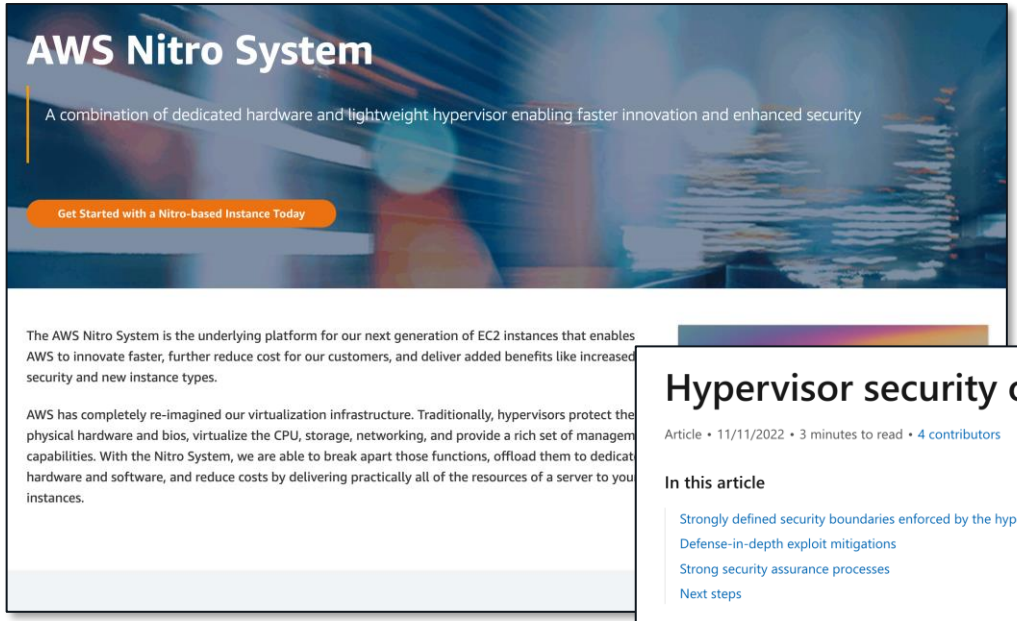
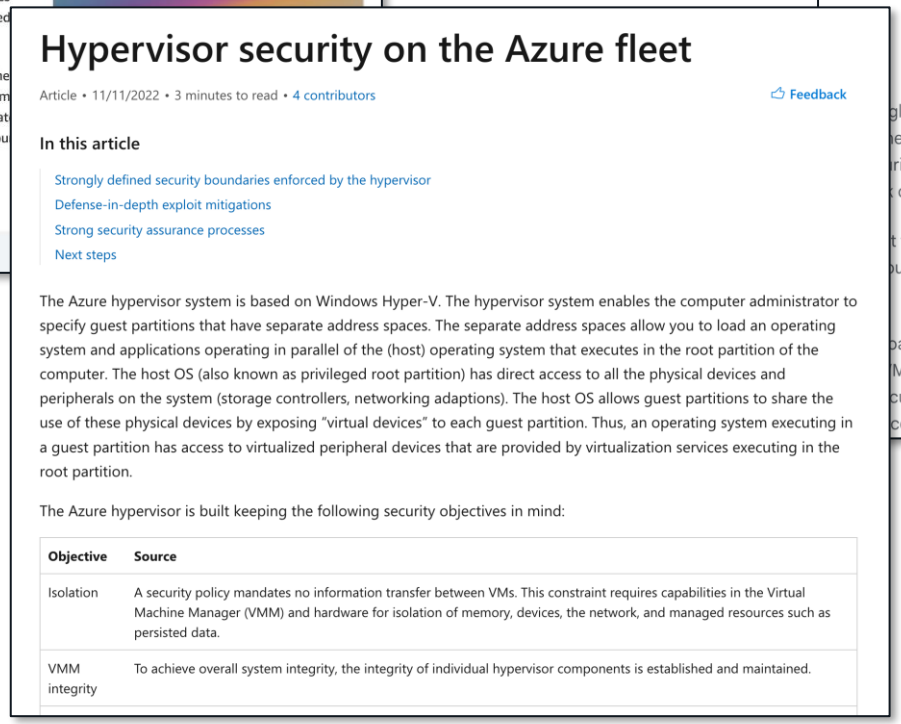
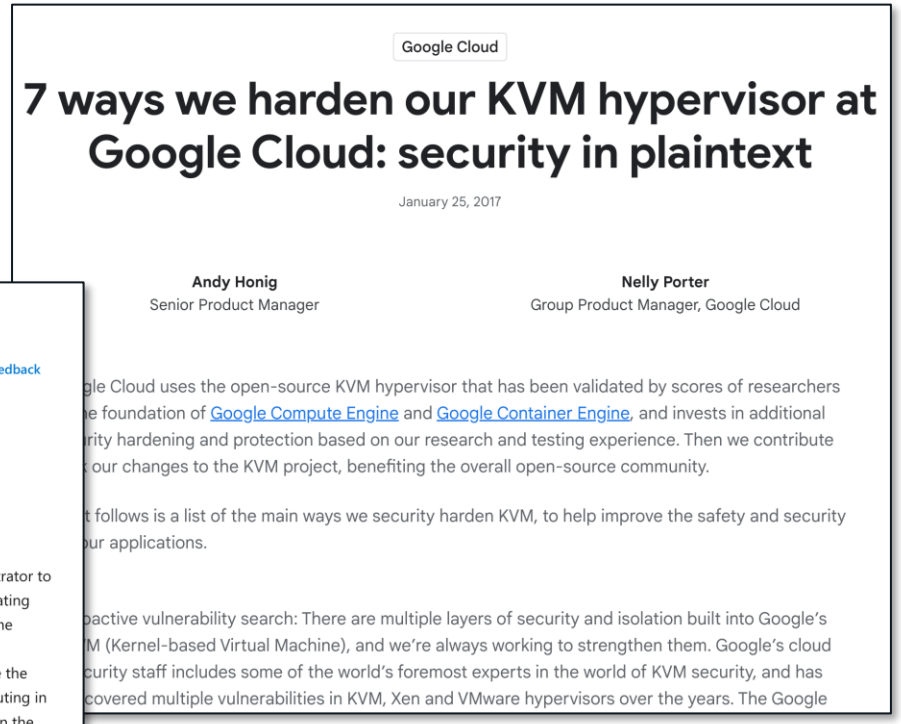
Different clouds run different hypervisors







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- Executive Sponsorship
- Cross Functional Teams
- New Talent Attraction
- Scaling
- New Culture
- Think Agile
- Evolution Instead of Revolution
- Partnerships 2.0

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A cloud operating model succeeds best when there is a new organizational culture…

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Cloud operating models have changed the way that security is implemented...

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With a cloud operating model, security rules are typically declared with the application constructs...

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Conversely, within enterprise Data Centers security has been implemented by network and/or security administrators at a VRF boundary…

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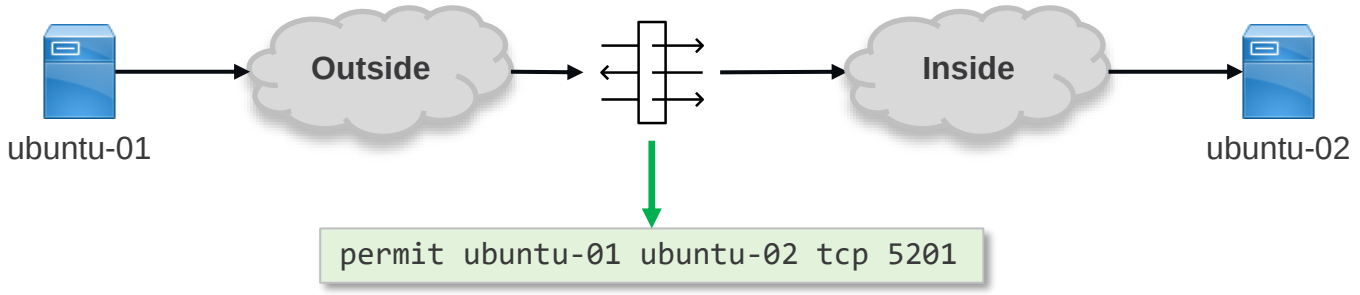
Traditional Enterprise Security Model



Traffic is routed through a firewall which typically becomes a pinch point with thousands of rules

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What are the network characteristics required to enable us to operate in a cloud like manner...?

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ACI is the foundation for an internal private cloud...!

Day0 automation out-of-the-box; physical fabric and underlay

Per-application service-chaining

Pervasive Security Model

Hybrid cloud capability; public cloud-like networking constructs

Single API Model for 100s of switches and 1000s of ports; cloud-like consumption model

Infrastructure as Code with Ansible and Terraform

Automation | Classification and Segmentation | Security

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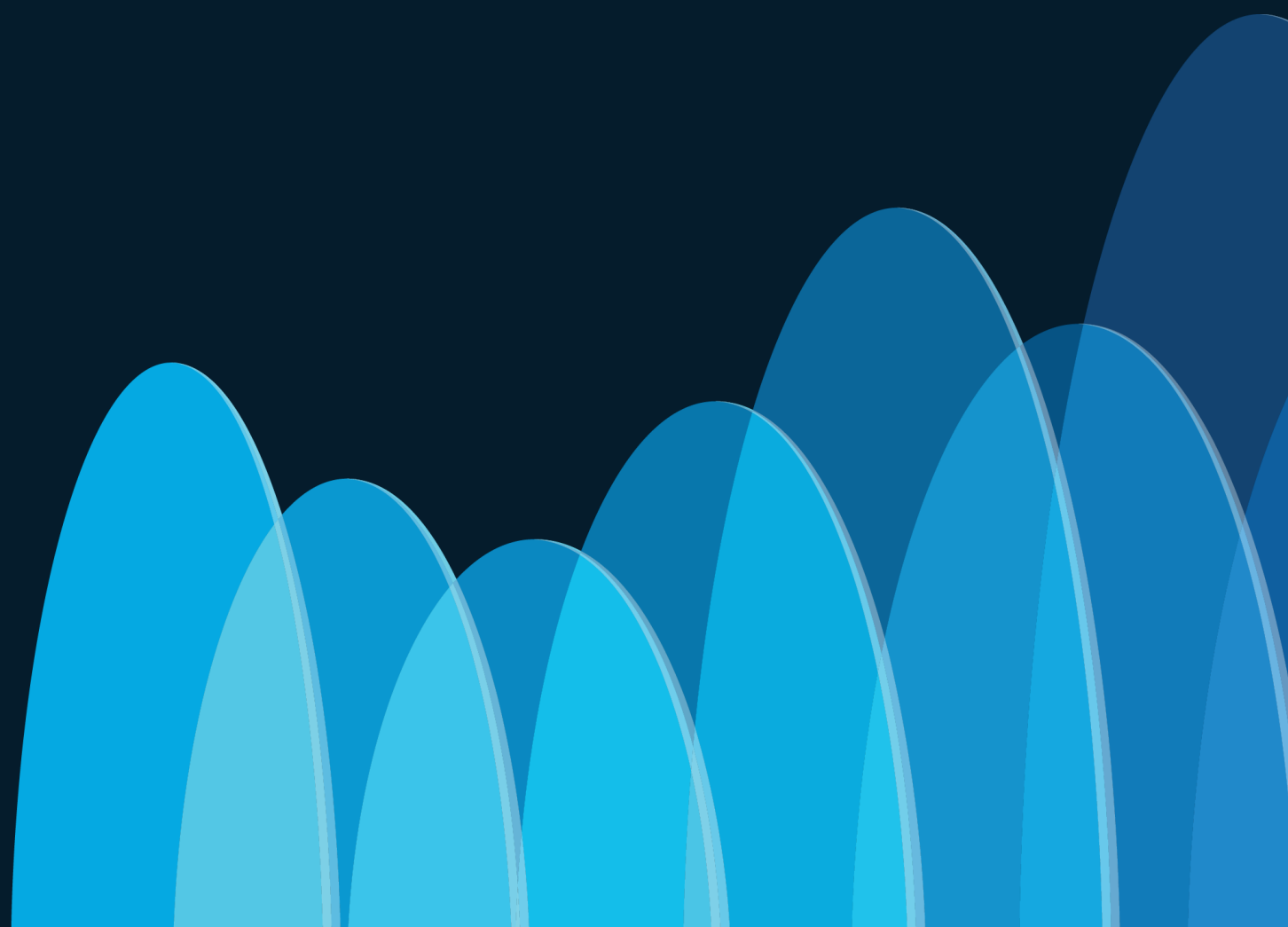
The ACI Vision...



The ACI reference application from circa 2014...

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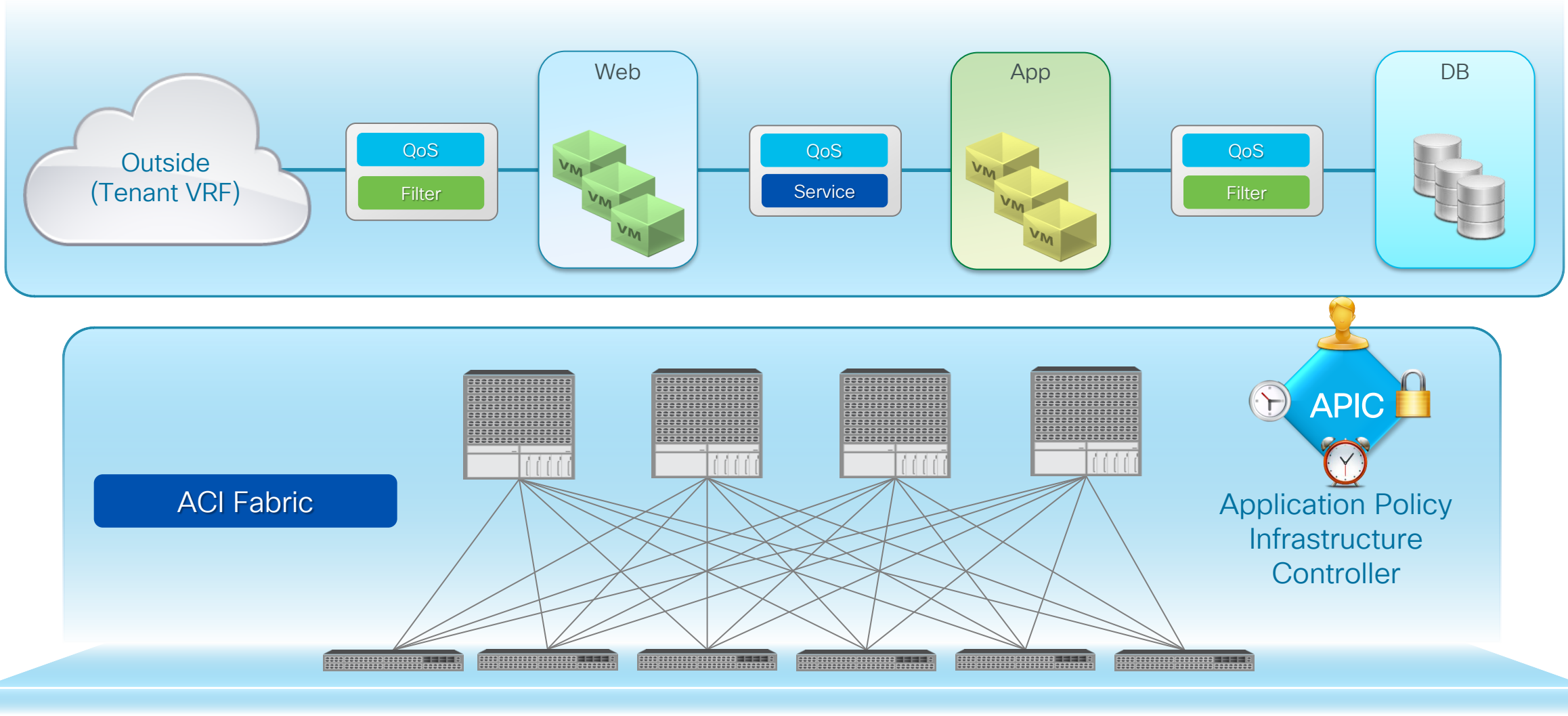
The mythical three tier application...!



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Our reference application for this presentation...

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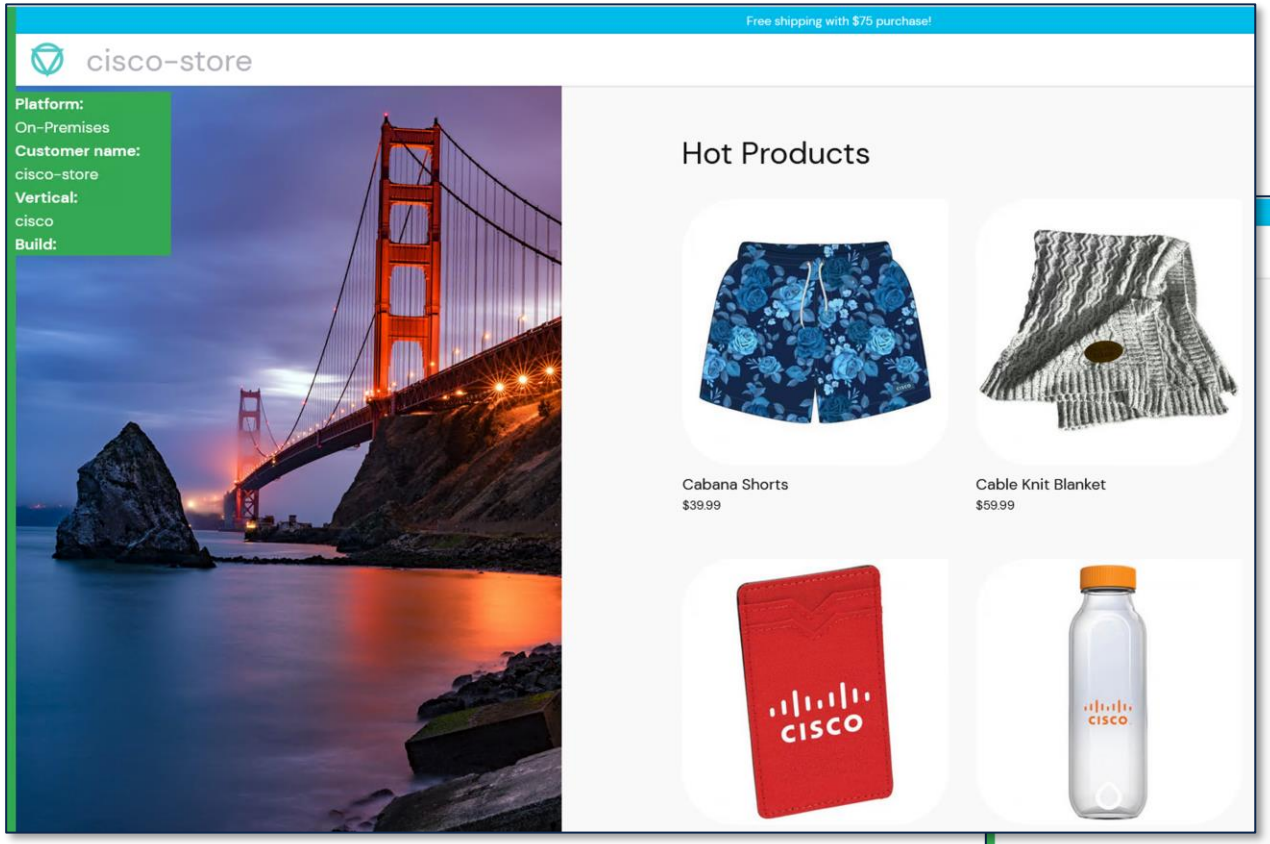
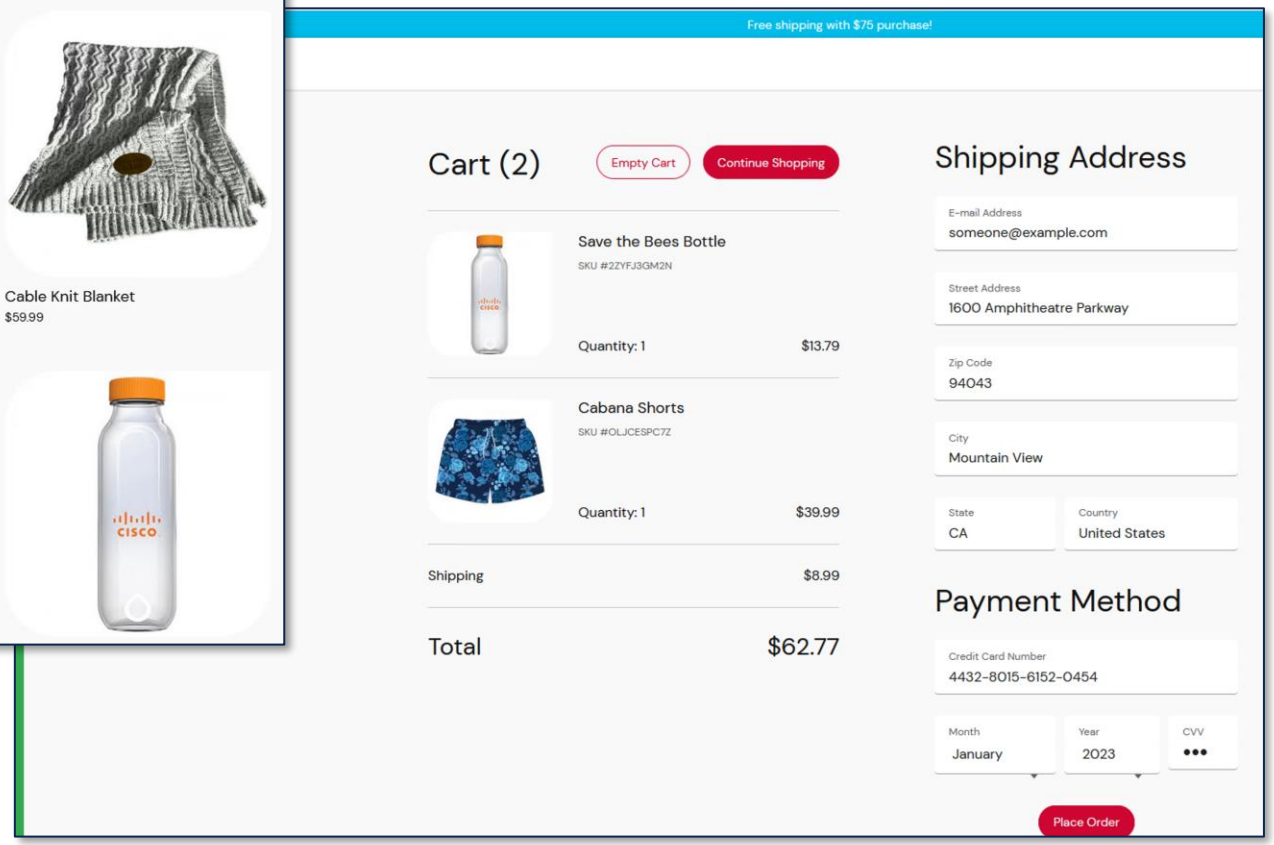
Online Boutique

https://github.com/GoogleCloudPlatform/microservices-demo





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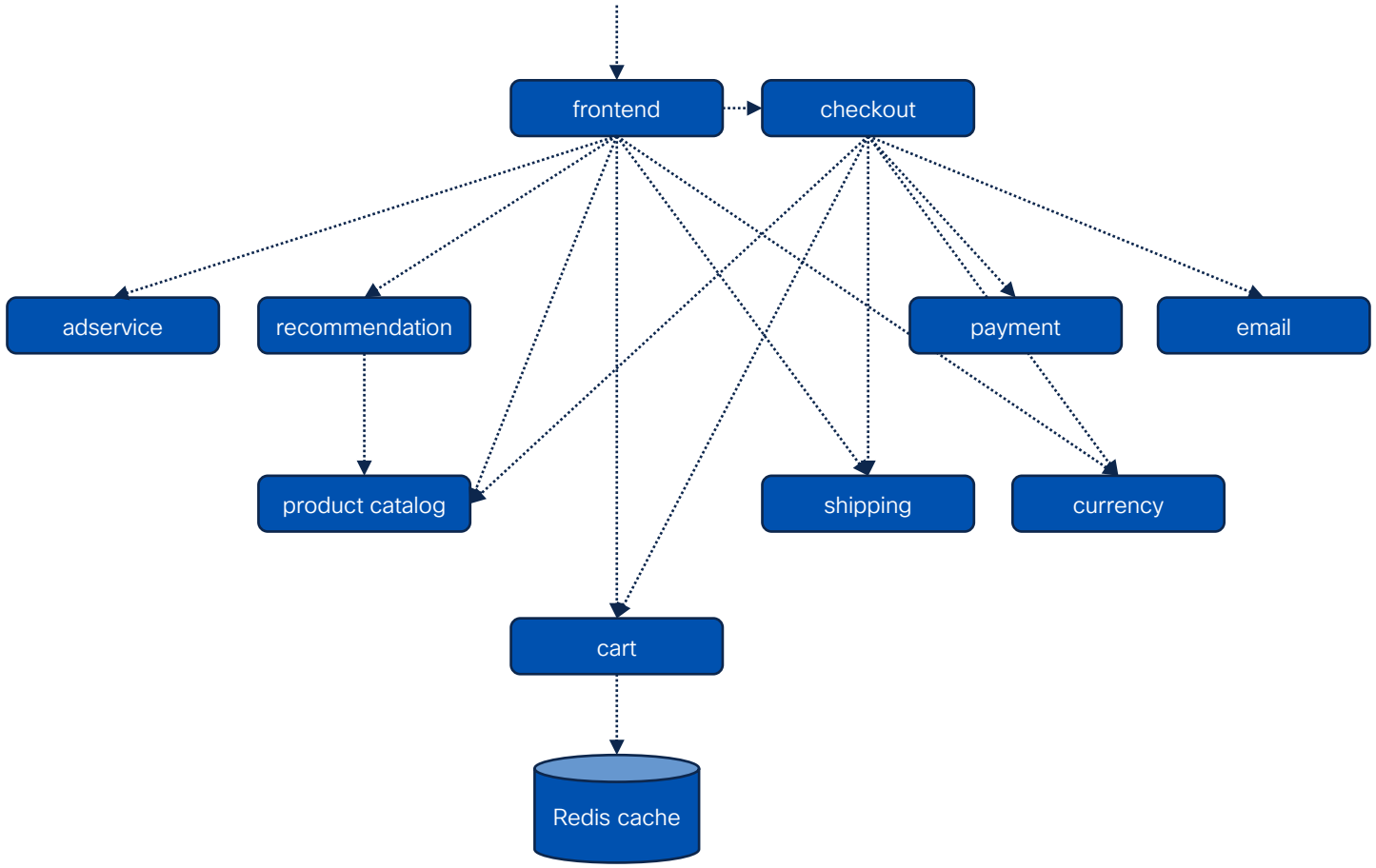

Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart currency email payment product catalog shipping	TCP 7070 TCP 7000 TCP 8080 TCP 50051 TCP 3550 TCP 50051
frontend	adservice cart checkout currency product catalog recommendation shipping	TCP 9555 TCP 7070 TCP 5050 TCP 7000 TCP 3550 TCP 8080 TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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Setting the scene...

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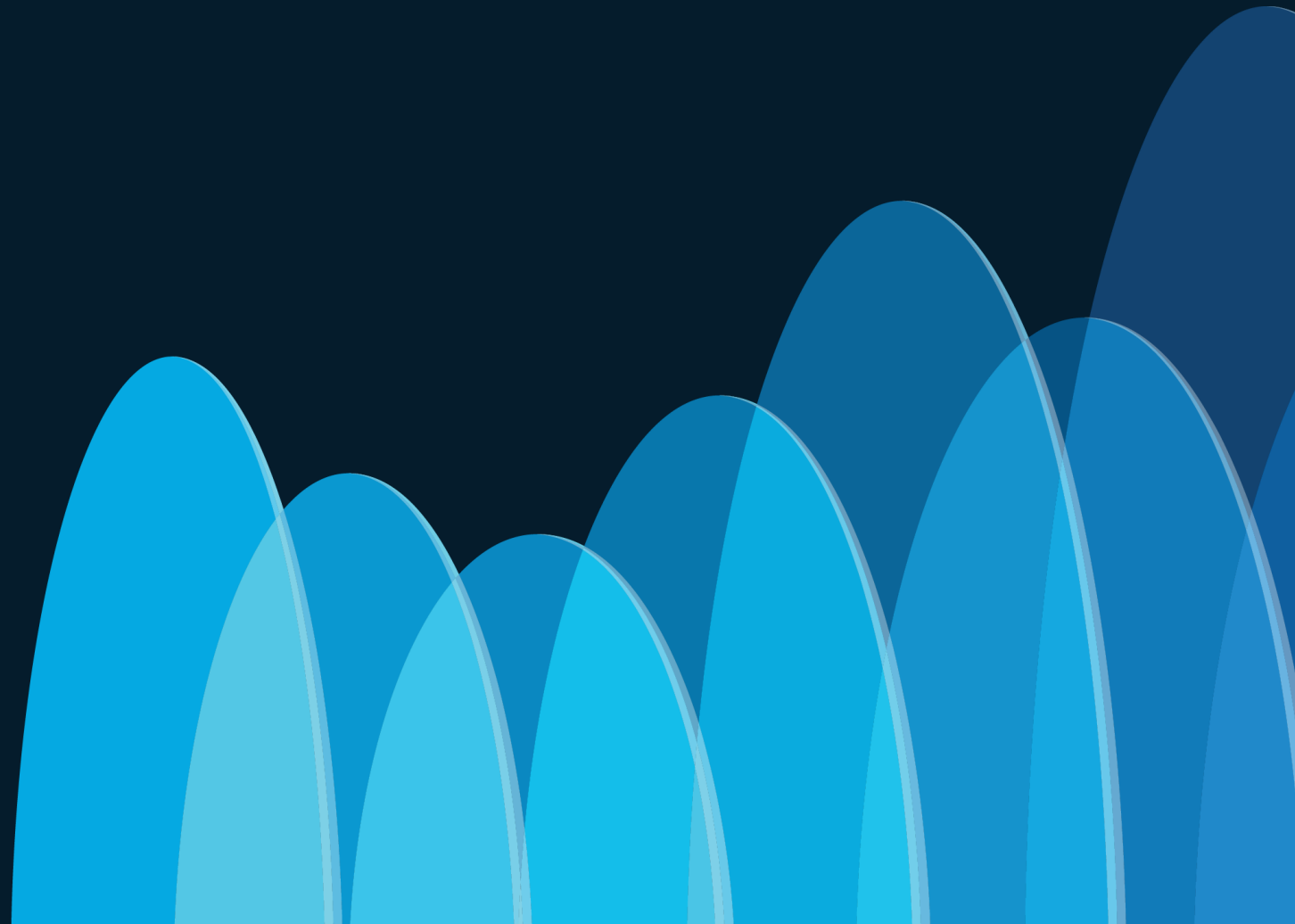

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Design Considerations...

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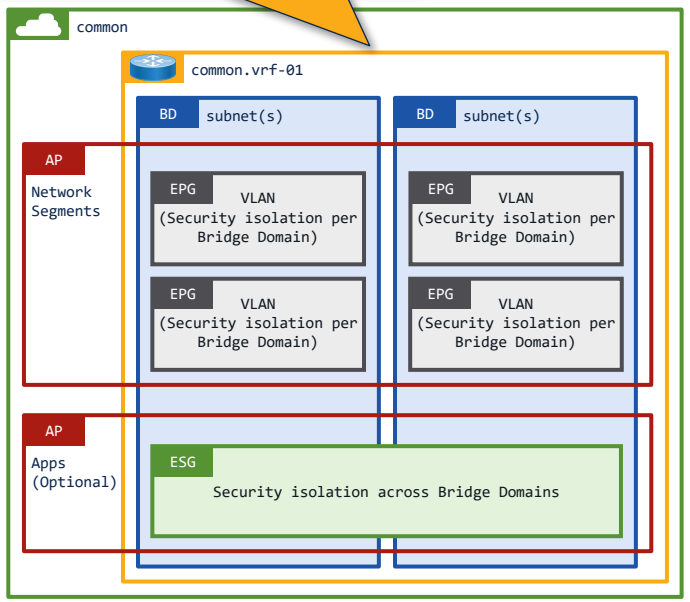
Design Patterns

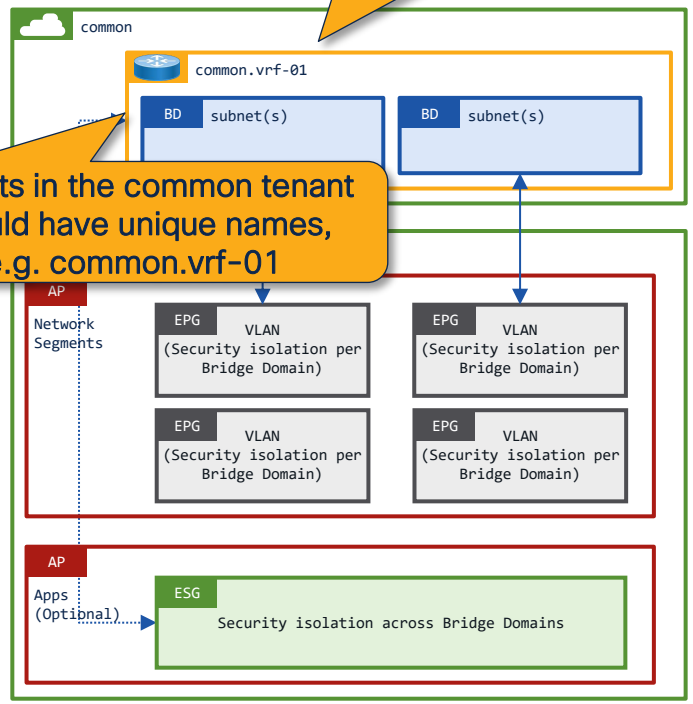
Everything in the “common” Tenant is not typically seen



Used for functions which are accessible from any Tenant

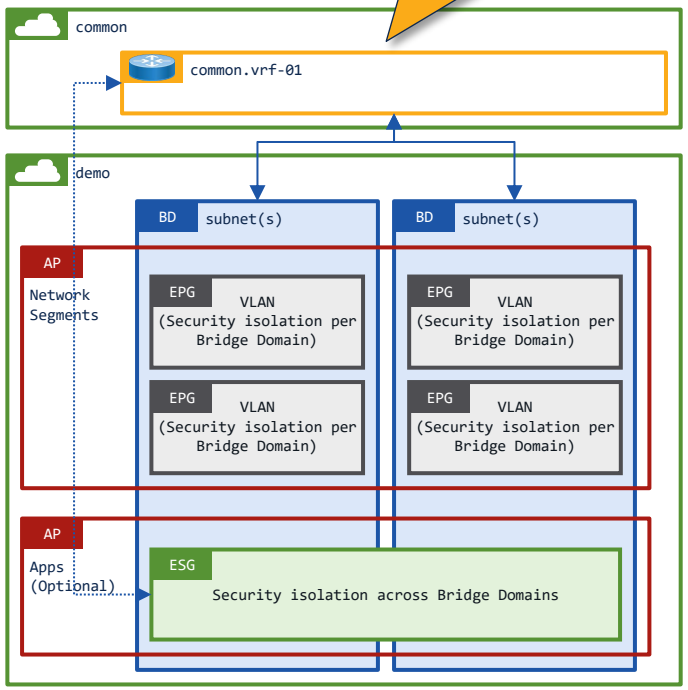
VRFs and BDs in “common” with EPGs and ESGs in the “user” tenant

Objects in the common tenant should have unique names, e.g. common.vrf-01



Typically, fewer larger subnets which can be (optionally) shared across Tenants

VRFs in “common” with BDs, EPGs and ESGs in the “user” tenant



Dedicated subnets for tenants with VRFs that can be (optionally) shared by different Tenants

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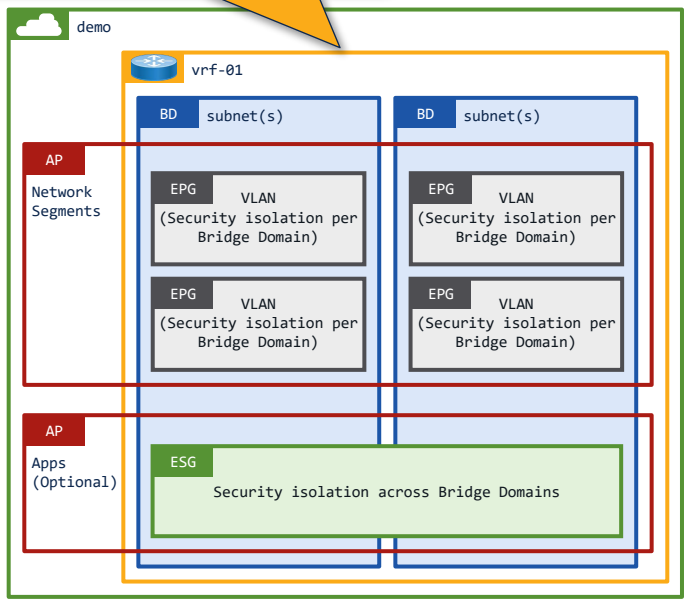
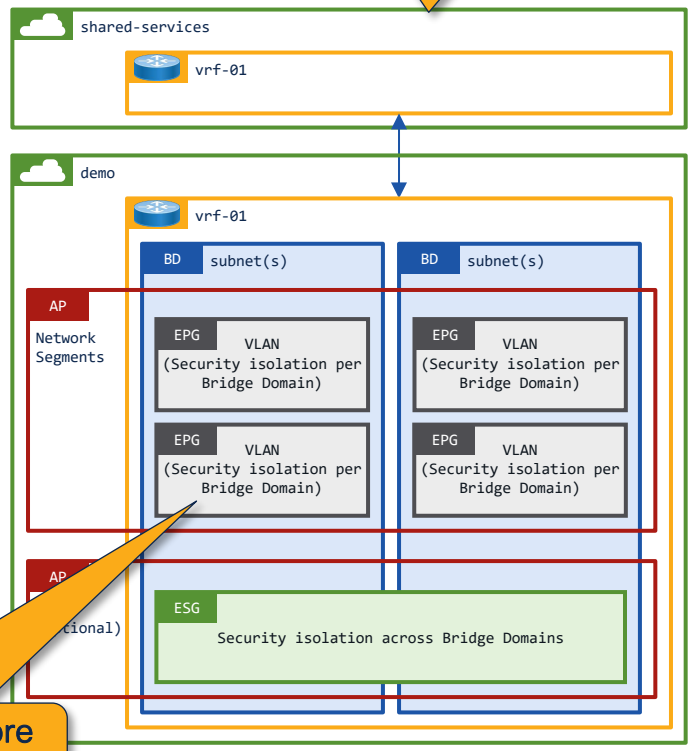
Design Patterns

All networking constructs contained within a Tenant



Dedicated VRFs and subnets for each Tenant with Dedicated L3outs

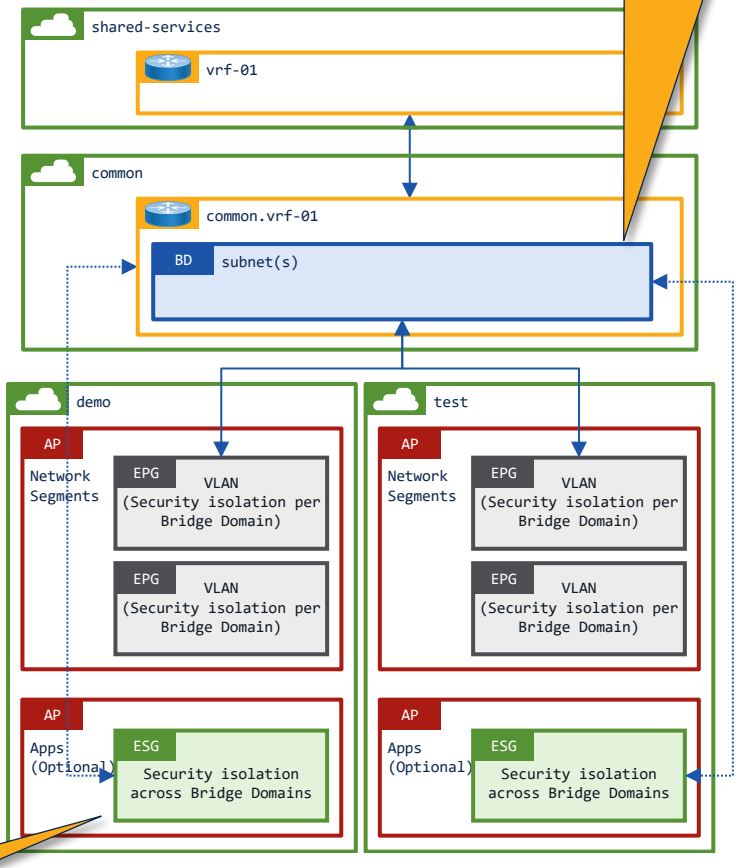
Network team controls inbound/outbound routing



Each Tenant has one or more network security groups

Dedicated VRFs and subnets for each Tenant with Shared L3out

Large subnets can be shared across Tenants



Each Tenant has one or more endpoint security groups

EPG and ESG in the “user” Tenant with the VRF in the “common” Tenant, and a Shared L3out in shared-services

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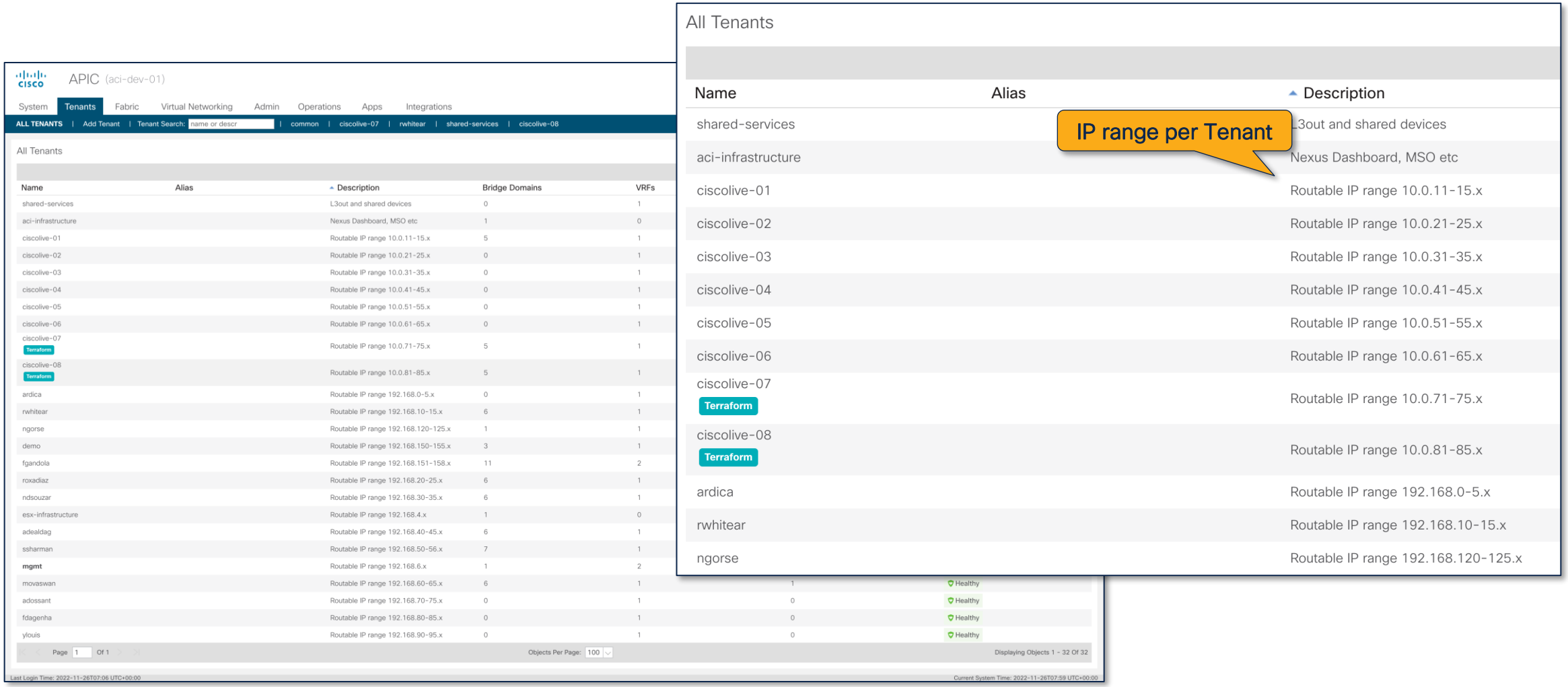
Each Tenant has their own IP Range



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Network engineers “view” of their ACI environment...

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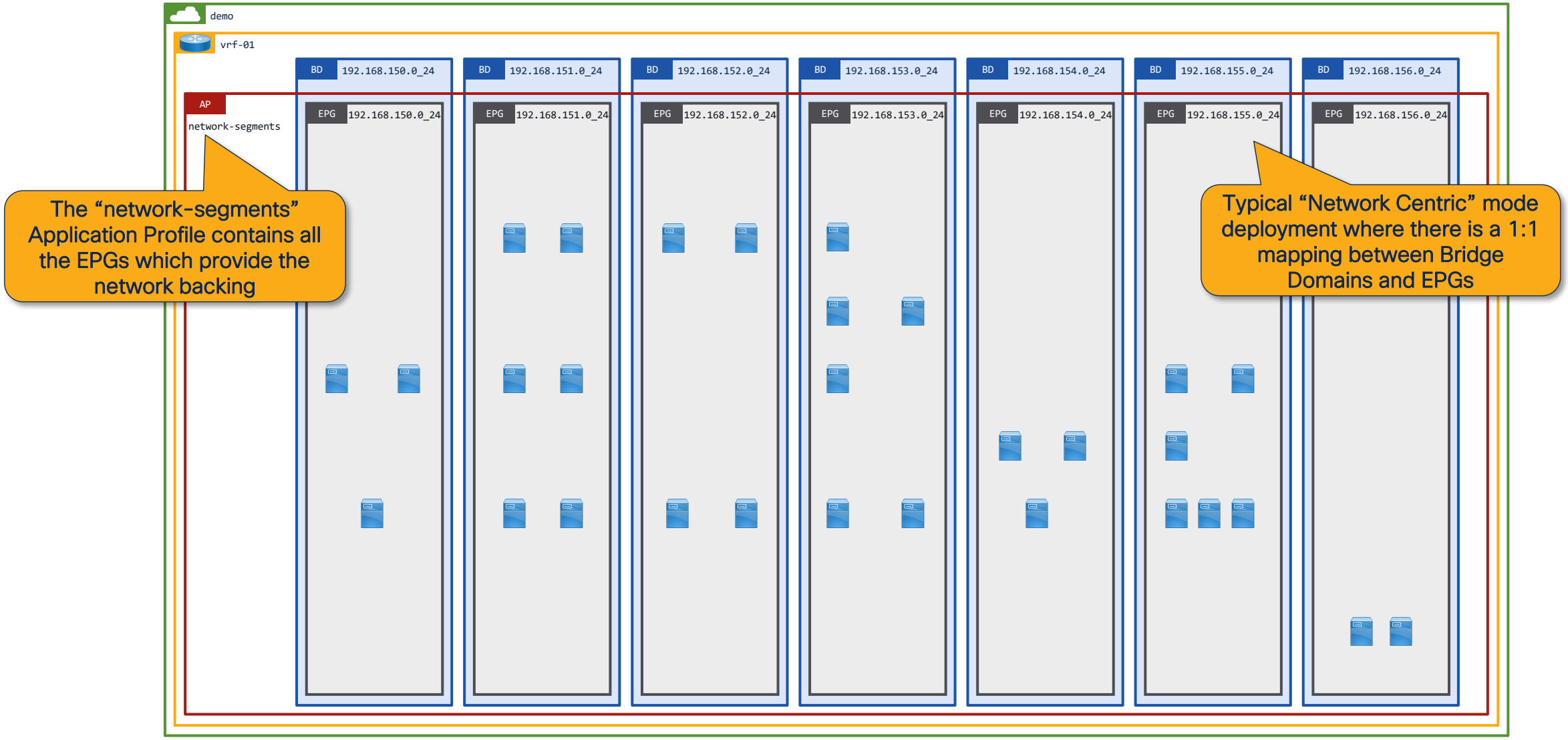
Workloads identified by IP and Mac address



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What does the application owner care about...?

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DNS names, IP addresses, Default Gateways, and Security Rules...

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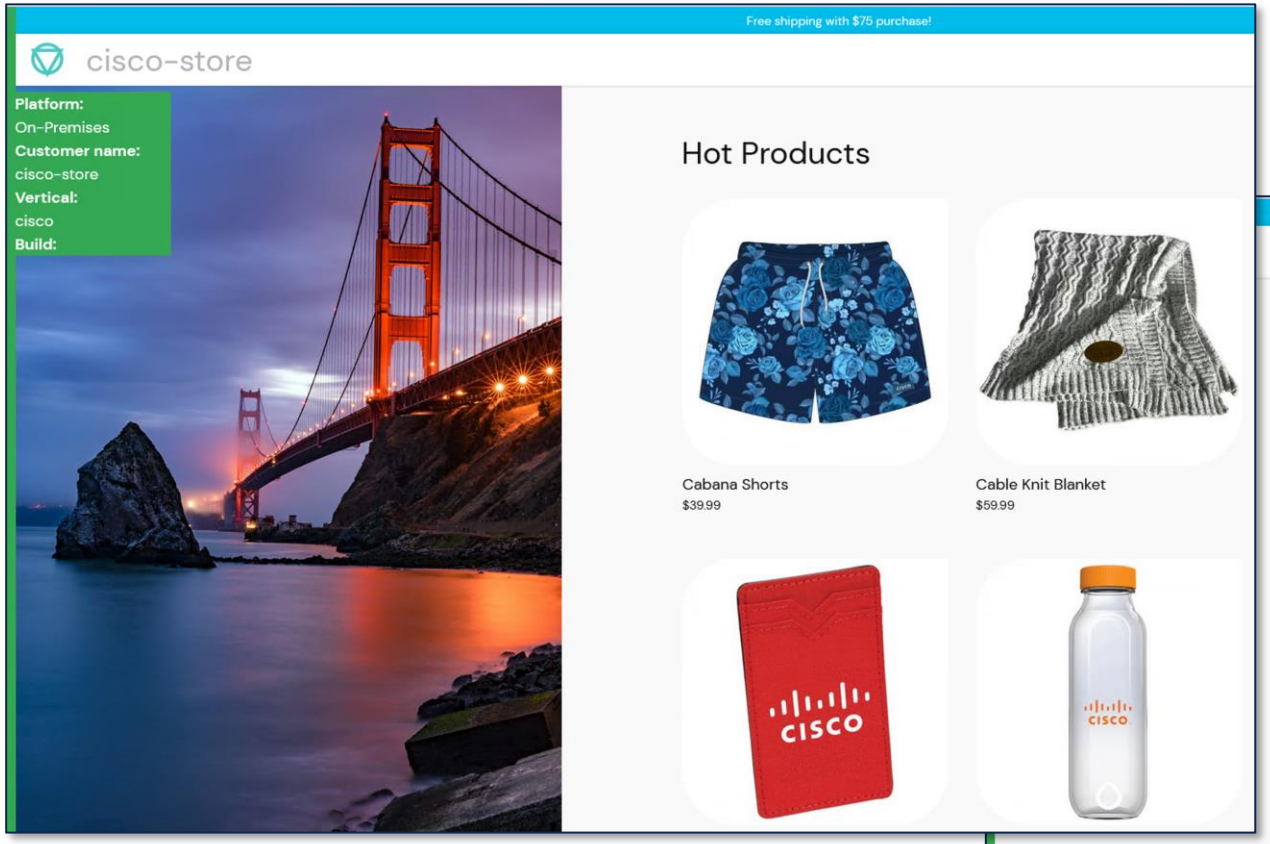
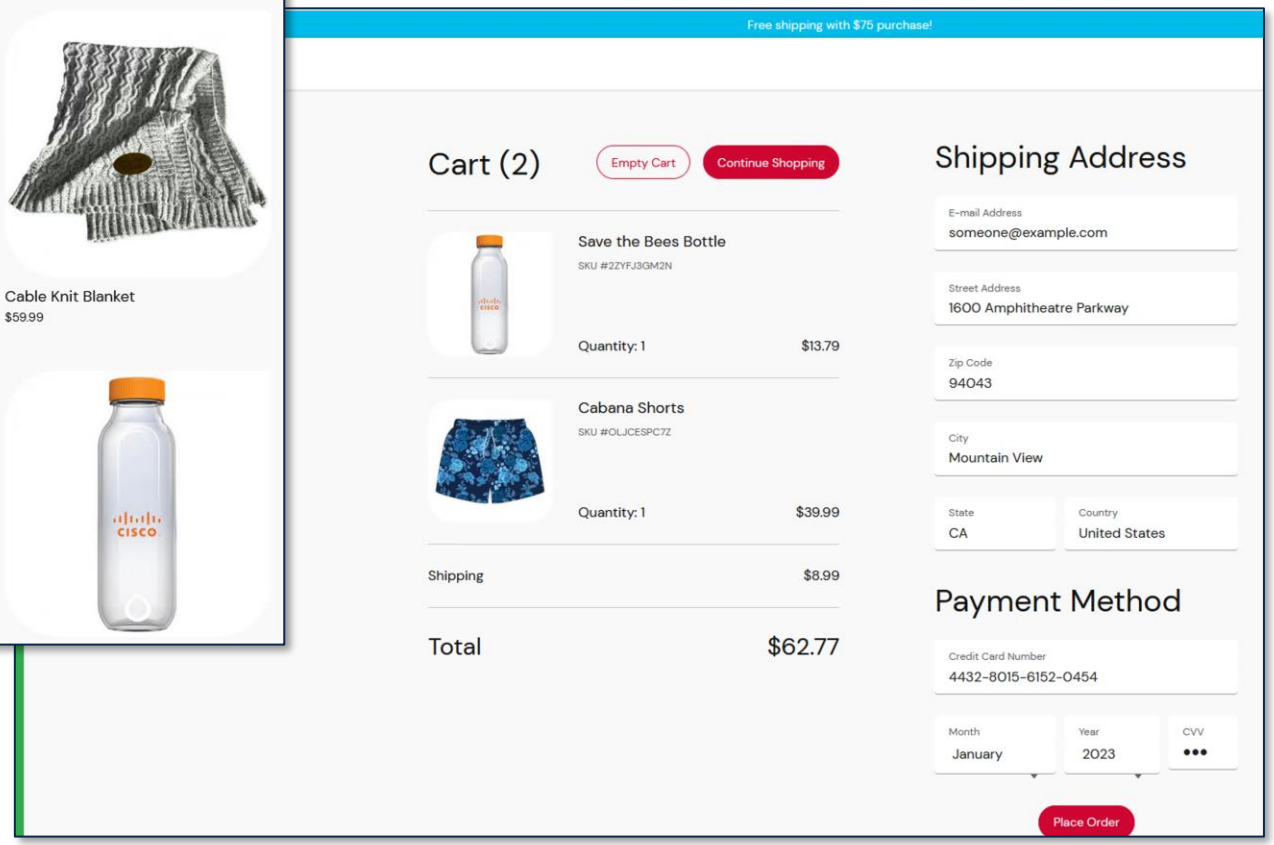
Online Boutique

https://github.com/GoogleCloudPlatform/microservices-demo





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Online Boutique

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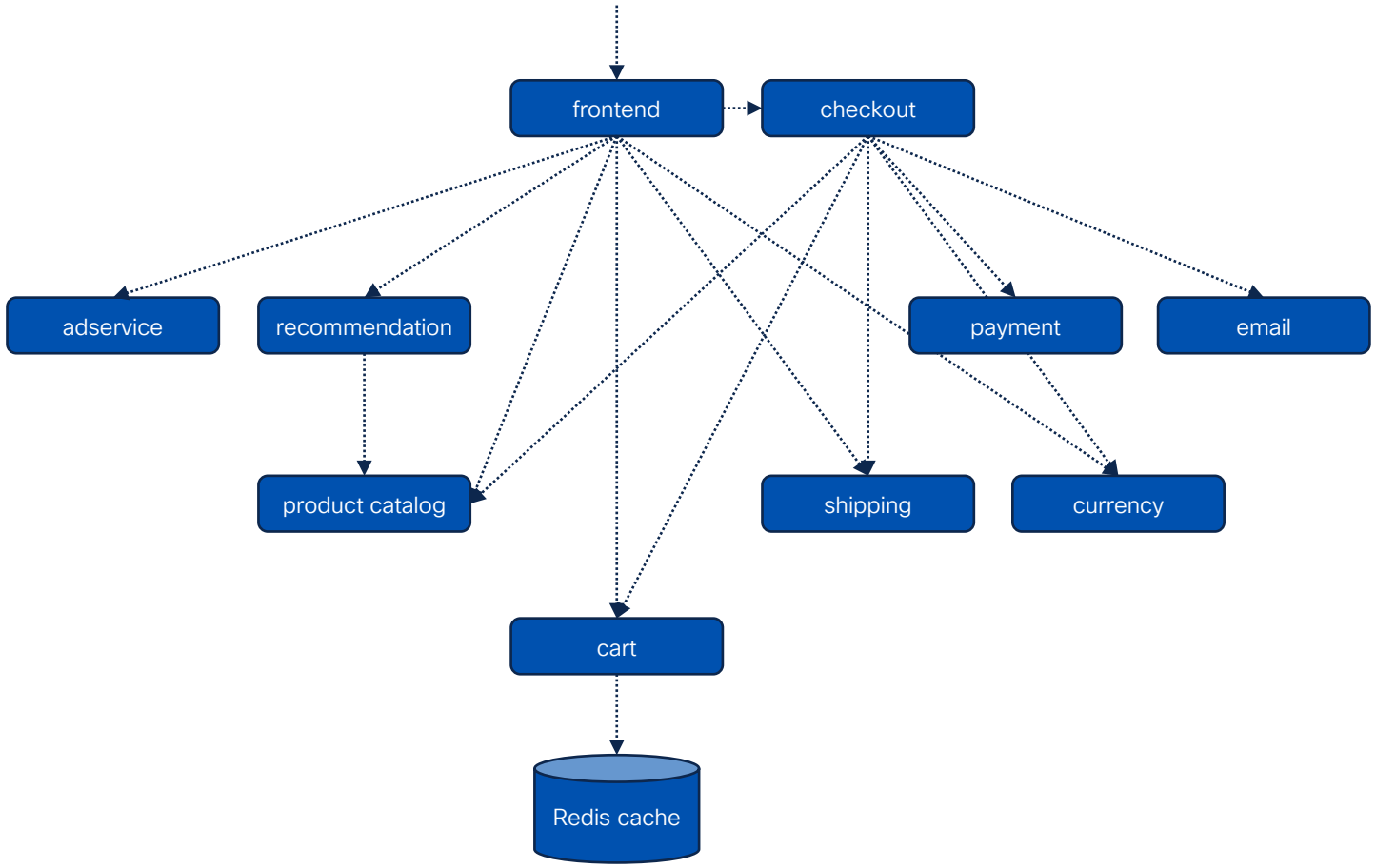

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outside	frontend	TCP 80/8080
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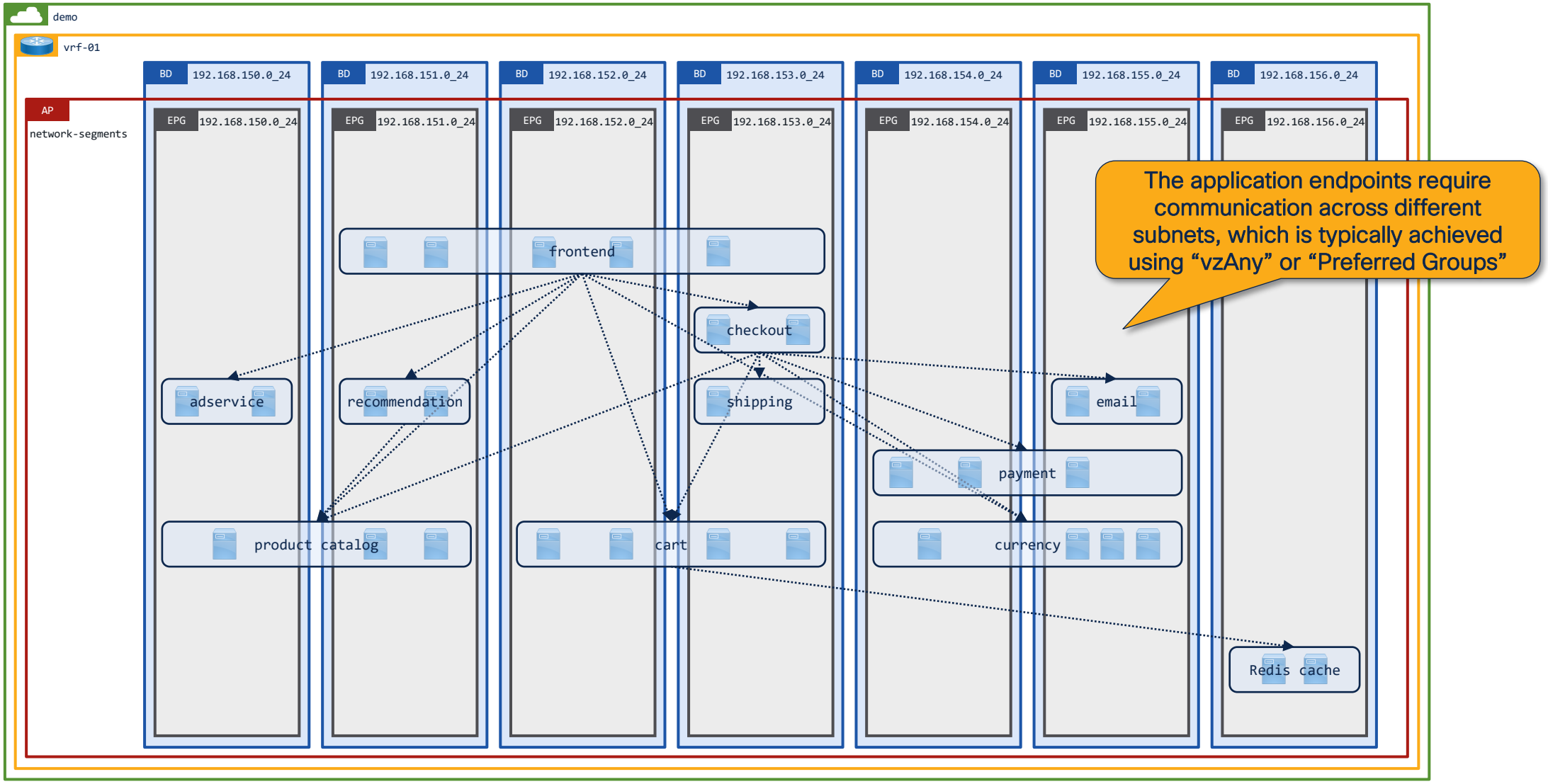
Where is our application running...?



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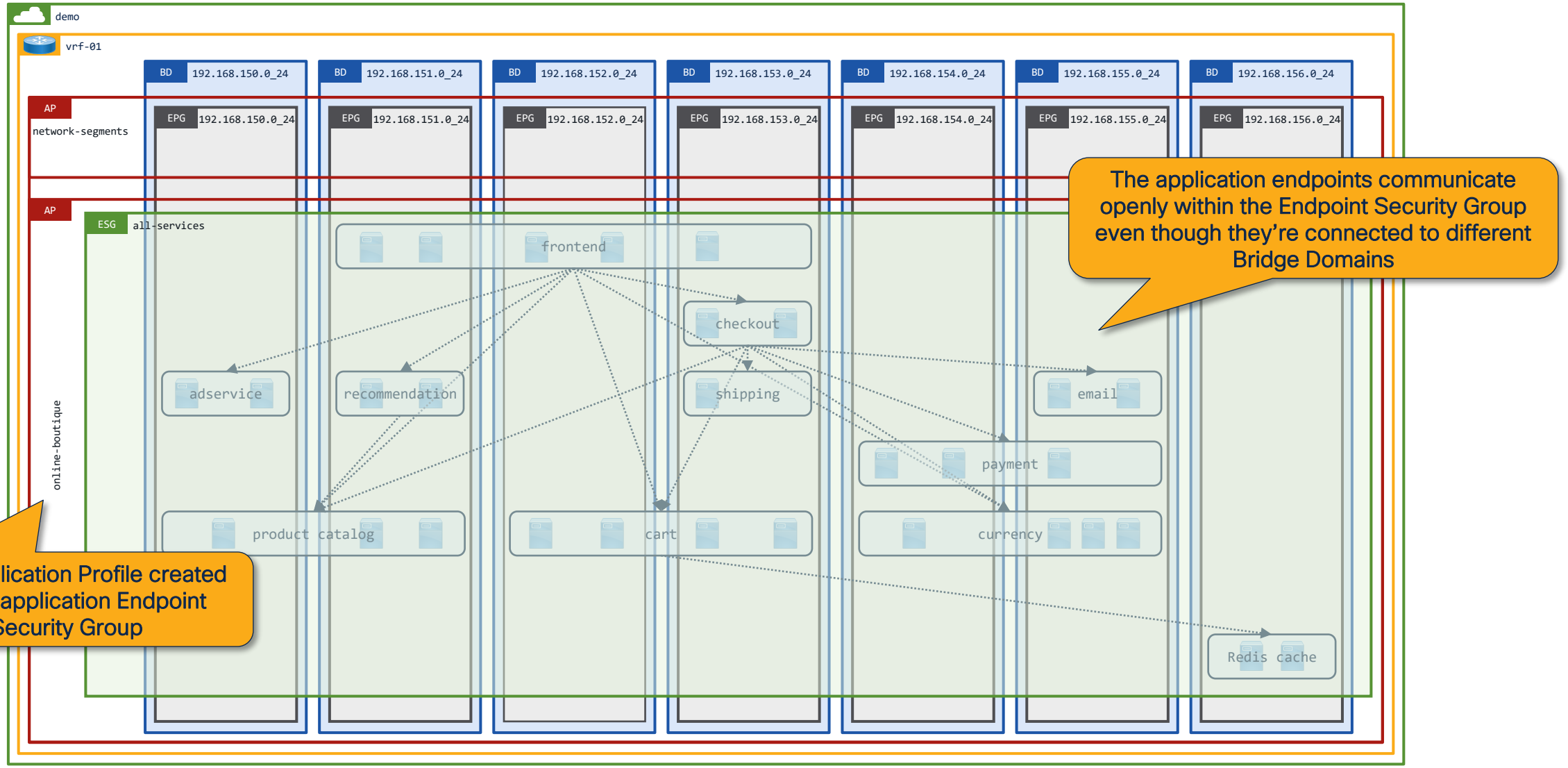
Let’s convert to “Application Centric” mode...



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What does this mean to the network admin...?

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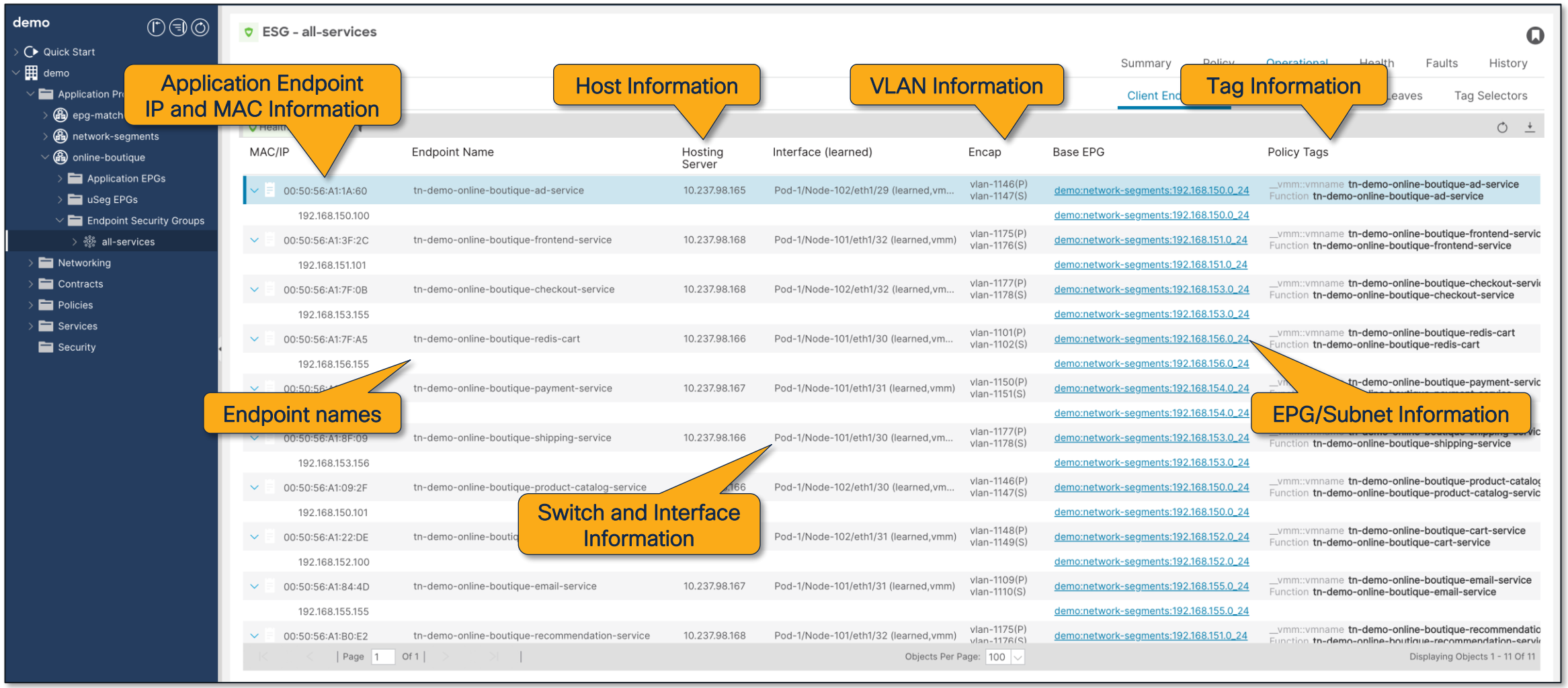
Application Visibility...!



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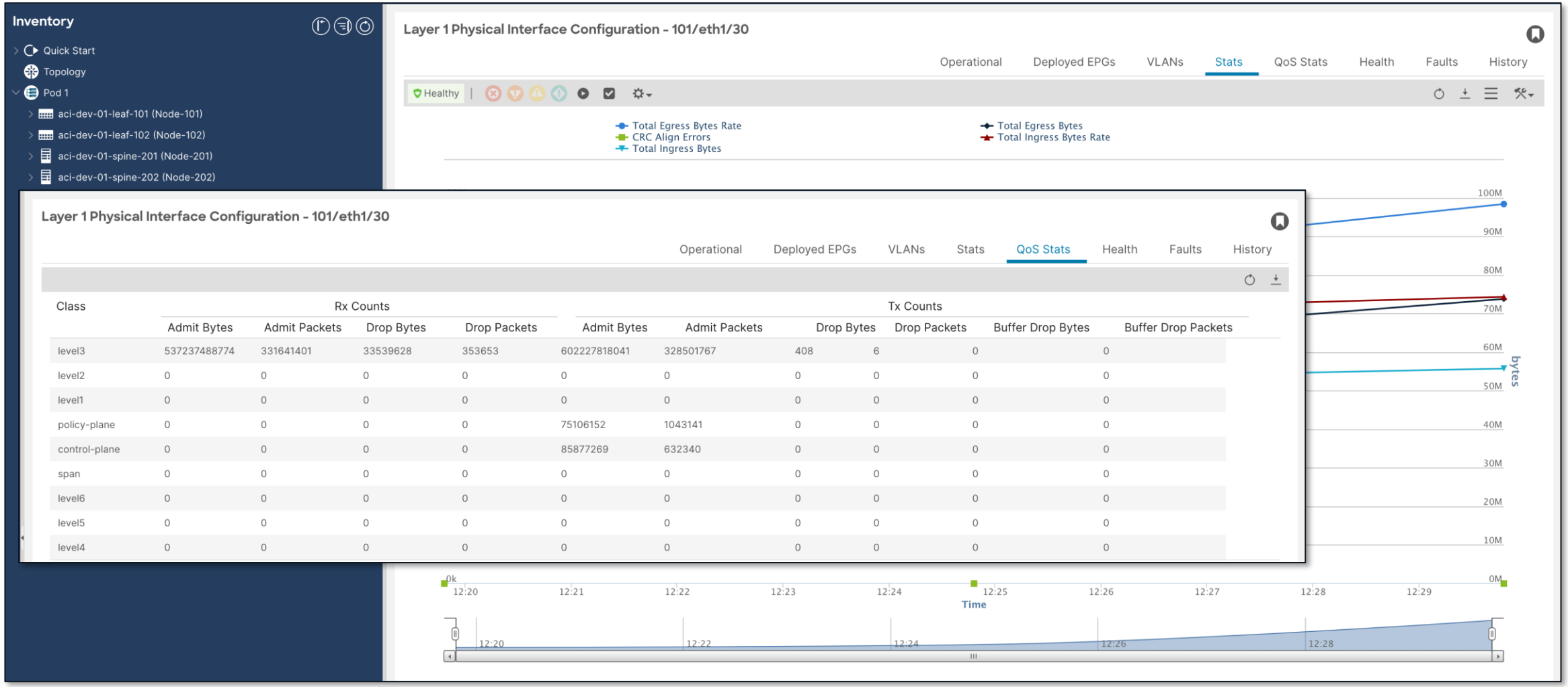
Correlate Endpoints to Switch Interfaces...



Layer 1 Physical Interface Configuration - 101/eth1/30

Operational | Deployed EPGs | VLANs | Stats | QoS Stats | Health | Faults | History

Class	Rx Counts				Tx Counts					
	Admit Bytes	Admit Packets	Drop Bytes	Drop Packets	Admit Bytes	Admit Packets	Drop Bytes	Drop Packets	Buffer Drop Bytes	Buffer Drop Packets
level3	537237488774	331641401	33539628	353653	602227818041	328501767	408	6	0	0
level2	0	0	0	0	0	0	0	0	0	0
level1	0	0	0	0	0	0	0	0	0	0
policy-plane	0	0	0	0	75106152	1043141	0	0	0	0
control-plane	0	0	0	0	85877269	632340	0	0	0	0
span	0	0	0	0	0	0	0	0	0	0
level6	0	0	0	0	0	0	0	0	0	0
level5	0	0	0	0	0	0	0	0	0	0
level4	0	0	0	0	0	0	0	0	0	0

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What if don’t want my classification to be this granular...?

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Broad-brush classification...

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What if I'd like to gather data on a specific group of endpoints...?

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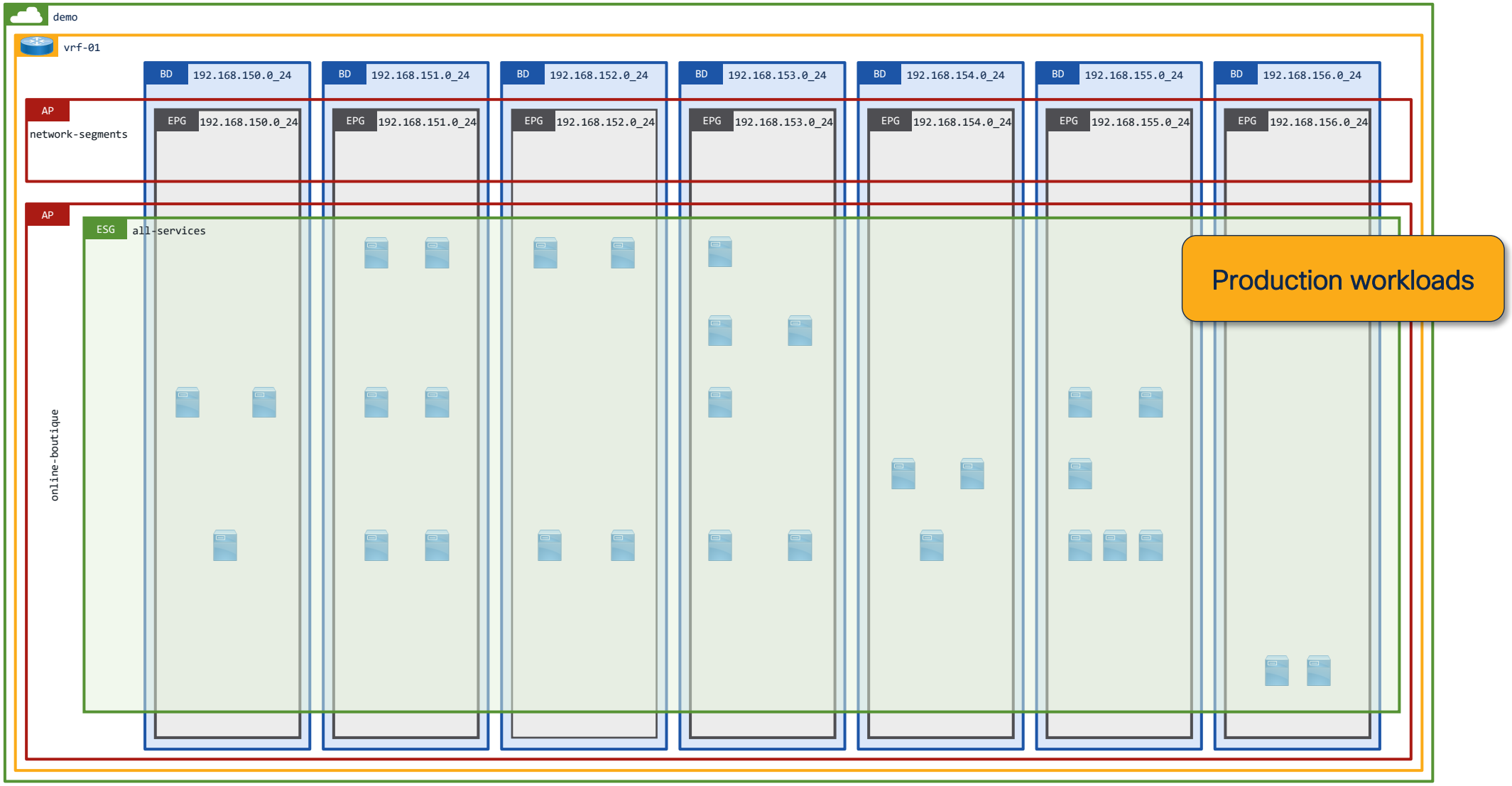
Endpoint classification for monitoring...



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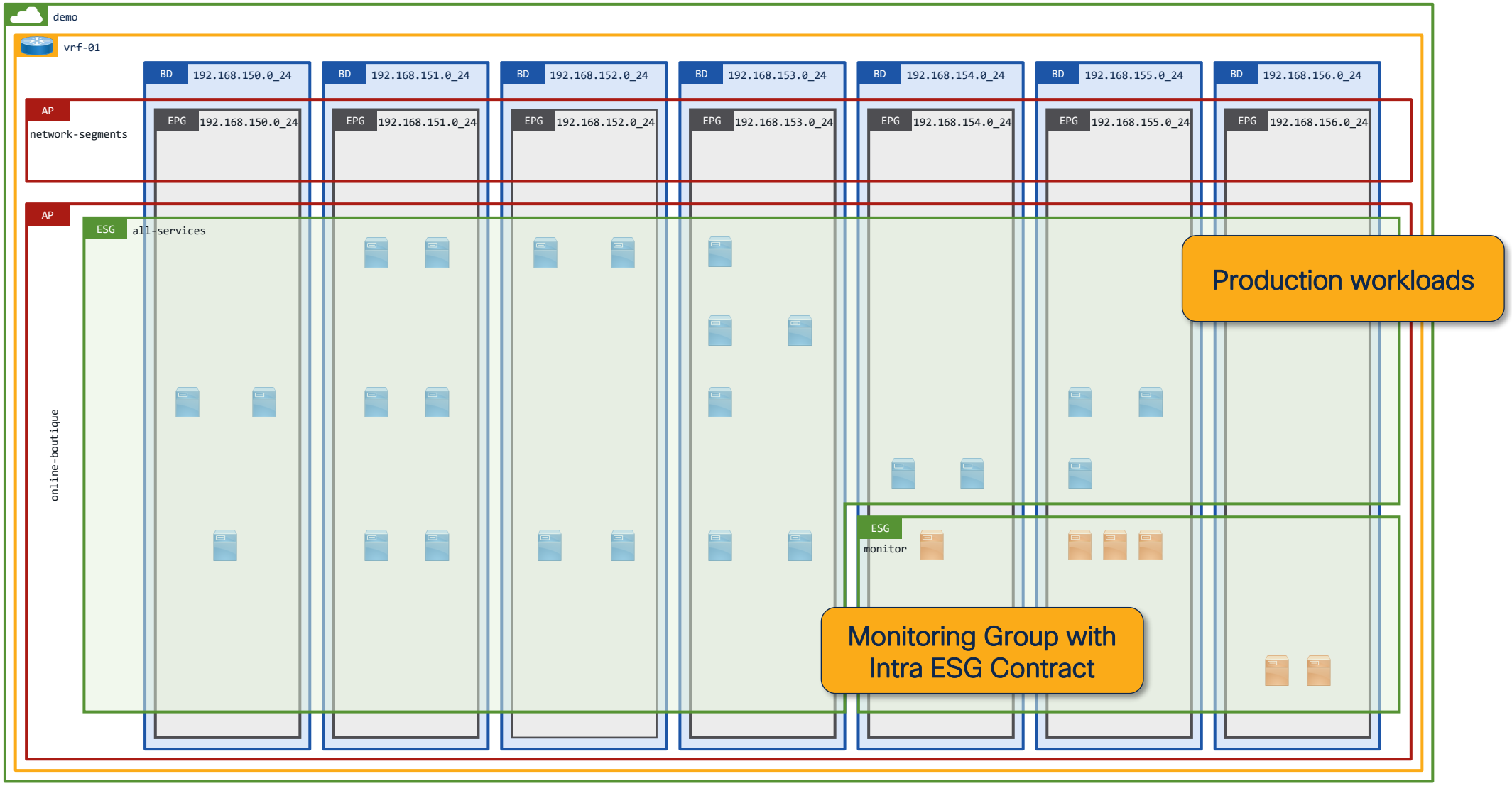
Endpoint classification for monitoring...



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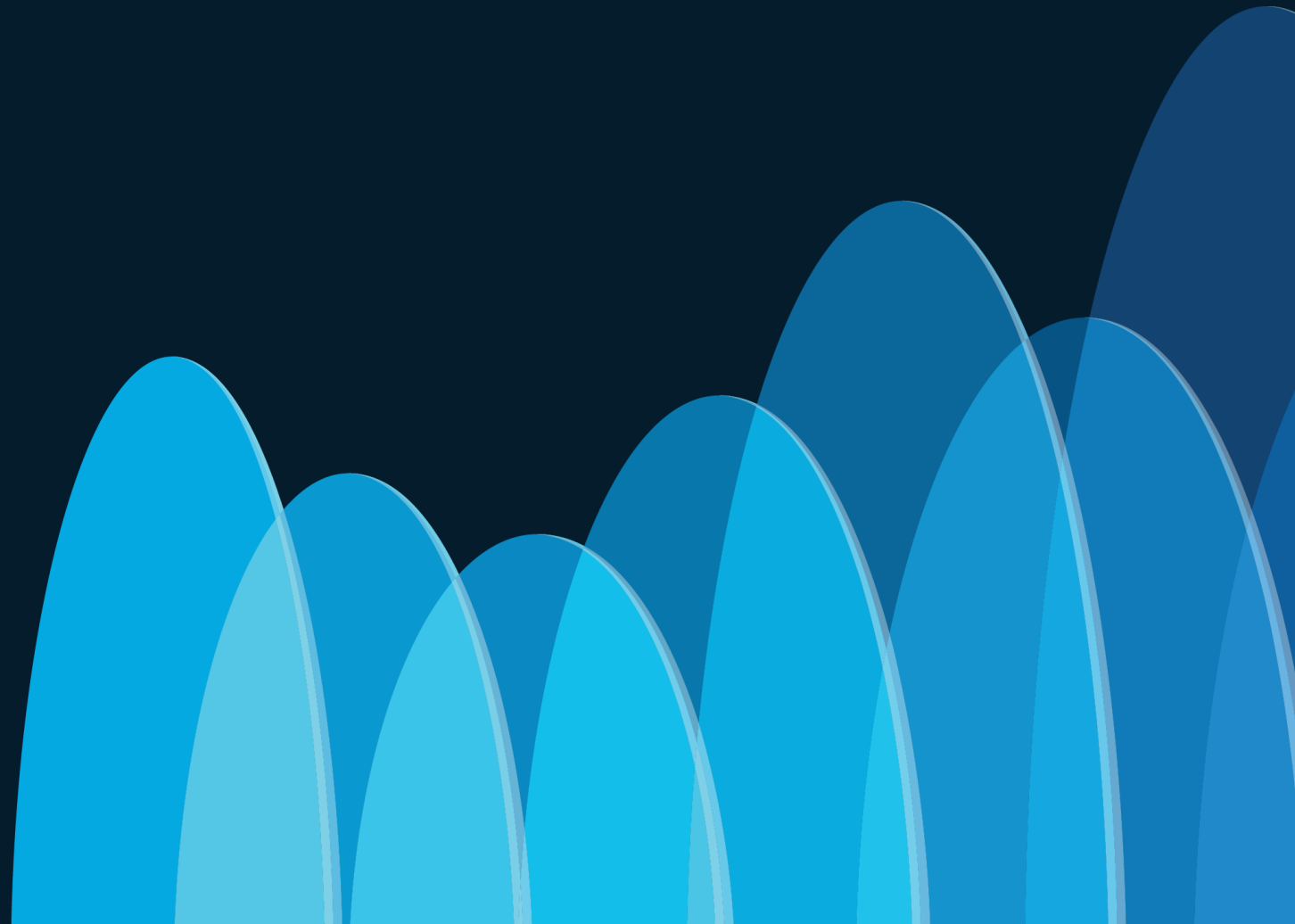

All we need are the application names and the associated IP addresses...!

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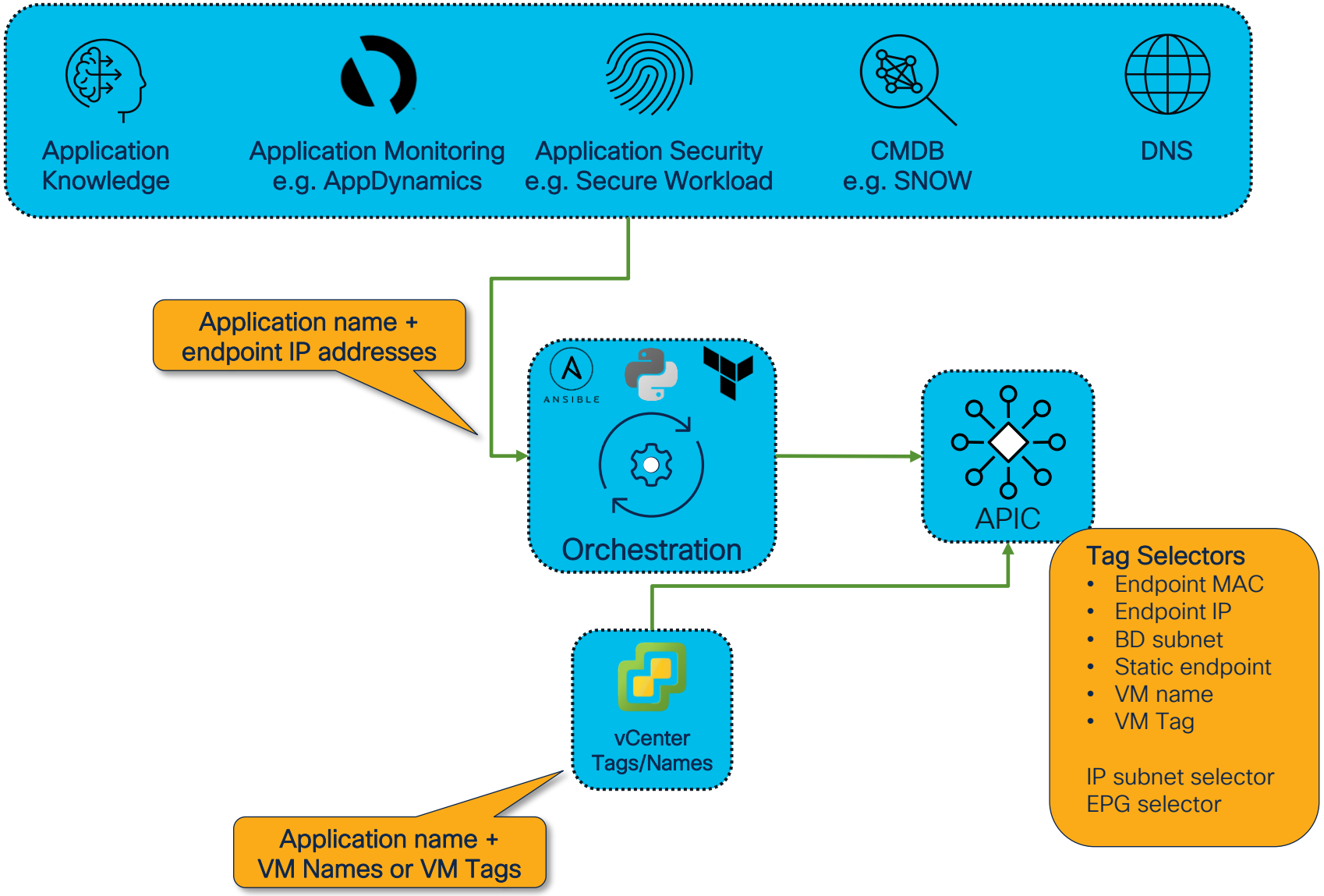
Application Knowledge taken from any source



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Physical or virtual workloads, with or without VMM Integration...!

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You can convert to Application Centric mode in two simple steps...

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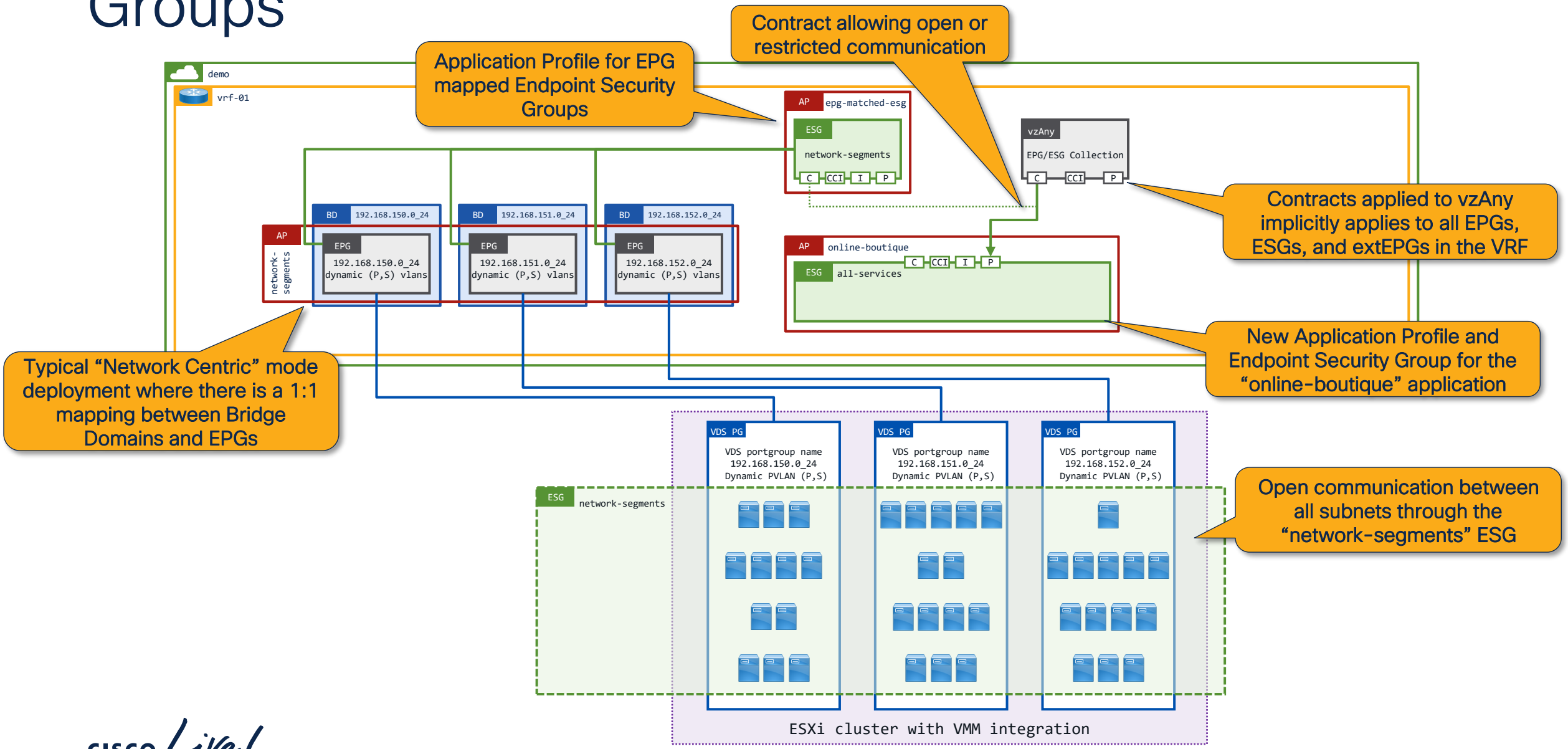
Step 1: Create Application Profiles and Security Groups



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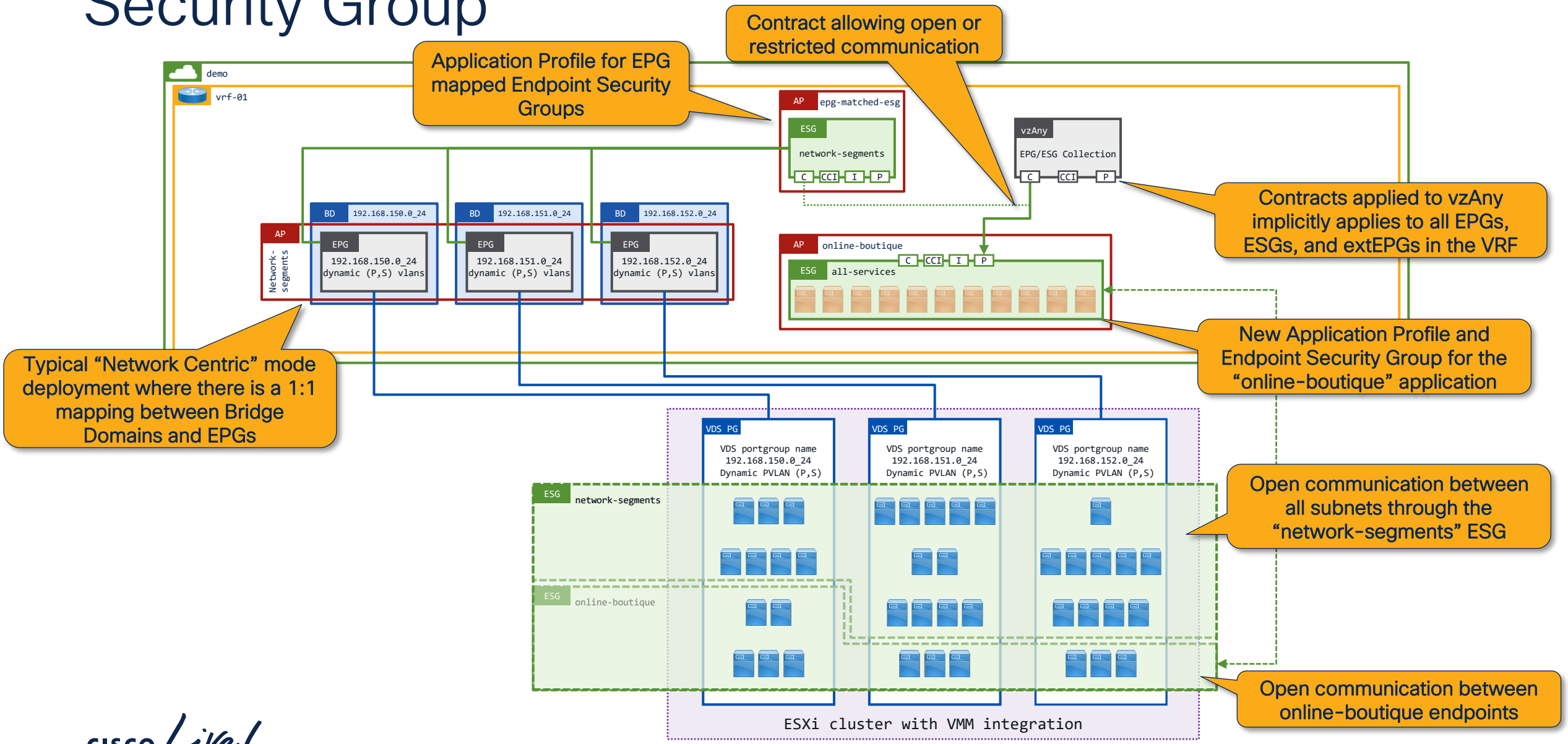
Step 2: Tag Workloads to move into the new Security Group



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Tagging Option 1: Static Tag Mapping (manual/automated)

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Automated conversion to “Application Centric”

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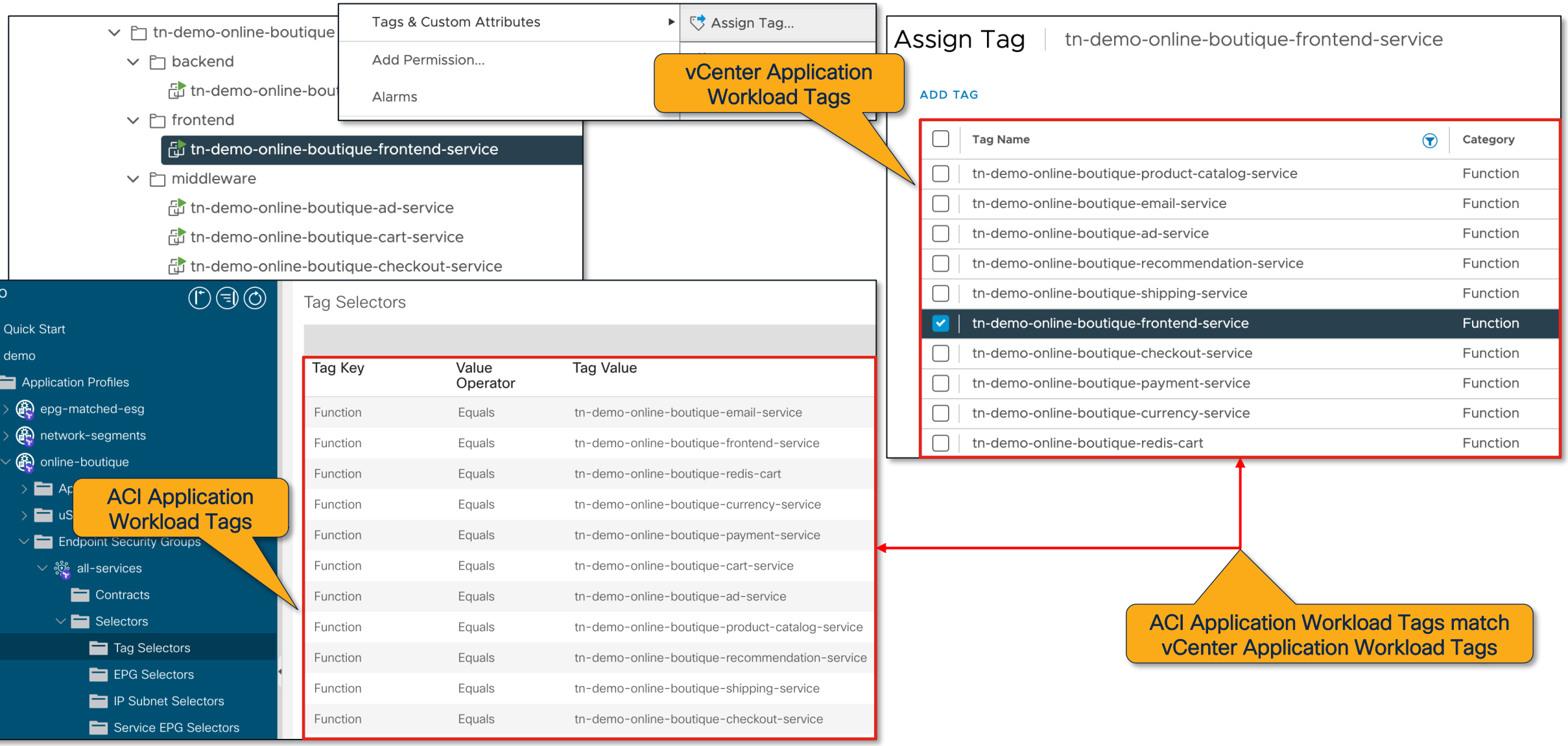
Tagging Option 2: VMM Tag Mapping



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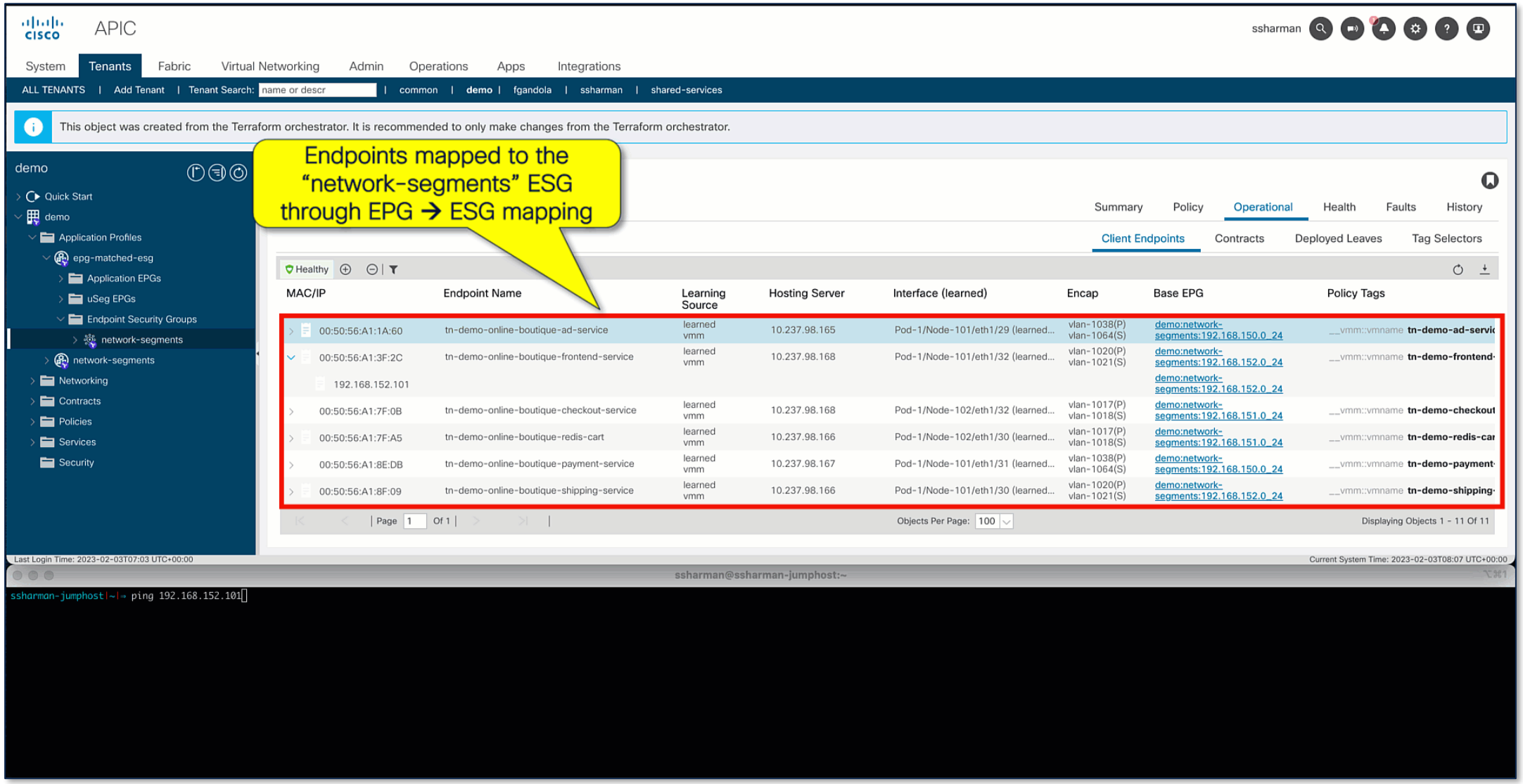
Automated conversion to “Application Centric”



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Scaling application connectivity with vzAny...

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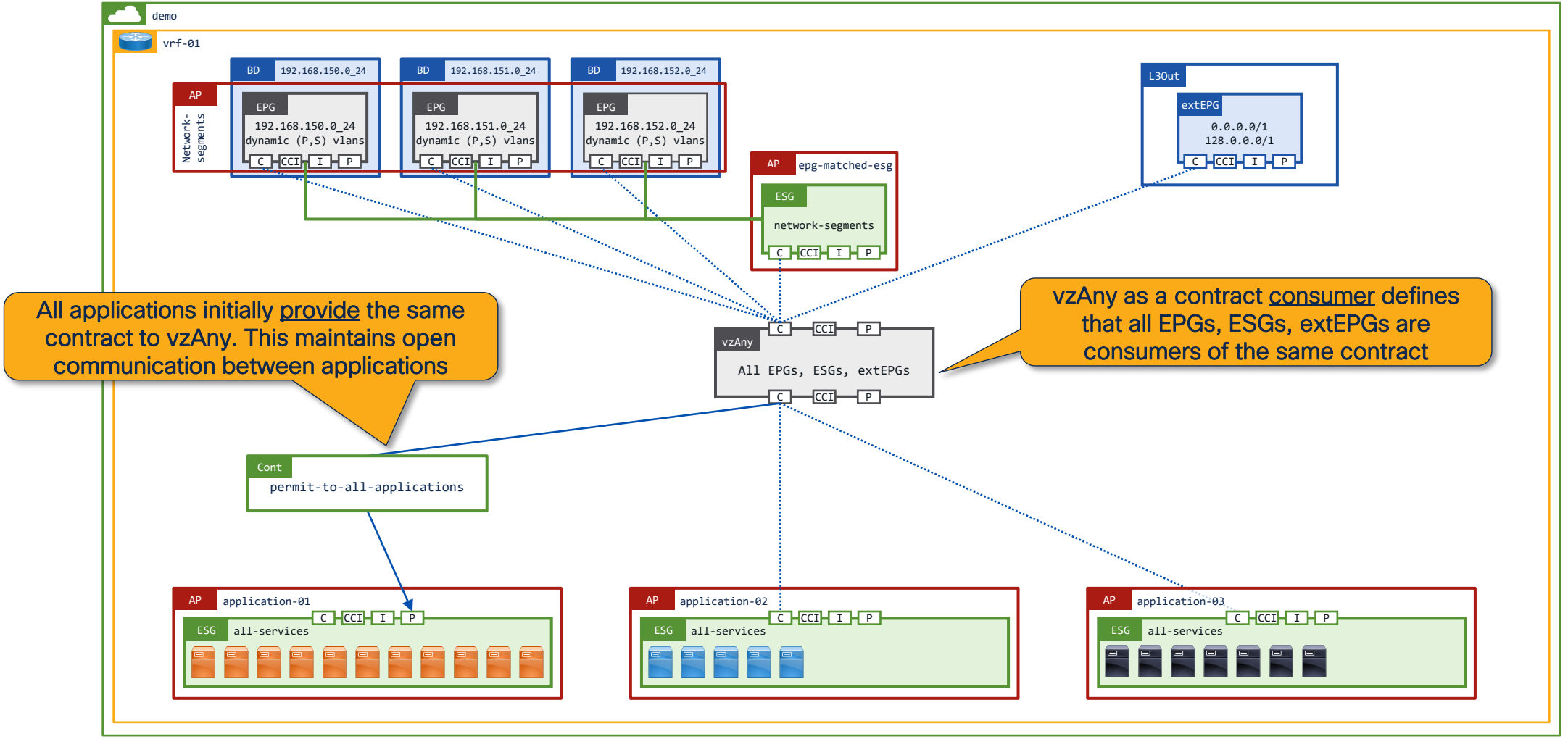
Scaling connectivity to “application-01”



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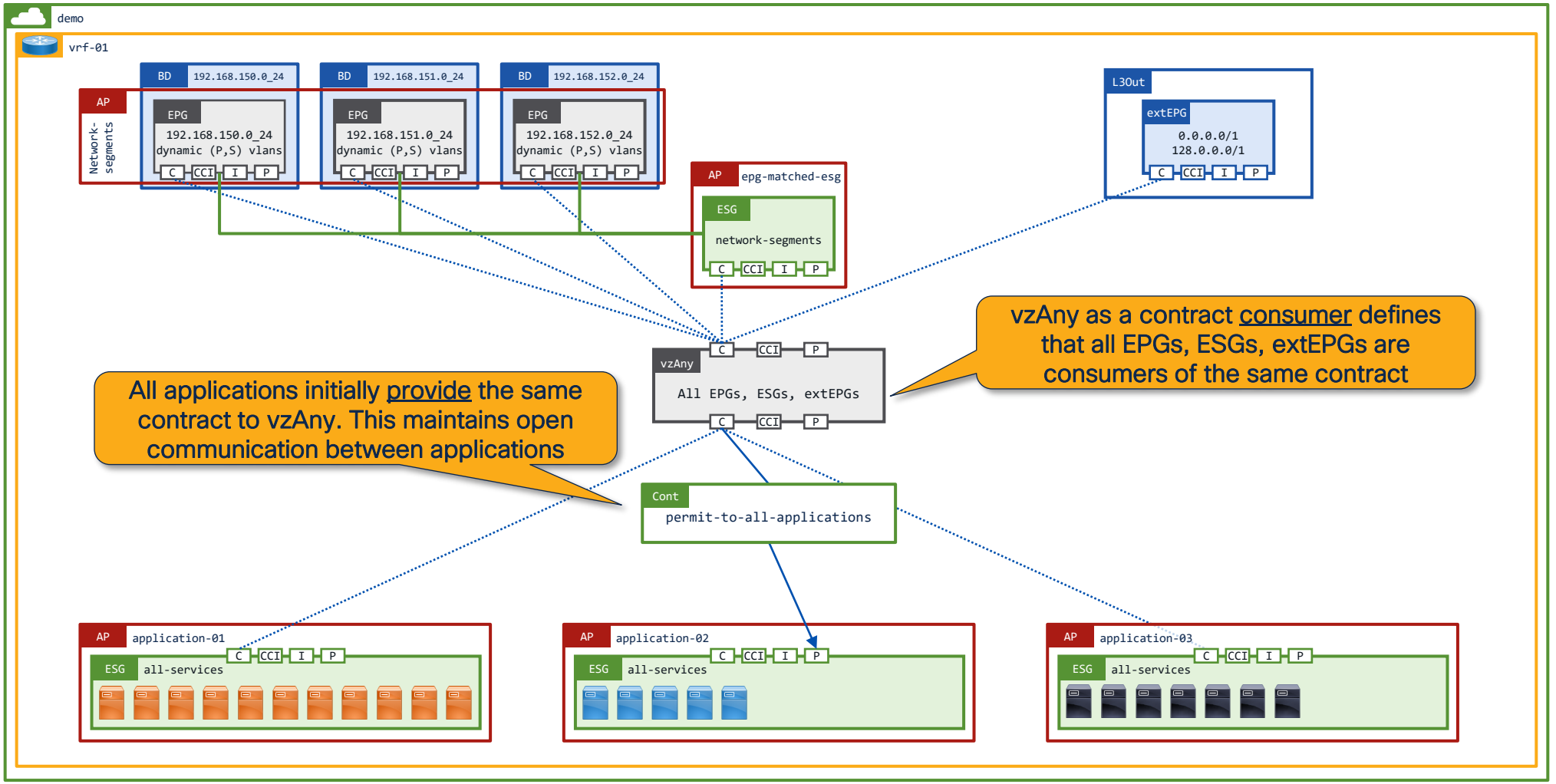
Scaling connectivity to “application-02”



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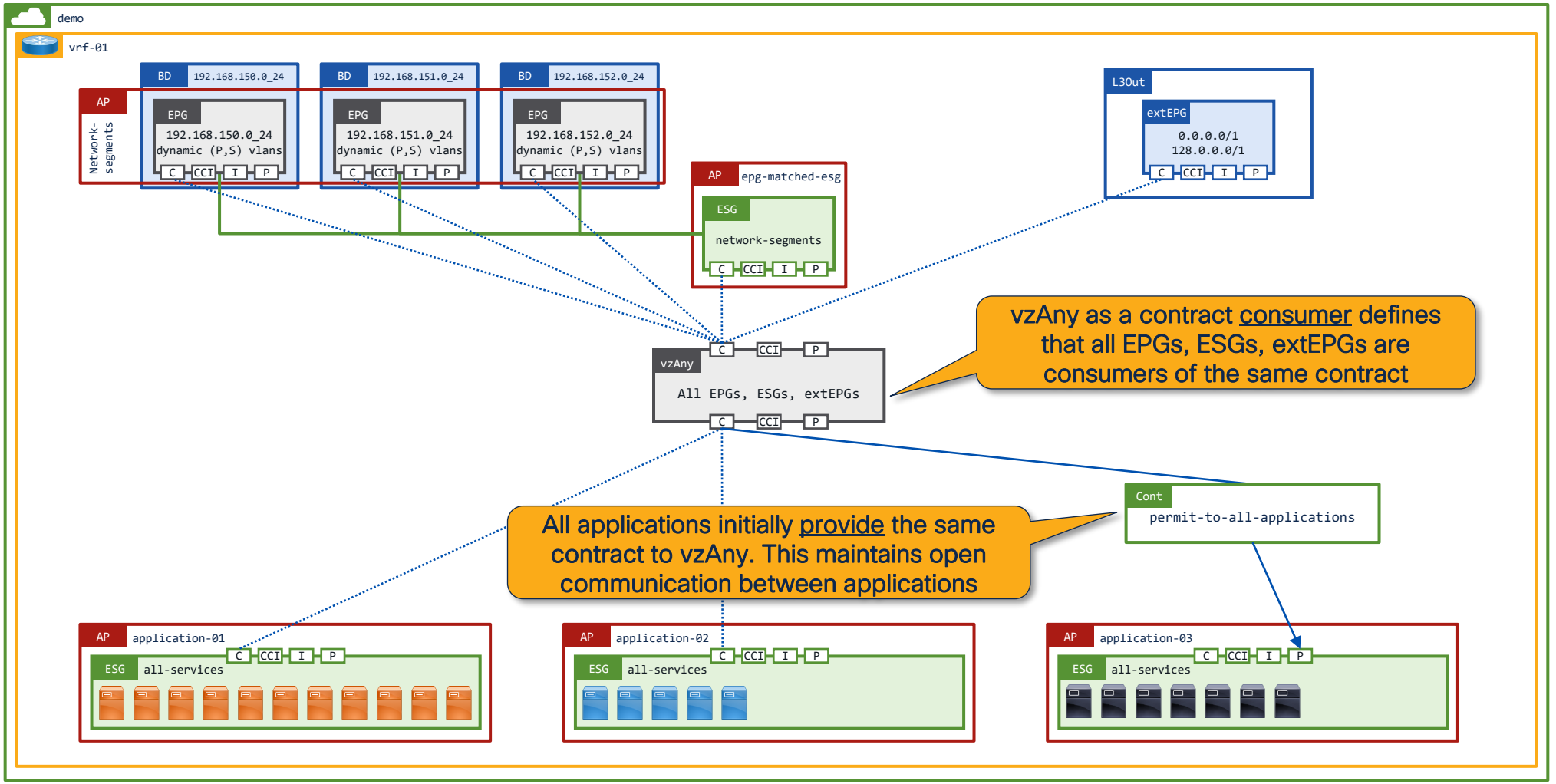
Scaling connectivity to “application-03”



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Setting the scene...

Designing your Tenants...

Switching to Application Centric mode...

Working with ESGs...

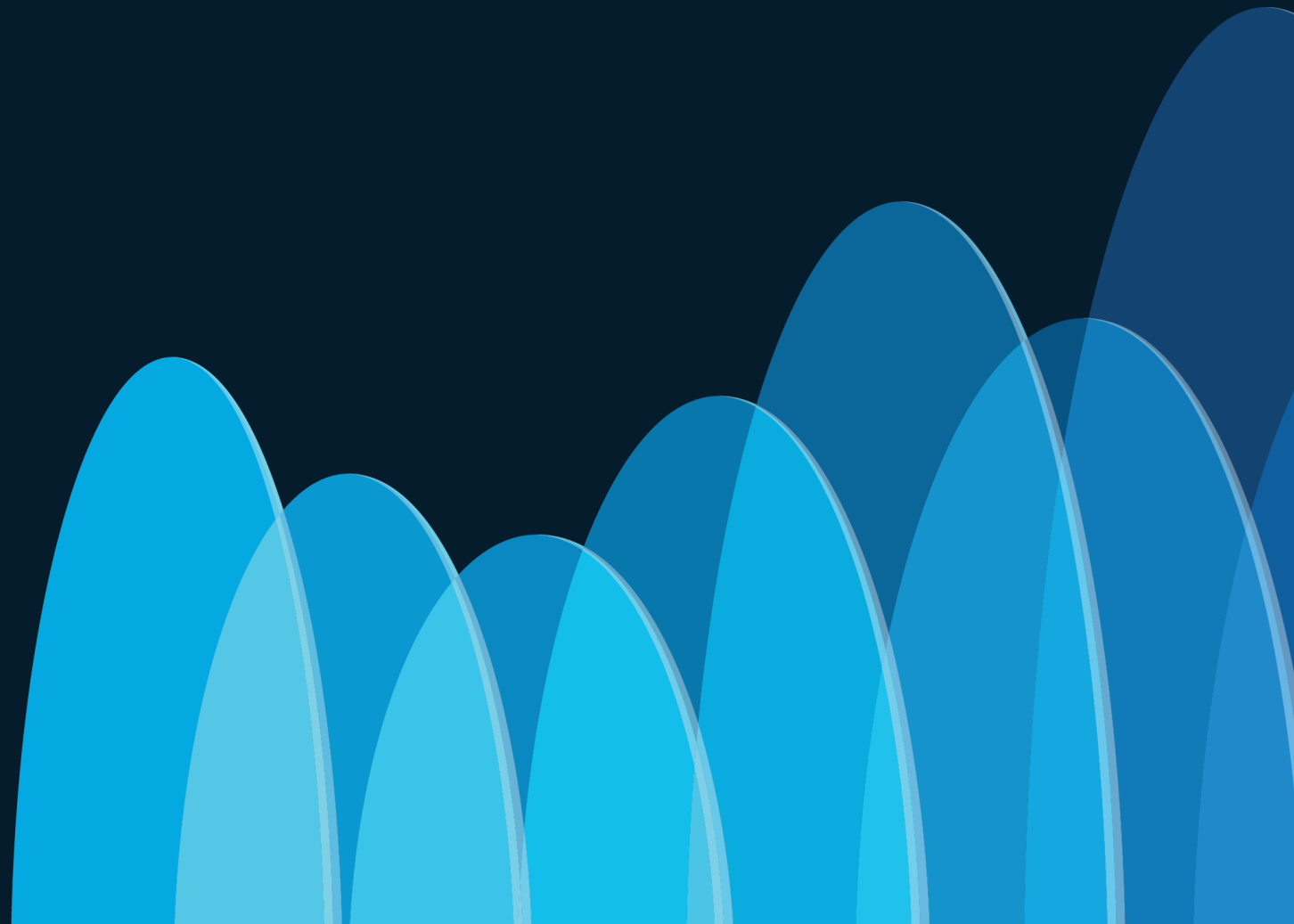
Understanding ACI security...

External Connectivity...

Increasing Security...

Automation Blueprints...

Wrapping up...



Why are ESGs a better classification option...?

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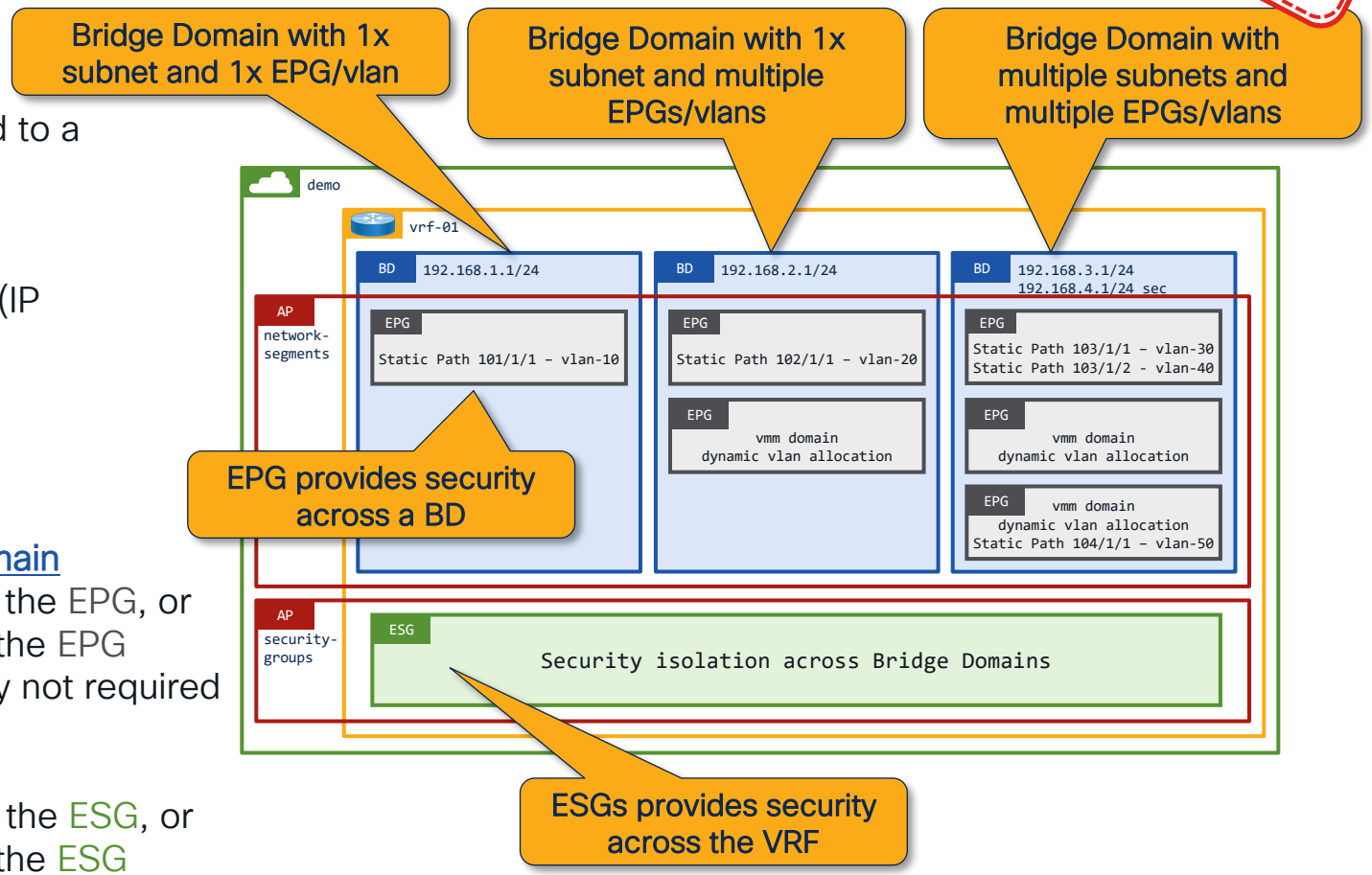
EPG Security vs ESG Security

For your reference

ACI foundational building blocks:

- A Tenant provides an RBAC boundary typically linked to a business function
- A VRF is mapped to a single Tenant
- A Bridge Domain is mapped to a single VRF
- A Bridge Domain provides one or more IP gateways (IP secondary)
- An EPG is mapped to a single Bridge Domain
- An EPG provides network backing and maps to:
  - VMM domains + static or dynamic VLAN(s)
  - Static path(s) + static VLAN(s)
- An EPG defines a security boundary on a Bridge Domain
- An EPG allows open communication for endpoints in the EPG, or (optionally) blocked communication for endpoints in the EPG
- Inter EPG communication requires contracts (typically not required when using ESGs)
- An ESG forms a security boundary on a VRF
- An ESG allows open communication for endpoints in the ESG, or (optionally) blocked communication for endpoints in the ESG
- Inter ESG communication requires contracts
- ESG contracts supersede EPG contracts



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What are our endpoint mapping options...?

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We can use EPGs, Tagged endpoints, Tagged subnets, or simply Static endpoint mapping…

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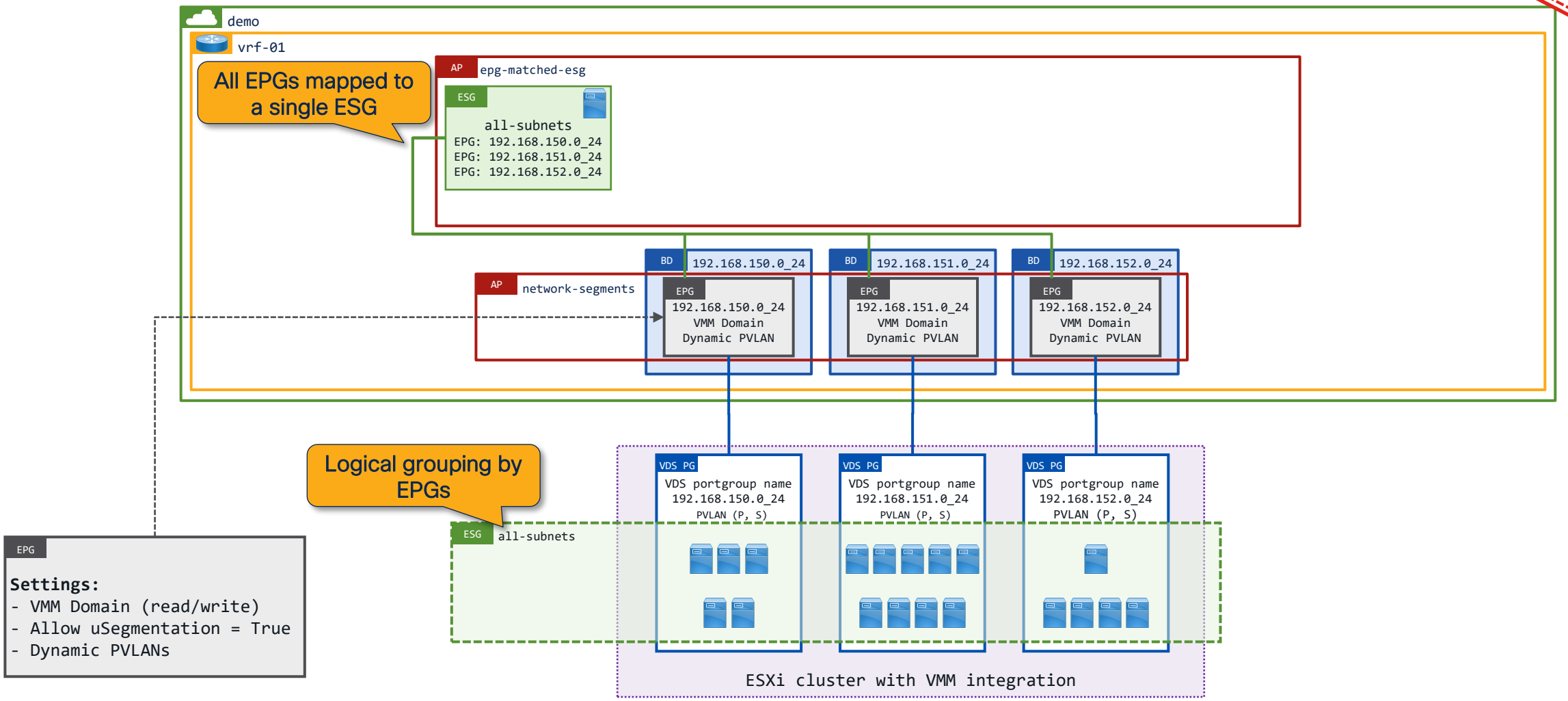
Option 1: EPG mapping to a single security zone

Open security comparable to vzAny, excluding the extEPG



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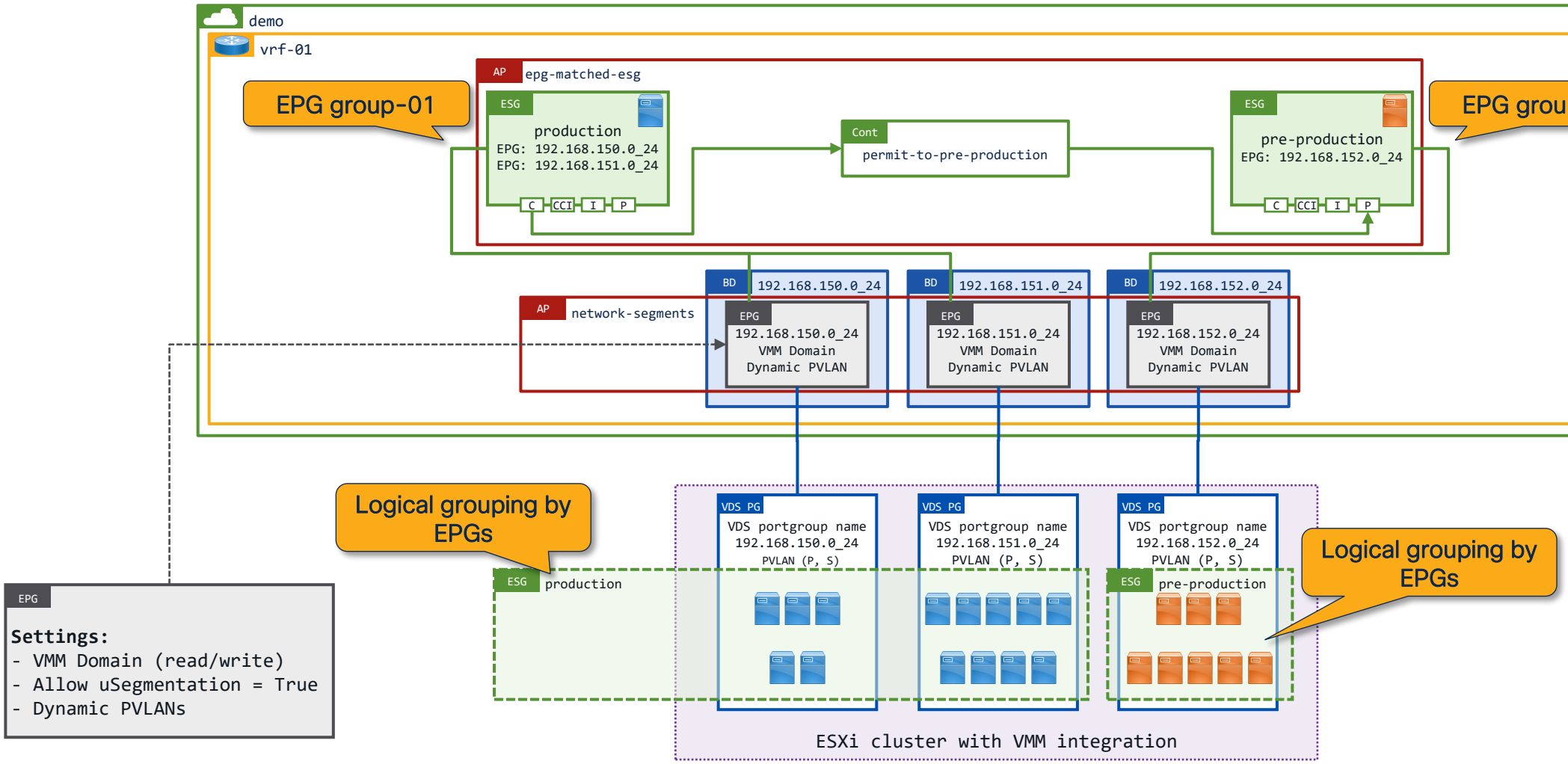
Option 2: EPG mapping for multiple security zones

Two or more security zones, e.g. Production and Pre-Production



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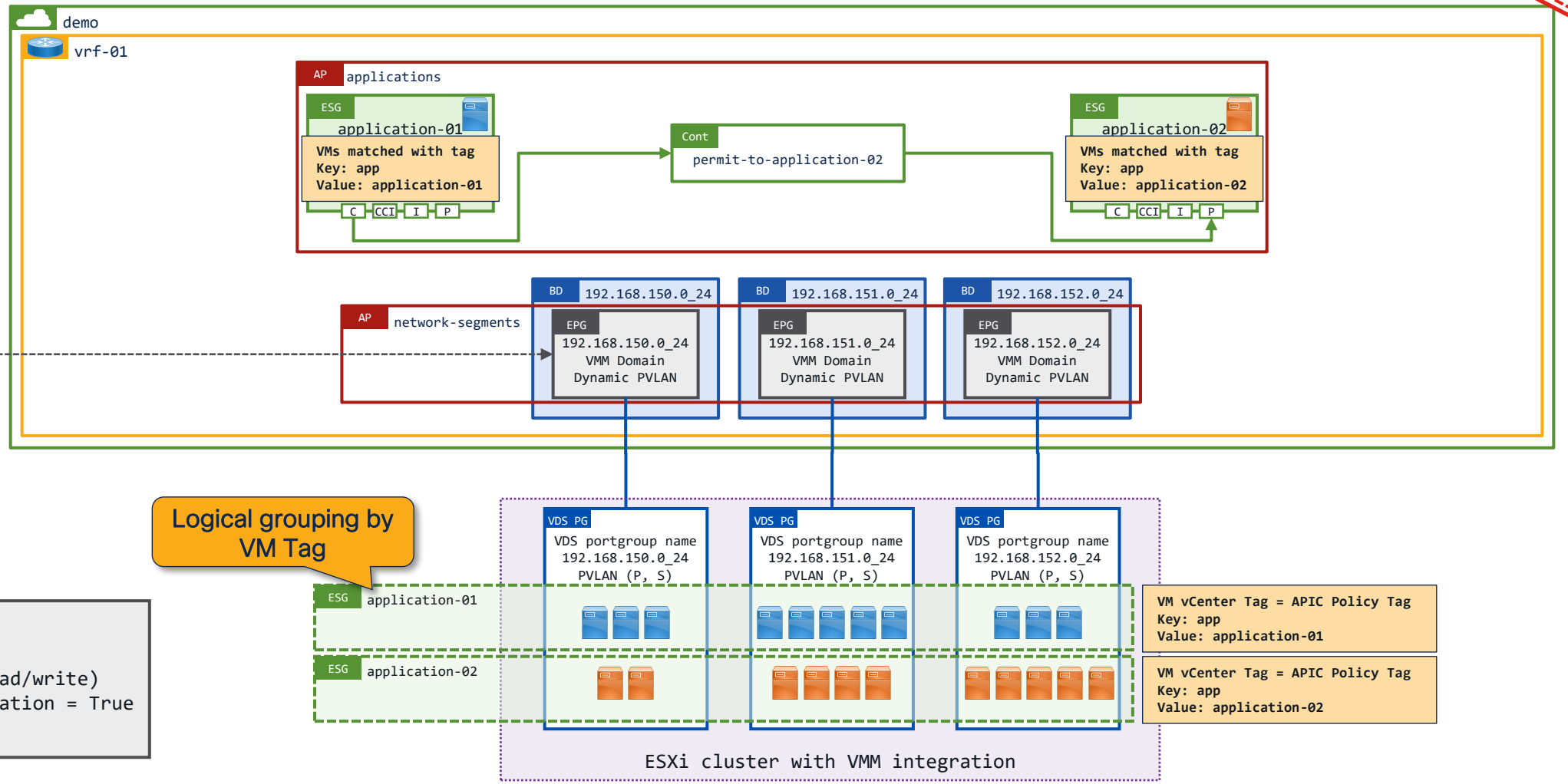
Option 3: Tag selectors with VMM integration

Endpoint assignment using vCenter Tags. Requires VMM read/write integration



EPG

Settings:
- VMM Domain (read/write)
- Allow uSegmentation = True
- Dynamic PVLANs

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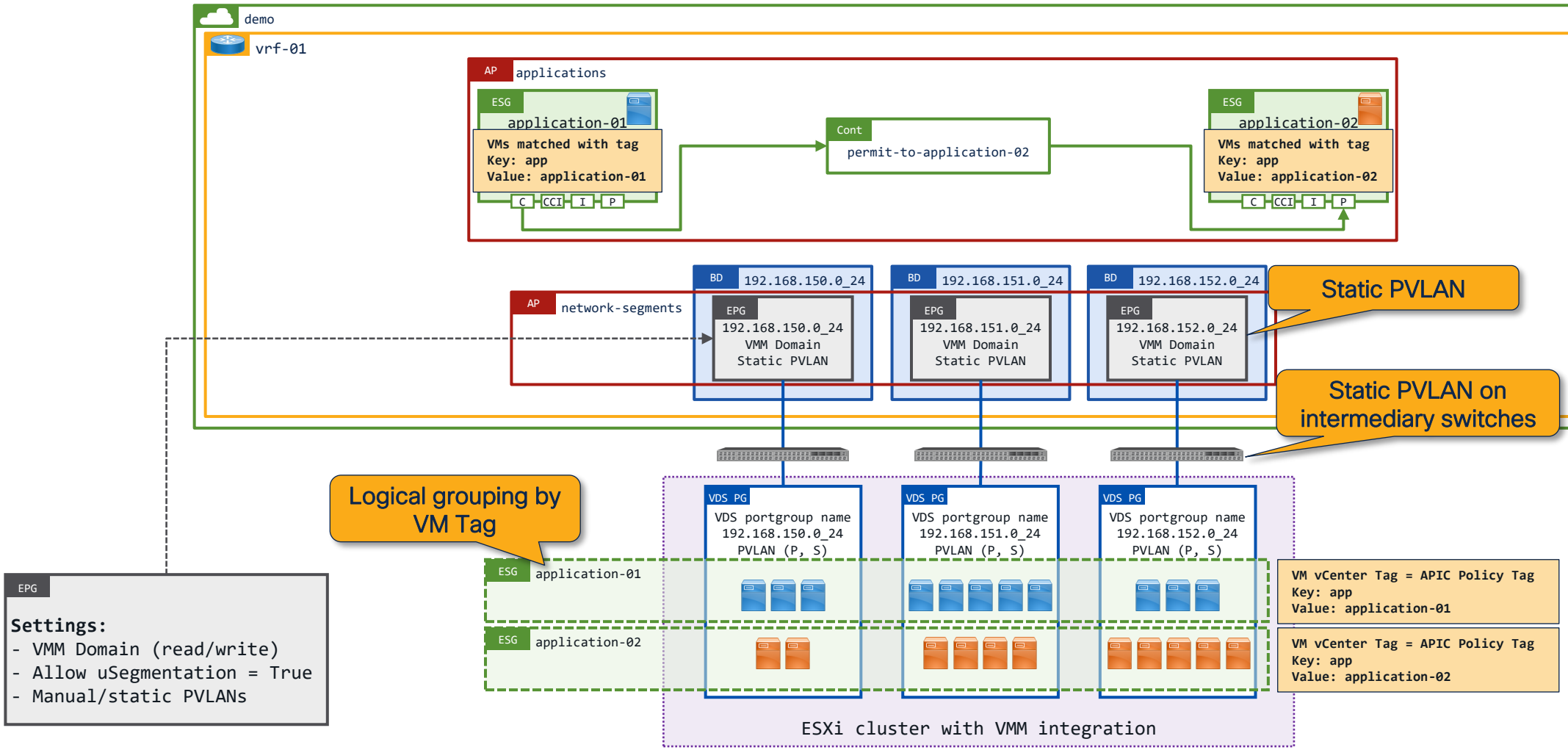
Option 4: Tag selectors with VMM integration and Intermediary switches

Intermediary switches require PVLAN pre-provisioning



EPG

Settings:
- VMM Domain (read/write)
- Allow uSegmentation = True
- Manual/static PVLANs

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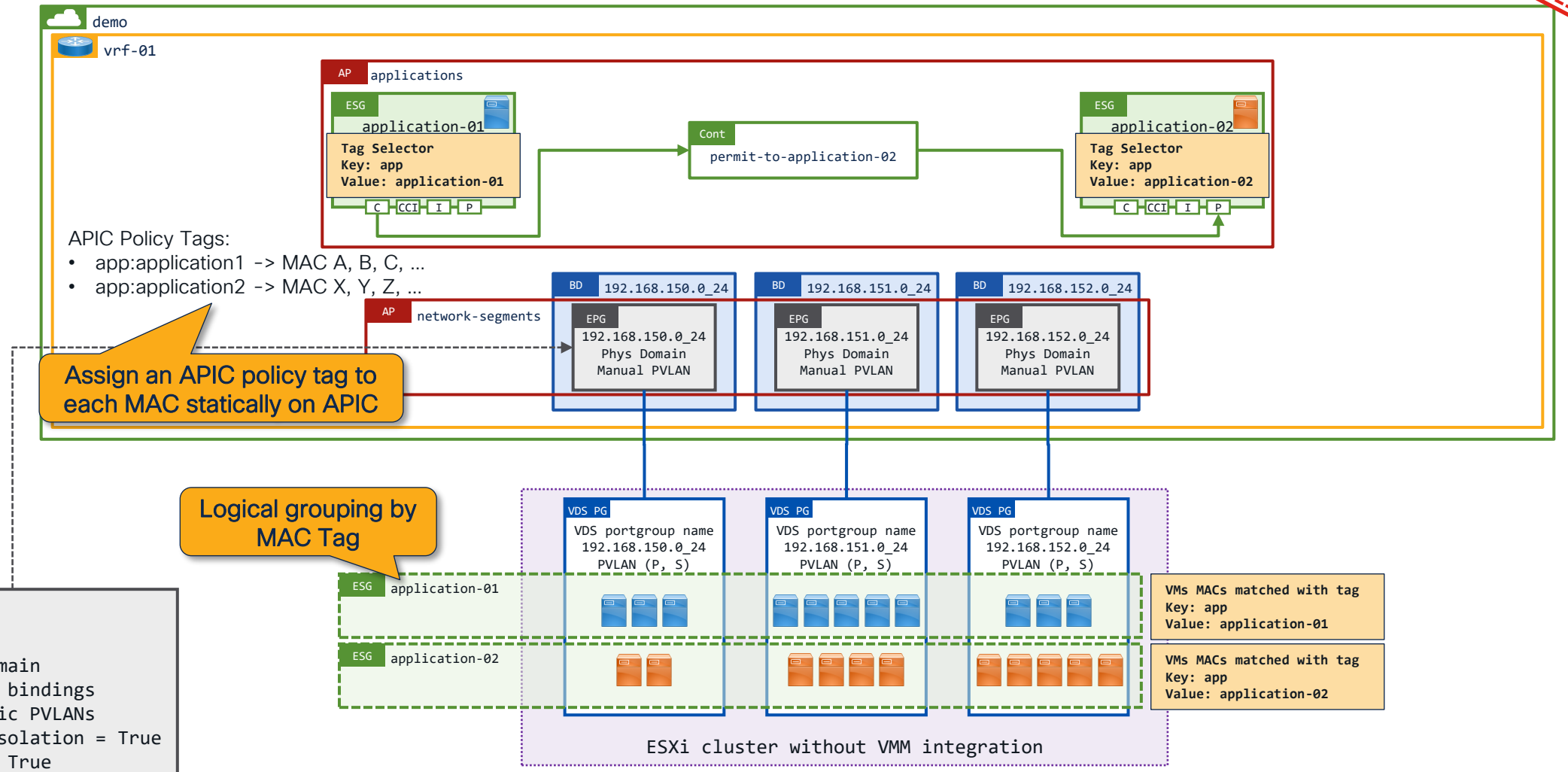
Option 5: MAC selectors, no VMM integration

Endpoint assignment using endpoint MAC addresses. Requires PVLAN on VDS



EPG

Settings:
- Physical Domain
- Static path bindings
- Manual/static PVLANs
- Intra EPG Isolation = True
- Proxy ARP = True

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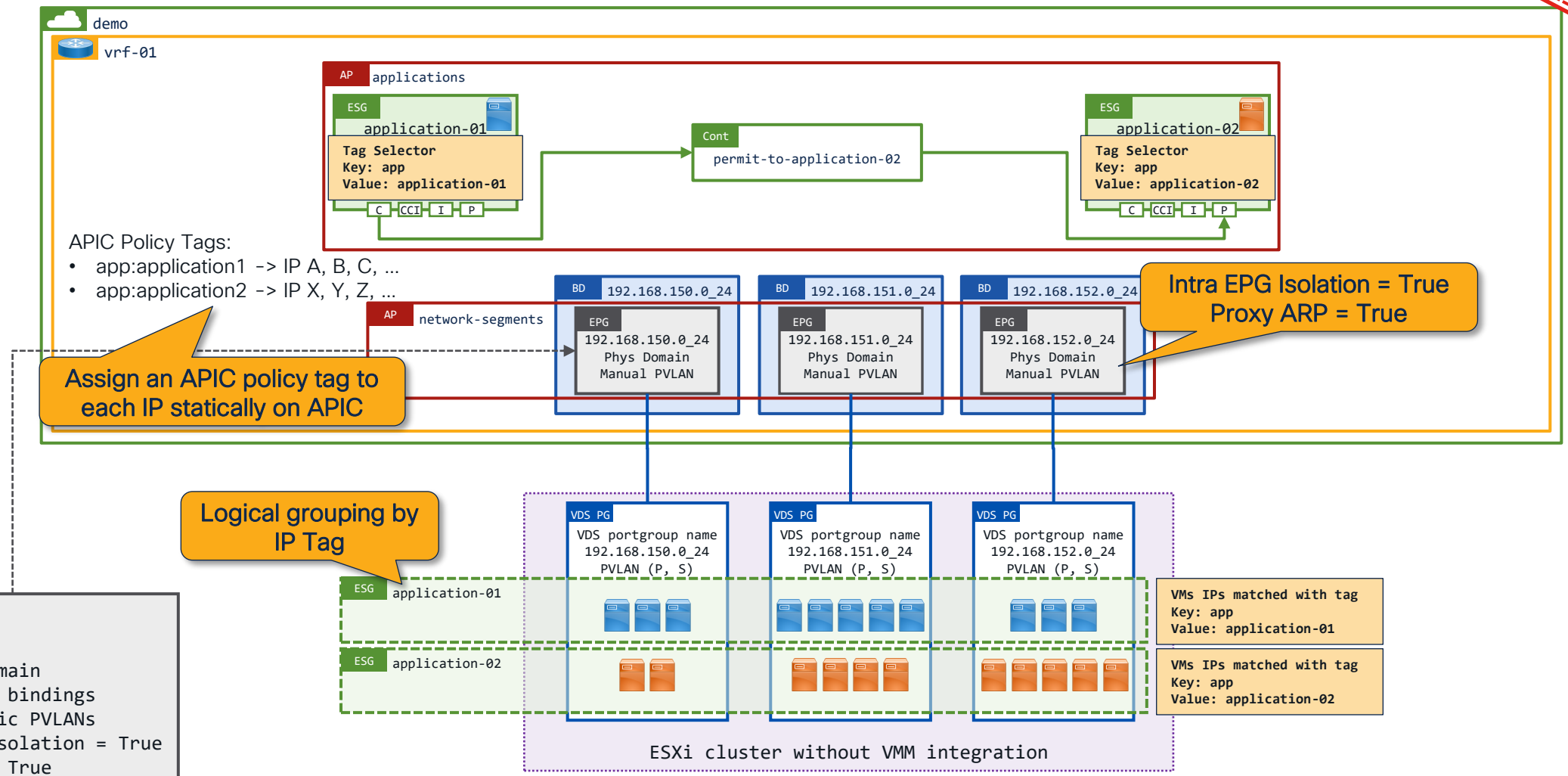
Option 6: IP selectors, no VMM integration

Endpoint assignment using endpoint IP addresses. Requires PVLAN on VDS



EPG

Settings:
- Physical Domain
- Static path bindings
- Manual/static PVLANs
- Intra EPG Isolation = True
- Proxy ARP = True

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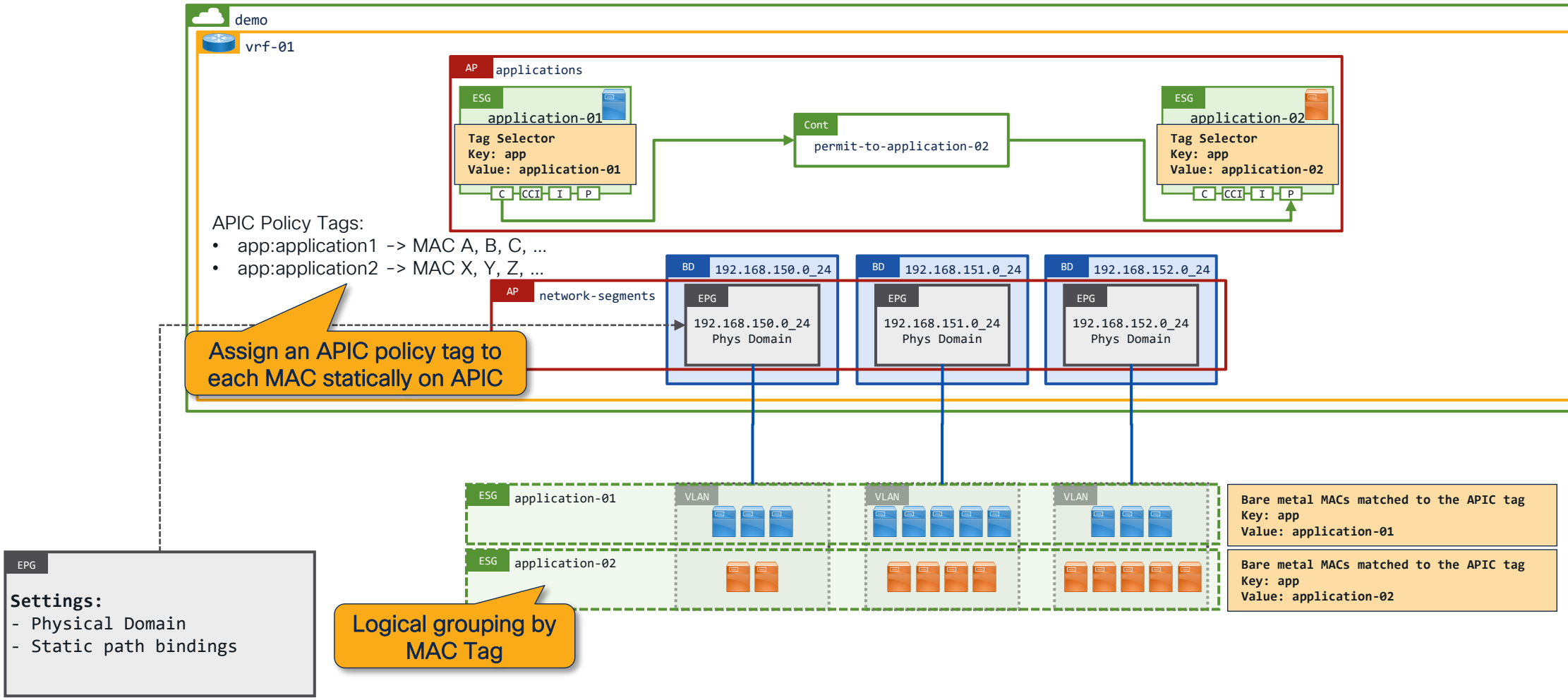
Option 7: MAC selectors for bare metal

Endpoint assignment using endpoint MAC addresses



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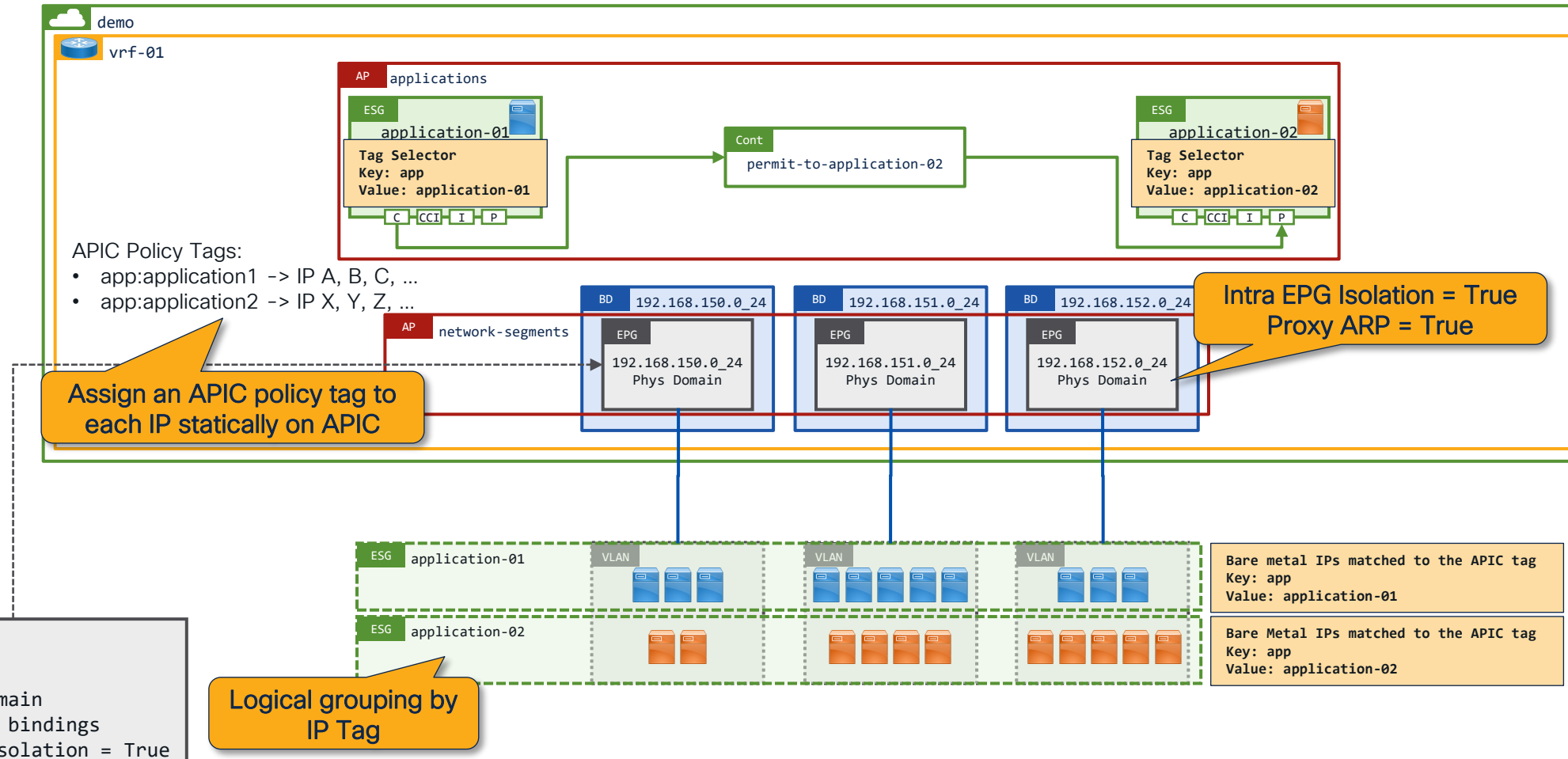
Option 8: IP selectors for bare metal

Endpoint assignment using endpoint IP addresses



EPG

Settings:
- Physical Domain
- Static path bindings
- Intra EPG Isolation = True
- Proxy ARP = True

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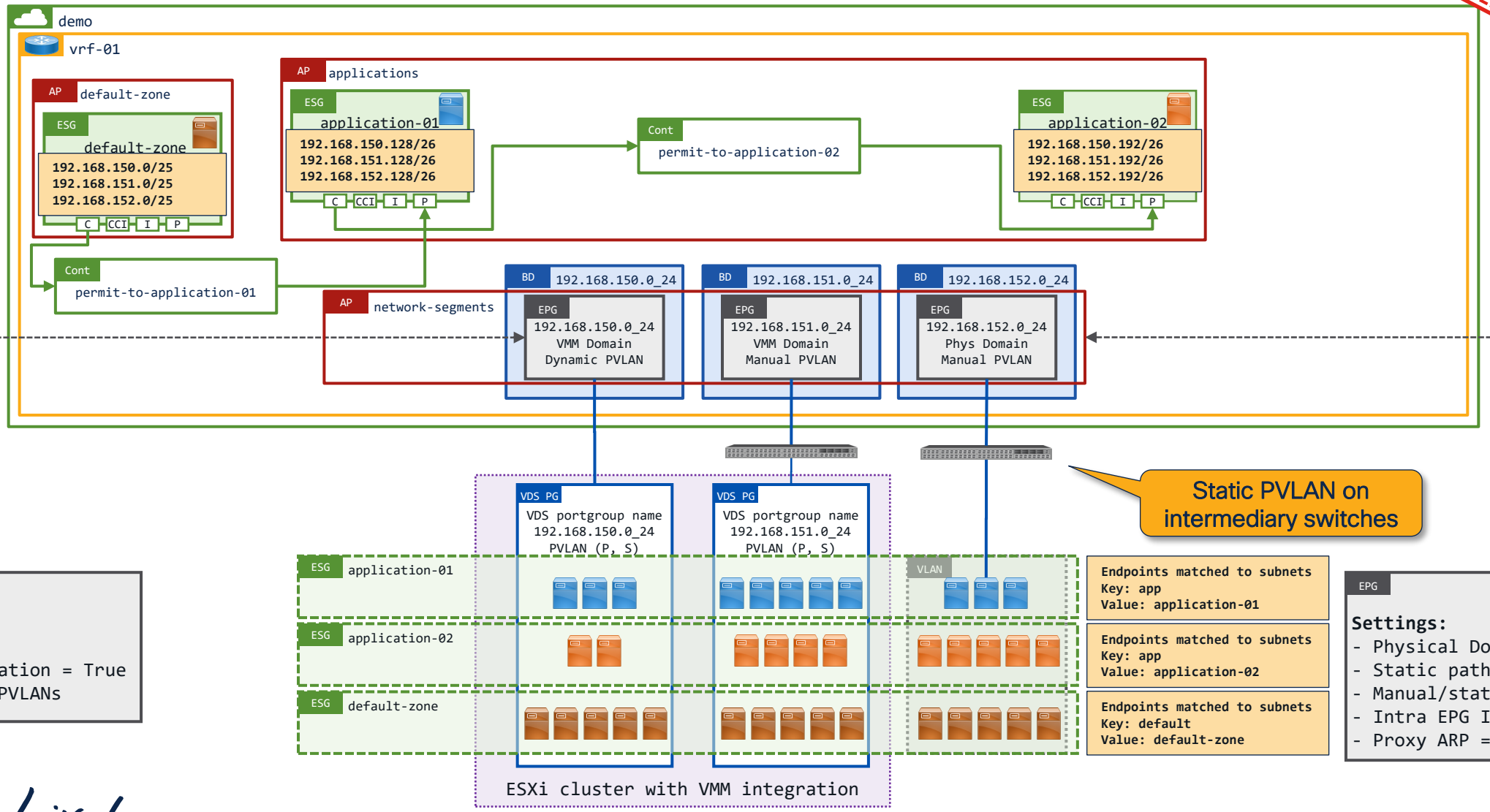
Option 9: Subnet selectors with mixed Domains

Endpoint assignment using subnet ranges



EPG

Settings:
- VMM Domain
- Allow uSegmentation = True
- Manual/static PVLANs

EPG

Settings:
- Physical Domain
- Static path bindings
- Manual/static PVLANs
- Intra EPG Isolation = True
- Proxy ARP = True

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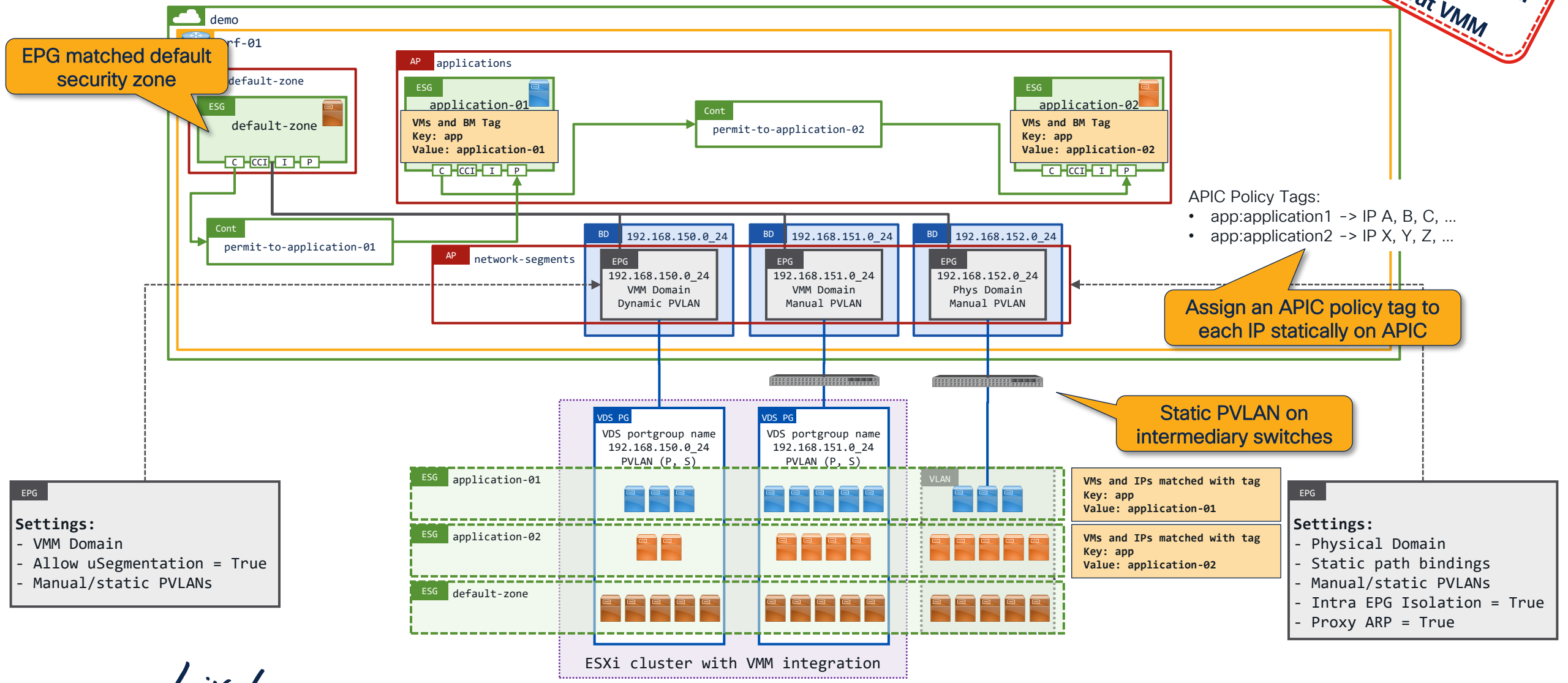
Option 10: Combined solution with/without VMM

Fully integrated solution for bare metal and VM's, with/without VMM



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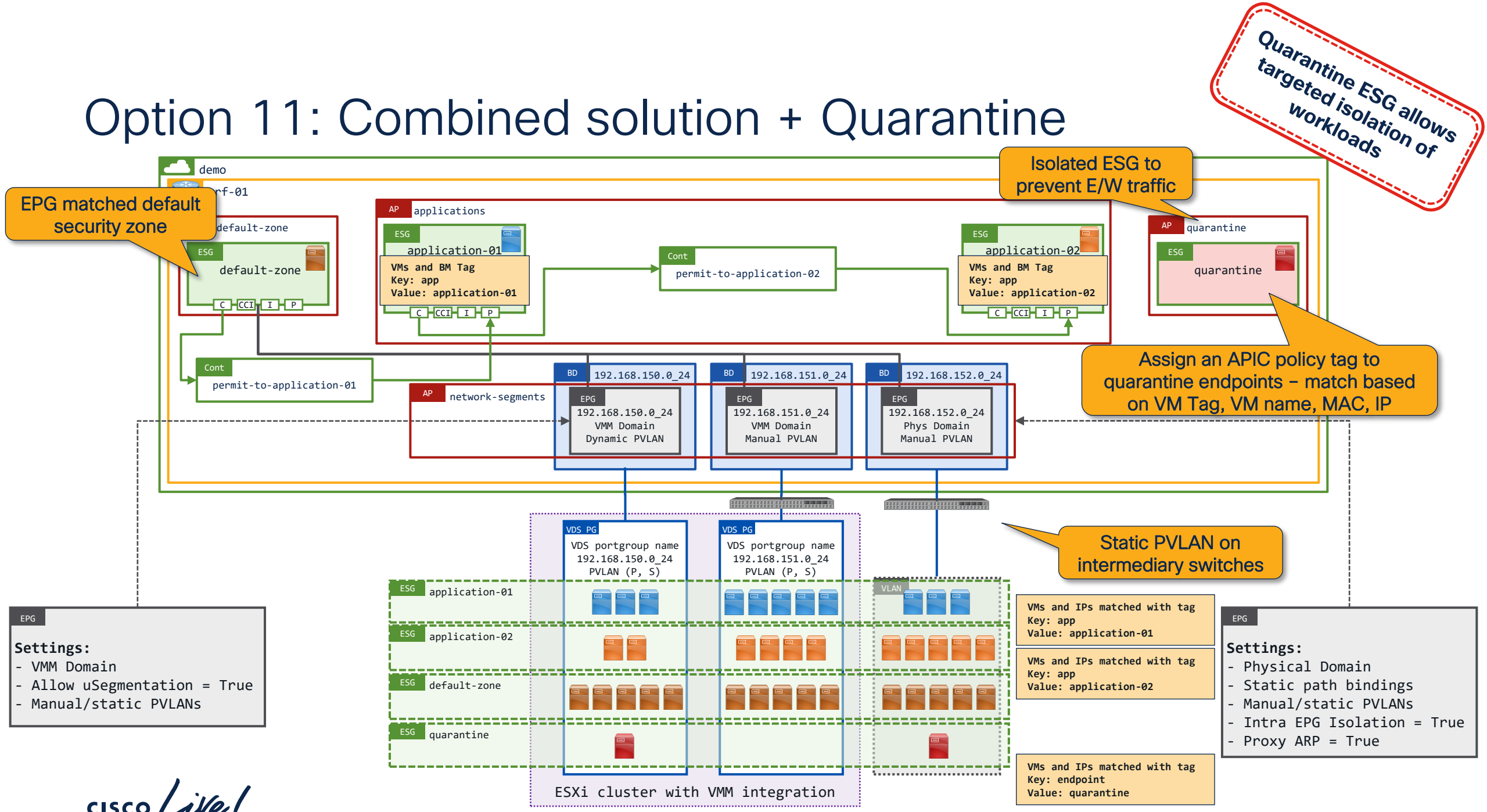
Option 11: Combined solution + Quarantine



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Why do we need to enable Proxy ARP for IP mapping...

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MAC addresses are not classified to ESGs when only IP-based selectors are used. Switching traffic (i.e. within the same subnet) will not use ESG contracts even if its payload has the IP address classified to an ESG...

If two IPs in the same subnet from the same EPG are classified into different ESGs, those two endpoints can still talk freely through the MAC and its original EPG...

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Proxy ARP

Why Proxy ARP...?

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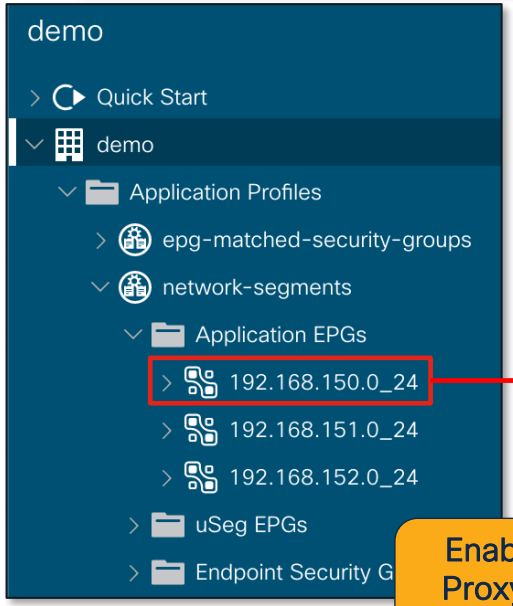
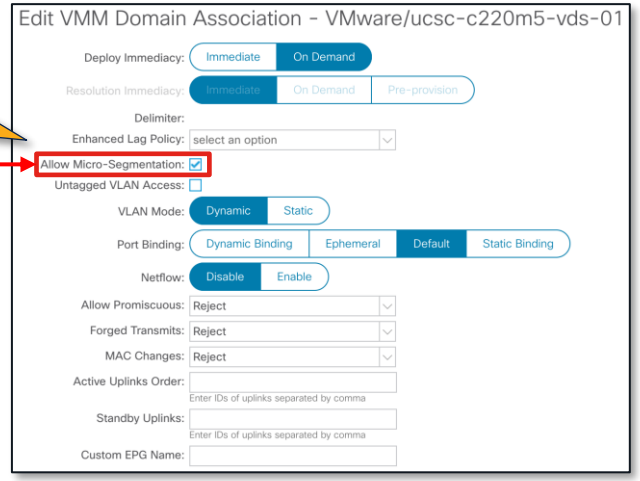
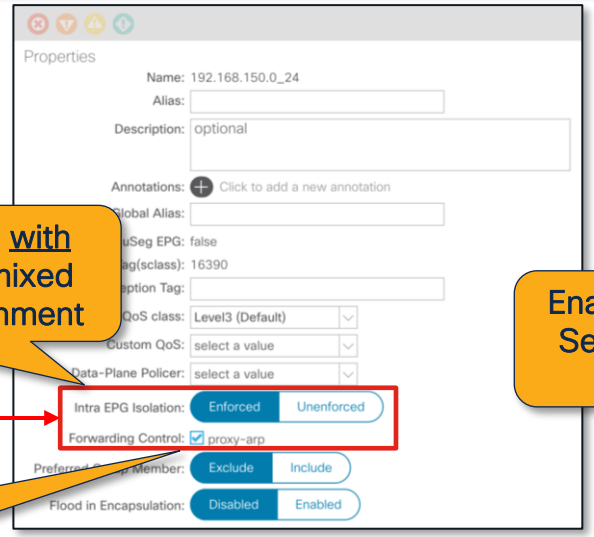
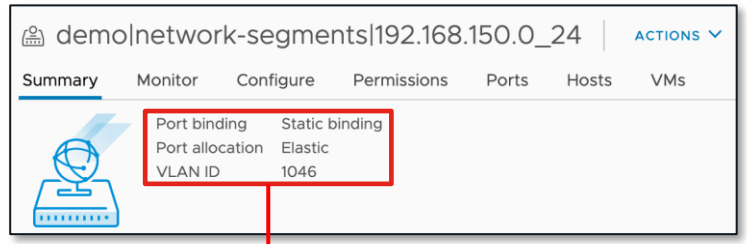
How do you enable Proxy ARP on the Leaf Switches…?

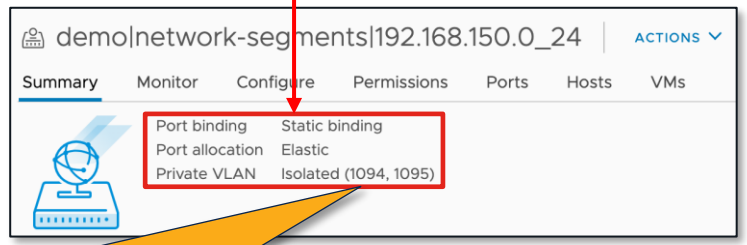
Enabling “Allow Micro-Segmentation” automatically enables Proxy ARP. Option in a 100% virtual deployment, use with or without Intra EPG isolation









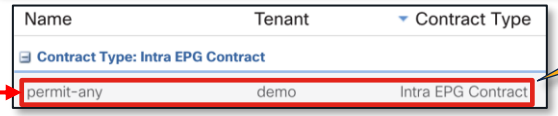


Enable Intra EPG isolation with Proxy ARP if you have a mixed virtual and physical environment

Enabling Intra EPG isolation / Allow Micro-Segmentation configures PVLANs on the port group

Proxy ARP is only available when Intra ESG isolation is enabled

Add an Intra EPG Contract



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vCenter tag/name matching requires read/write vmm integration...

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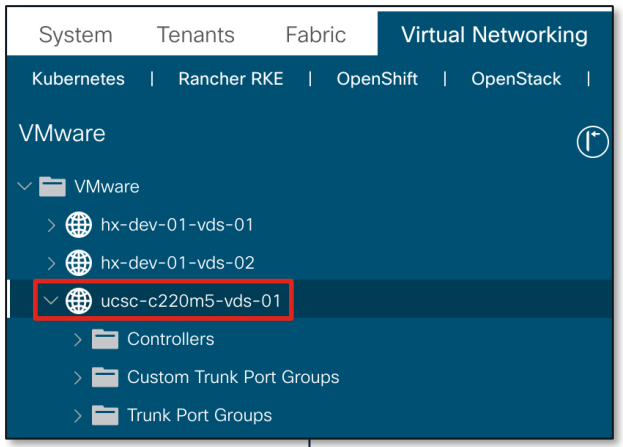
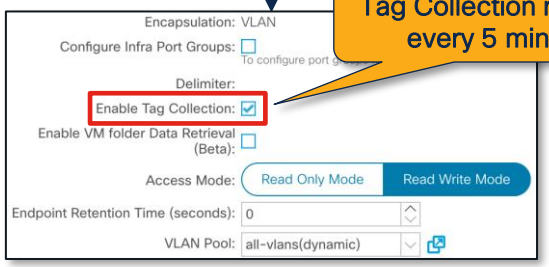
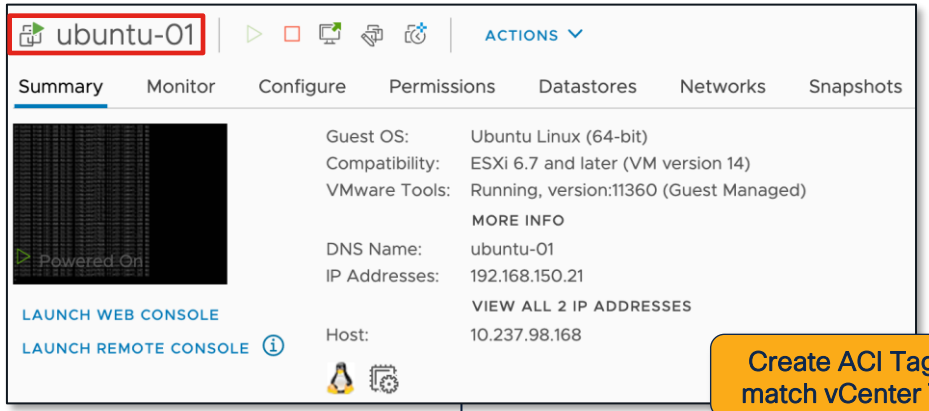
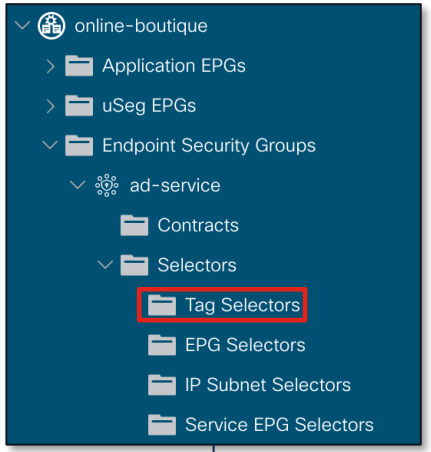
Dynamic Policy Tag matching from vCenter



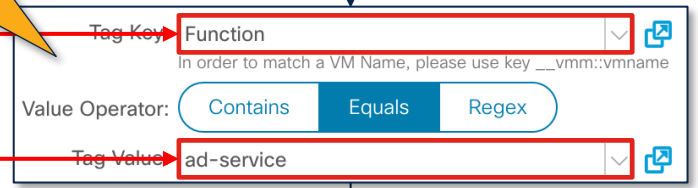


Tag Collection runs every 5 min

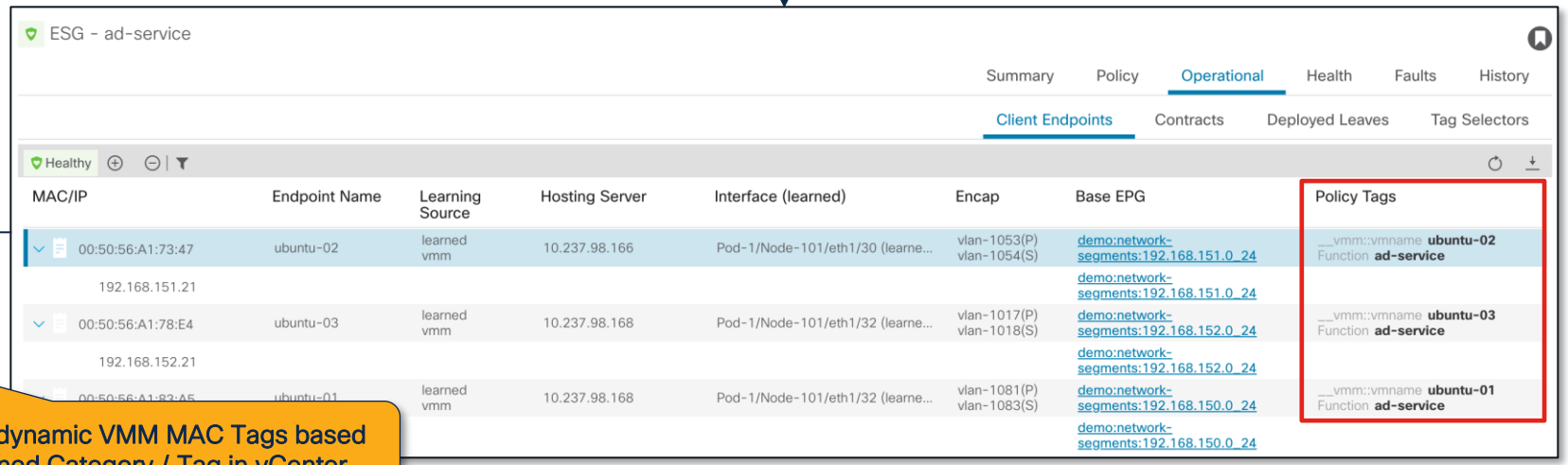




Create ACI Tags to match vCenter Tags



Tenant → Policies → Endpoint Tags



APIC creates dynamic VMM MAC Tags based on the assigned Category / Tag in vCenter

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Static endpoint mapping...

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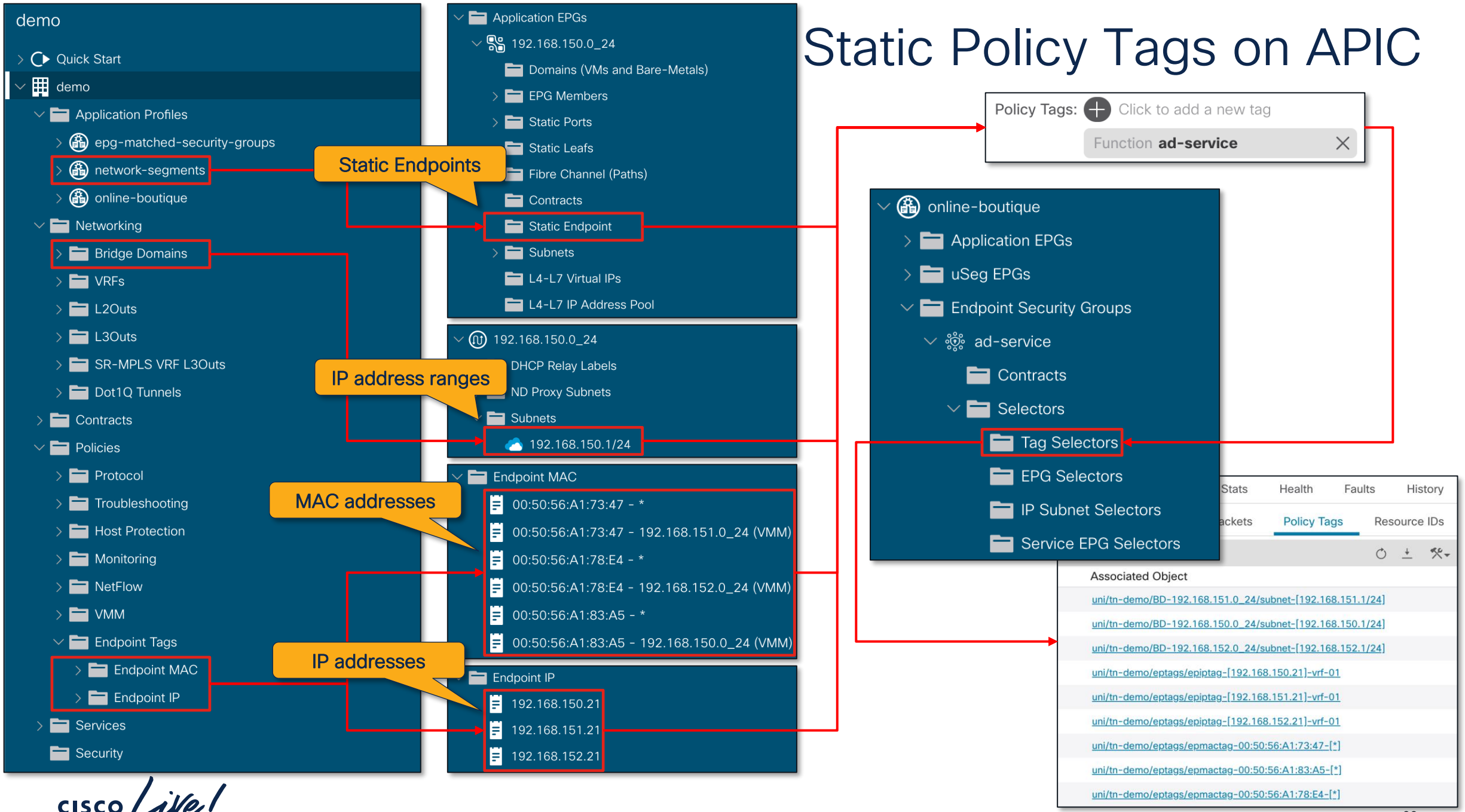
Static Policy Tags on APIC



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What if you have a Greenfield deployment...?

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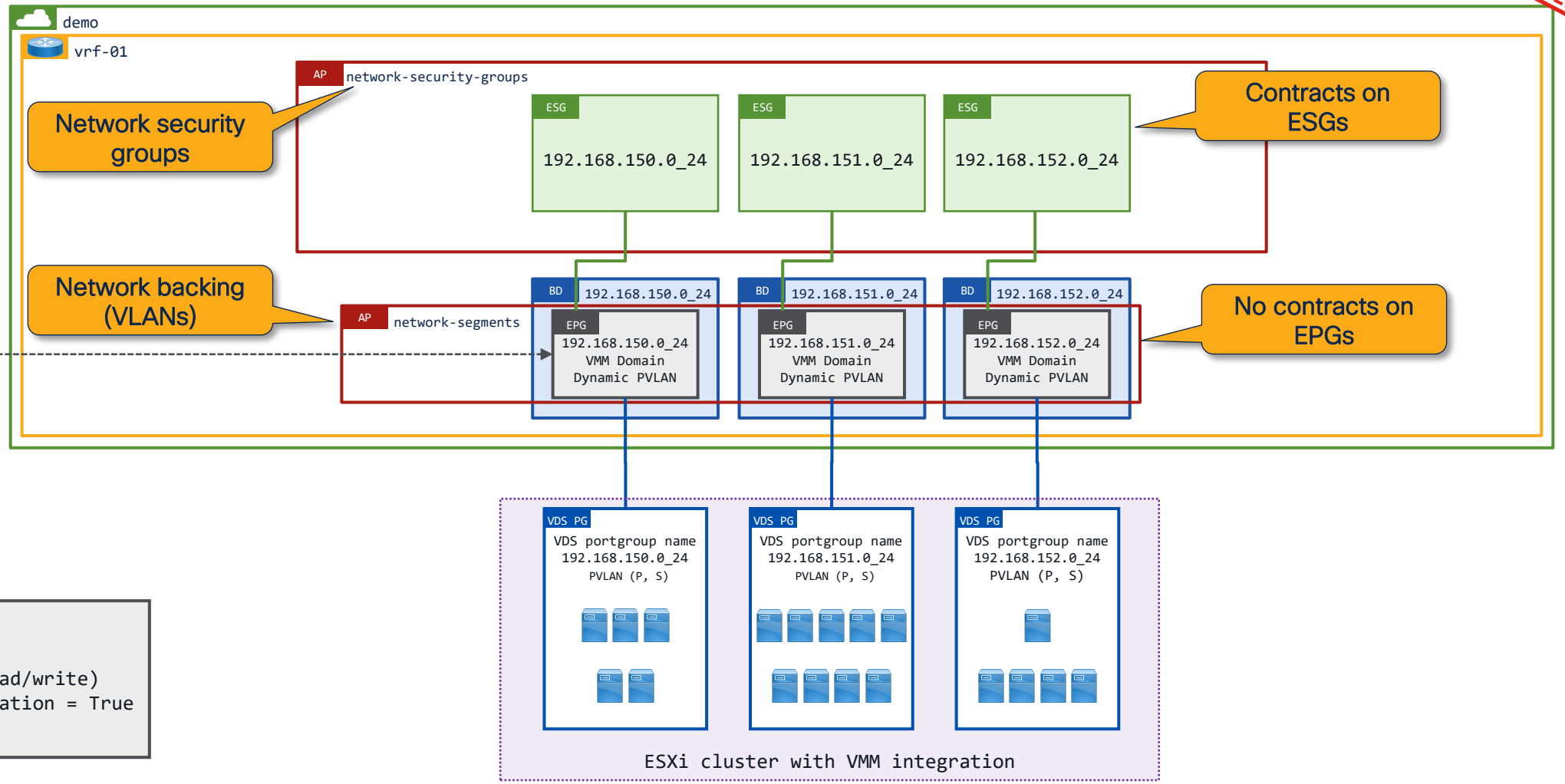
Greenfield option – 1:1 EPG to ESG mapping

Separate network backing from classification/security



EPG

Settings:
- VMM Domain (read/write)
- Allow uSegmentation = True
- Dynamic PVLANs

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Consider automated static MAC tagging derived from the endpoint IP address...

Works for Bare Metal and VMs, with or without VMM Integration...

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Setting the scene...

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Switching to Application Centric mode...

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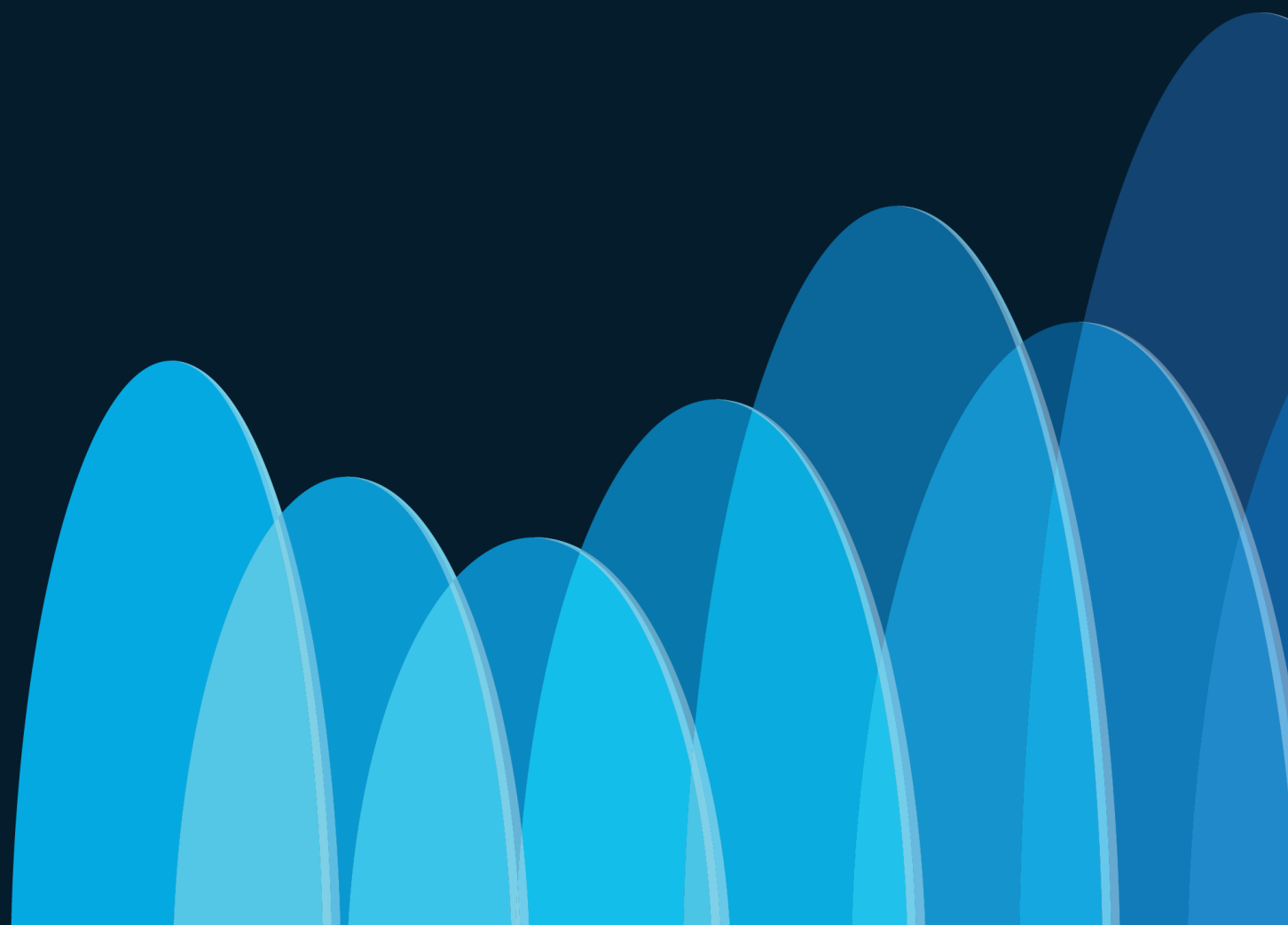
Understanding ACI security...

External Connectivity...

Increasing Security...

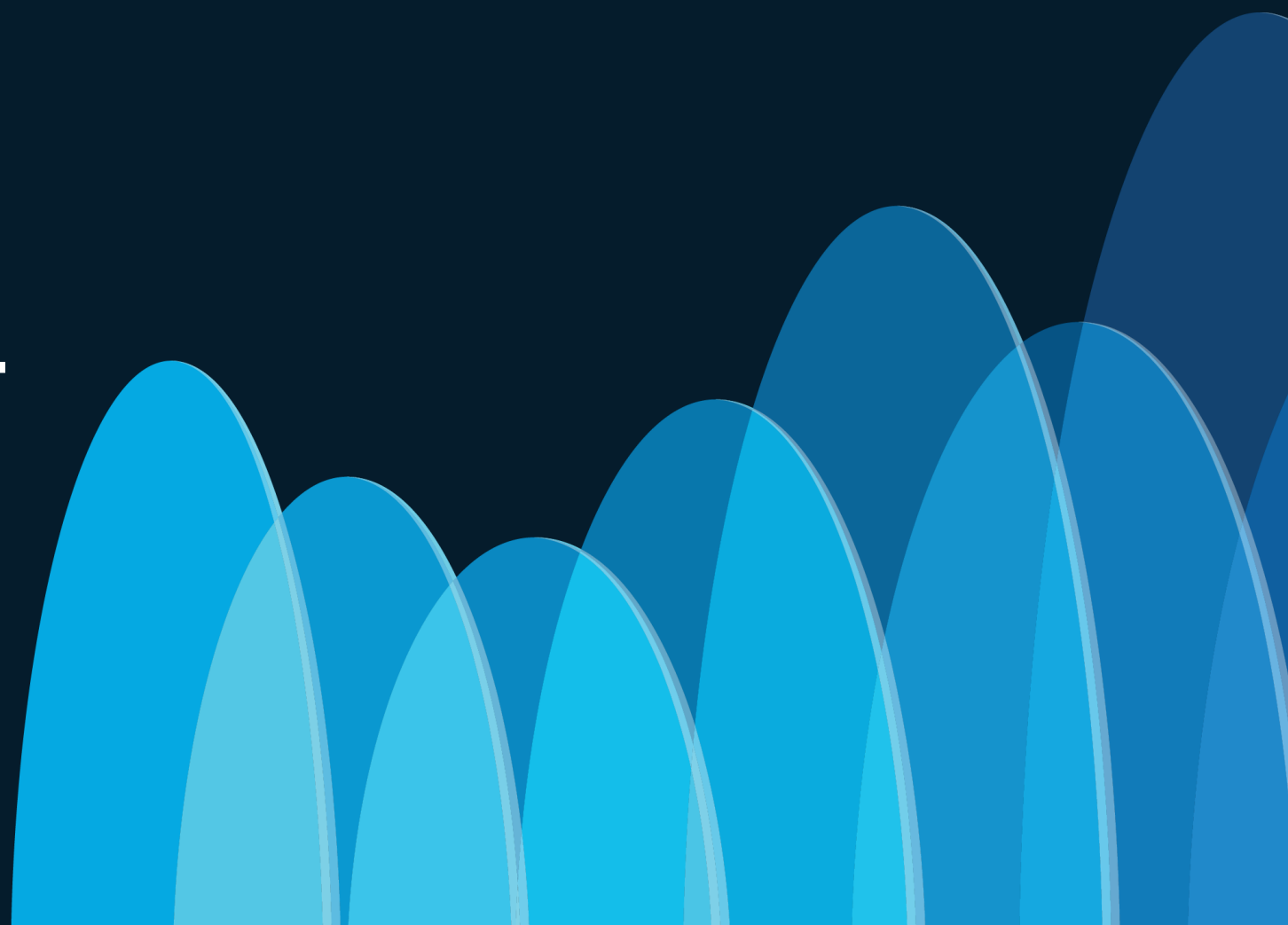
Automation Blueprints...

Wrapping up...



cisco Live!

Allowing open communication...



There are four options to allow open communication...

https://www.cisco.com/c/en/us/solutions/collateral/data-center-virtualization/application-centric-infrastructure/white-paper-c11-743951.html#Migrationexample

- vzAny
- Preferred Groups
- EPGs mapped Endpoint Security Groups
- Disable security (not covered, because why would you...?)

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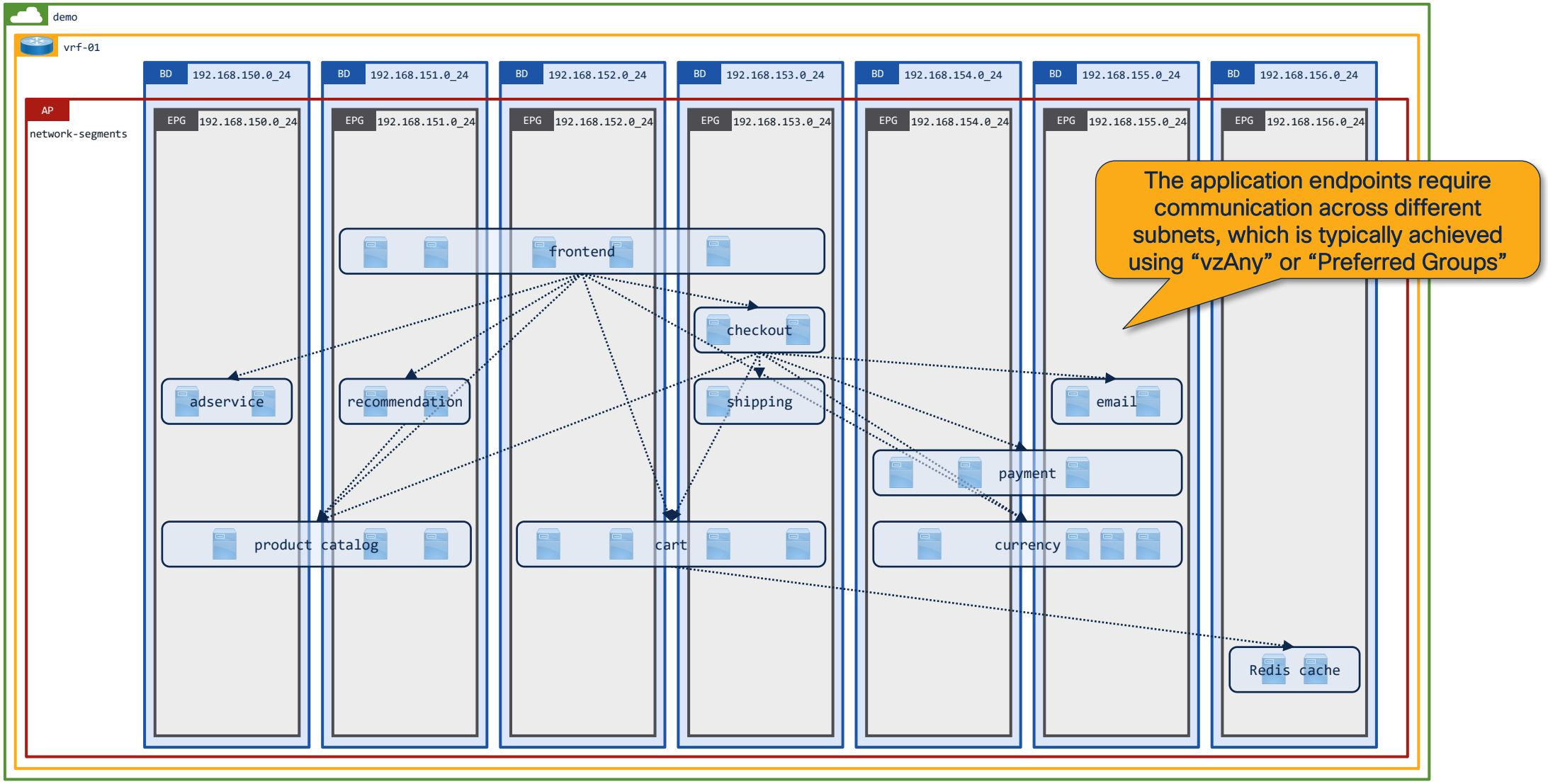
Existing applications typically require unrestricted communication



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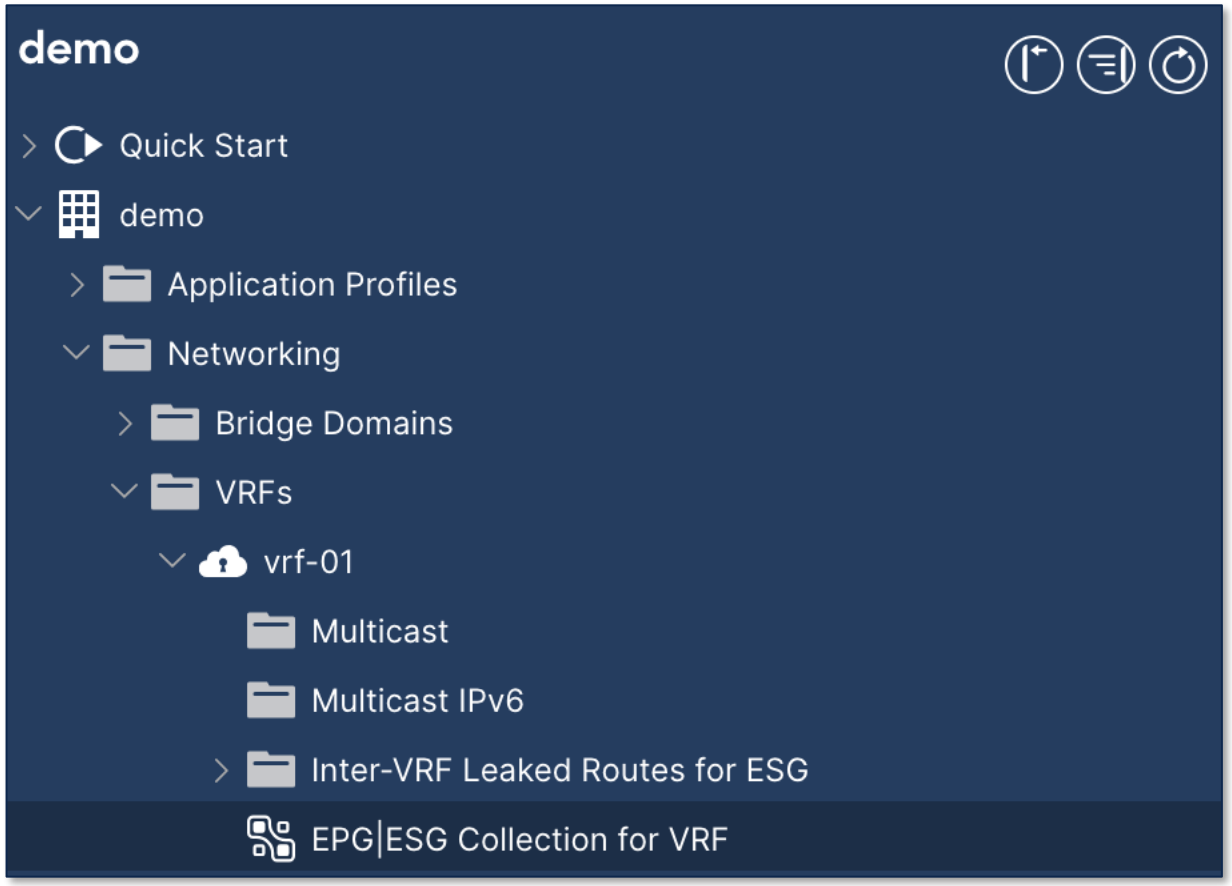
vzAny



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The great thing about vzAny provide/consume is that it allows open communication between all endpoints...

The “bad” thing about vzAny provide/consume is that it allows open communication between all endpoints...!

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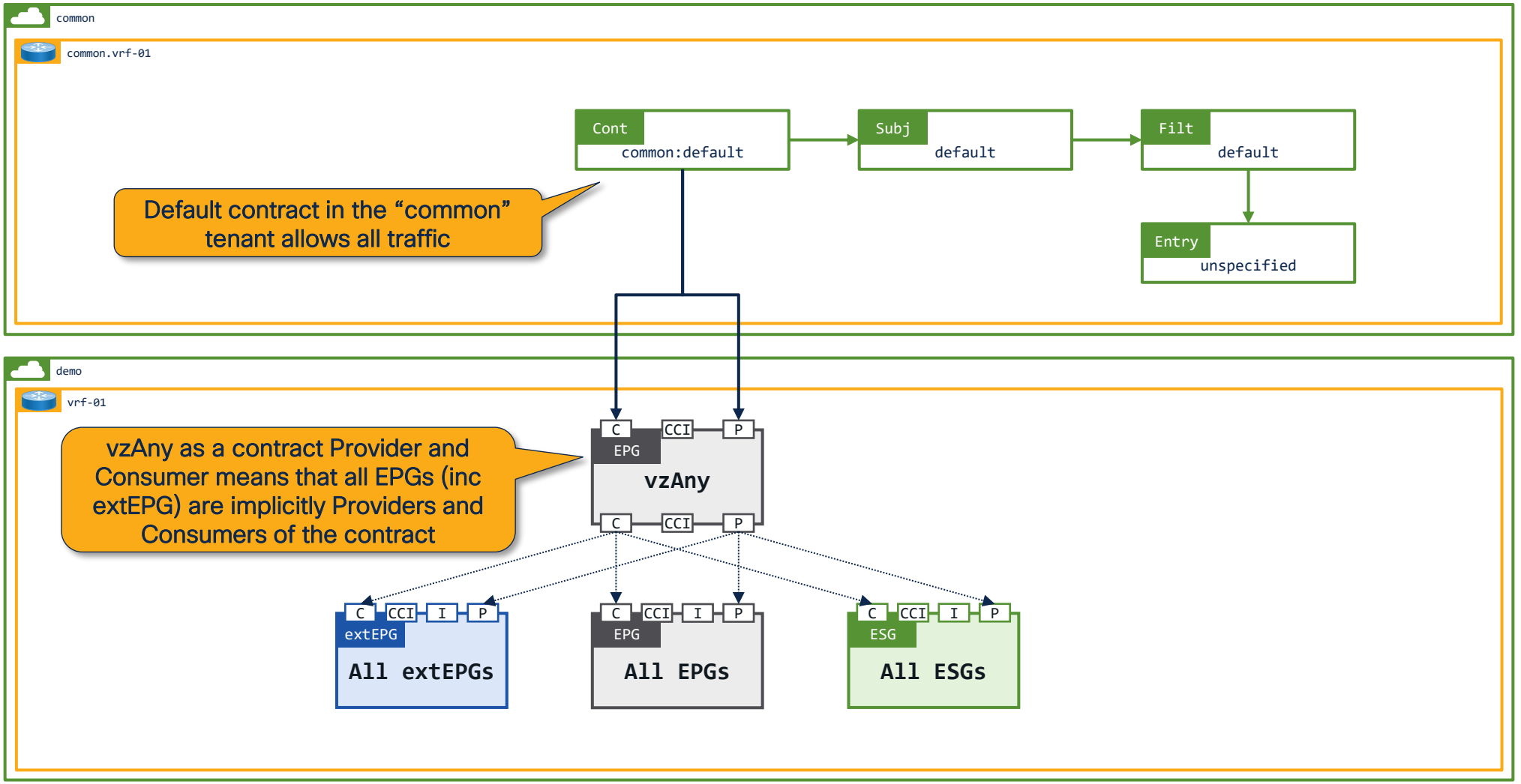
vzAny Operation – Consumer and Provider

https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/kb/b_KB_Use_vzAny_to_AutomaticallyApplyCommunicationRules_toEPGs.html



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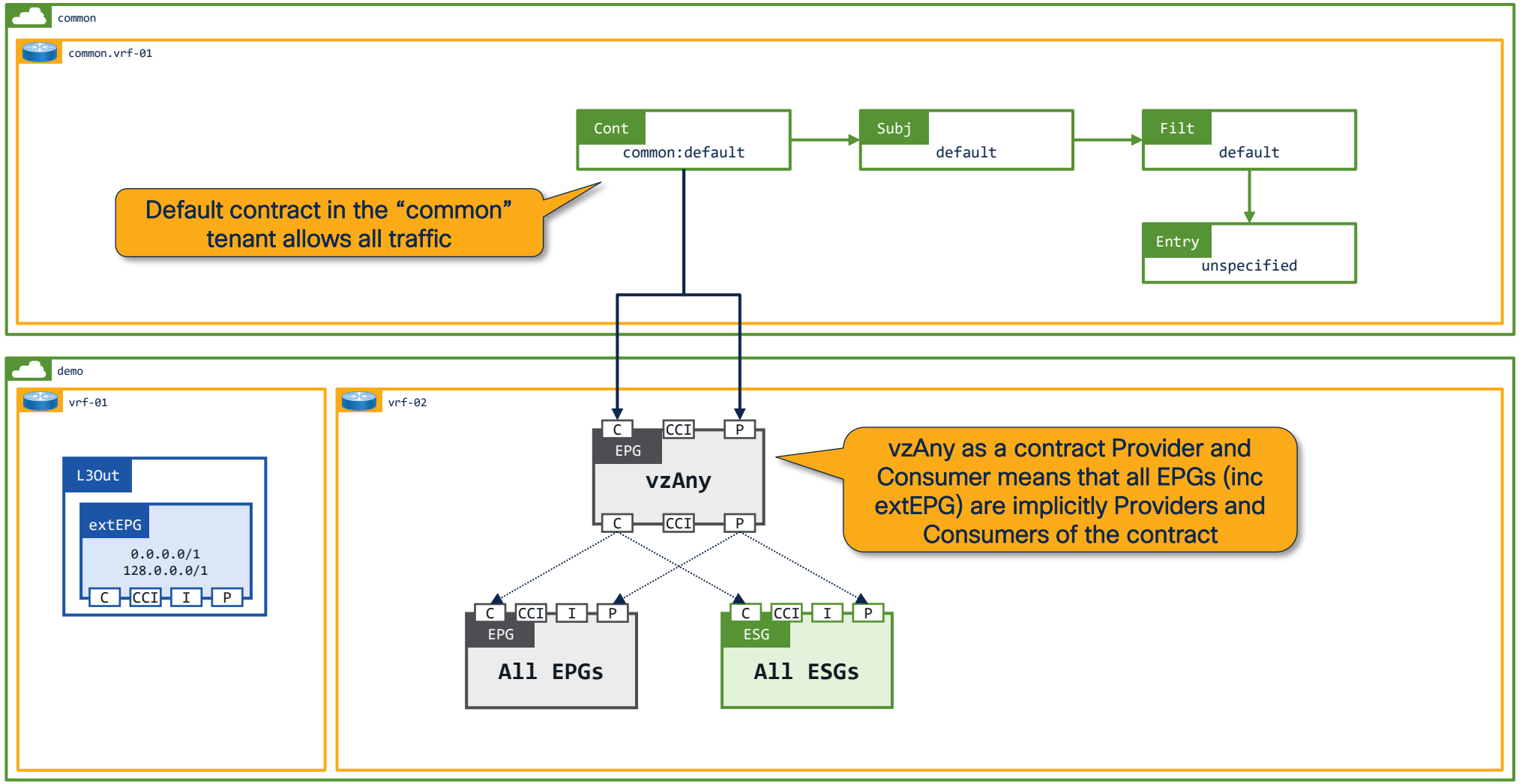
vzAny Operation – Consumer and Provider

https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/kb/b_KB_Use_vzAny_to_AutomaticallyApplyCommunicationRules_toEPGs.html



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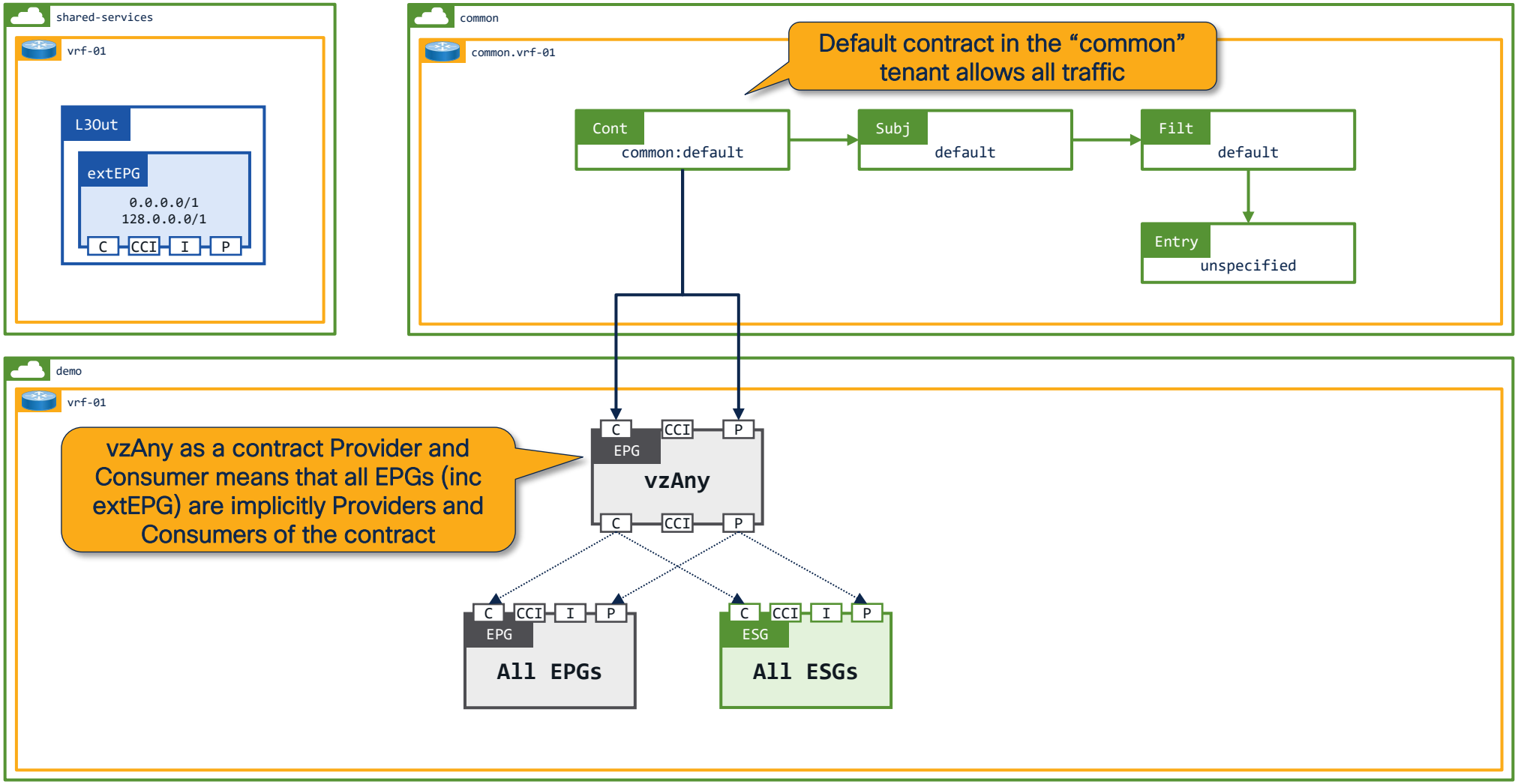
vzAny Operation – Consumer and Provider

https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/kb/b_KB_Use_vzAny_to_AutomaticallyApplyCommunicationRules_toEPGs.html



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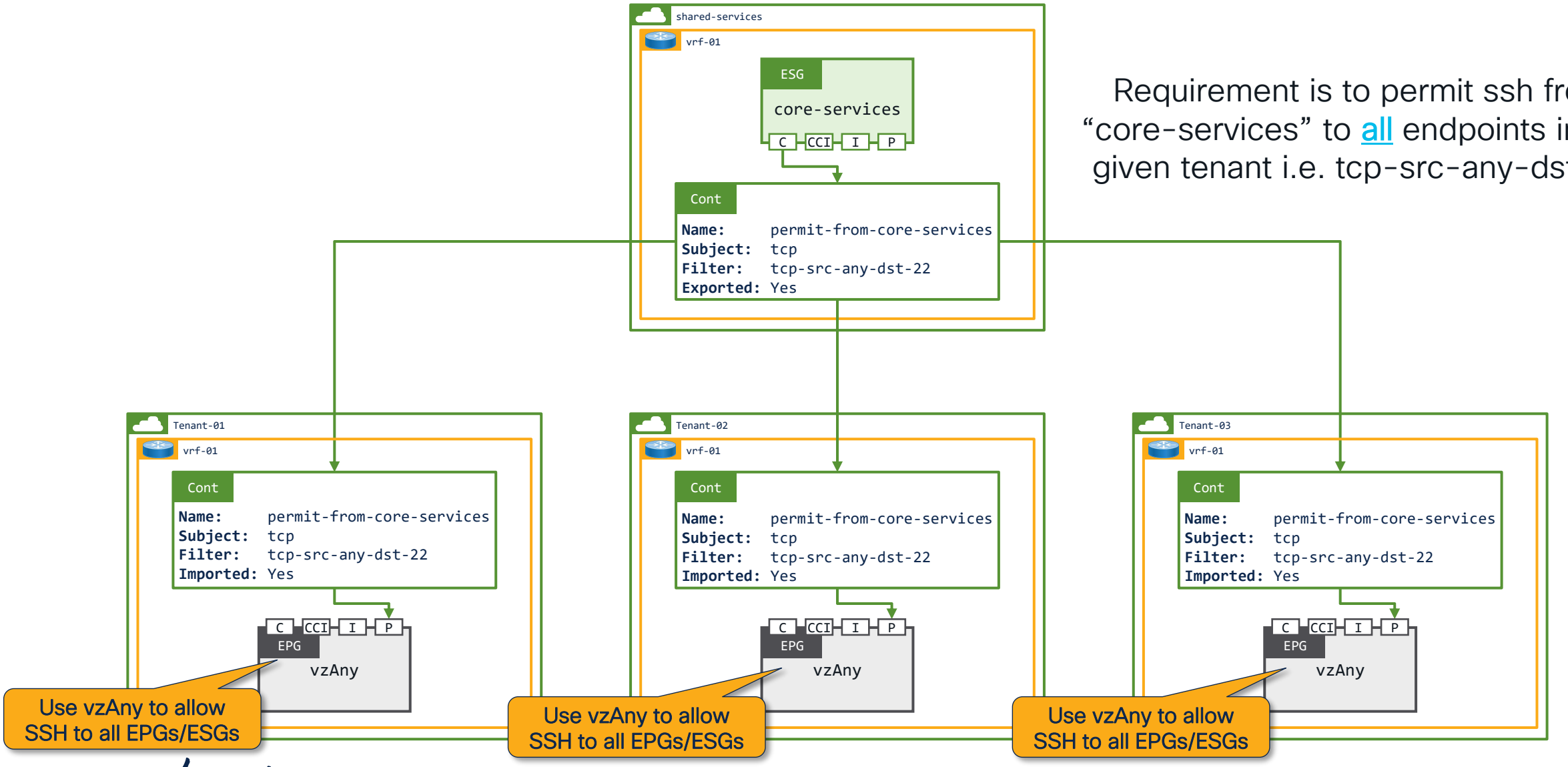
vzAny cannot be a Provider for Shared Services



Requirement is to permit ssh from “core-services” to all endpoints in any given tenant i.e. tcp-src-any-dst-22

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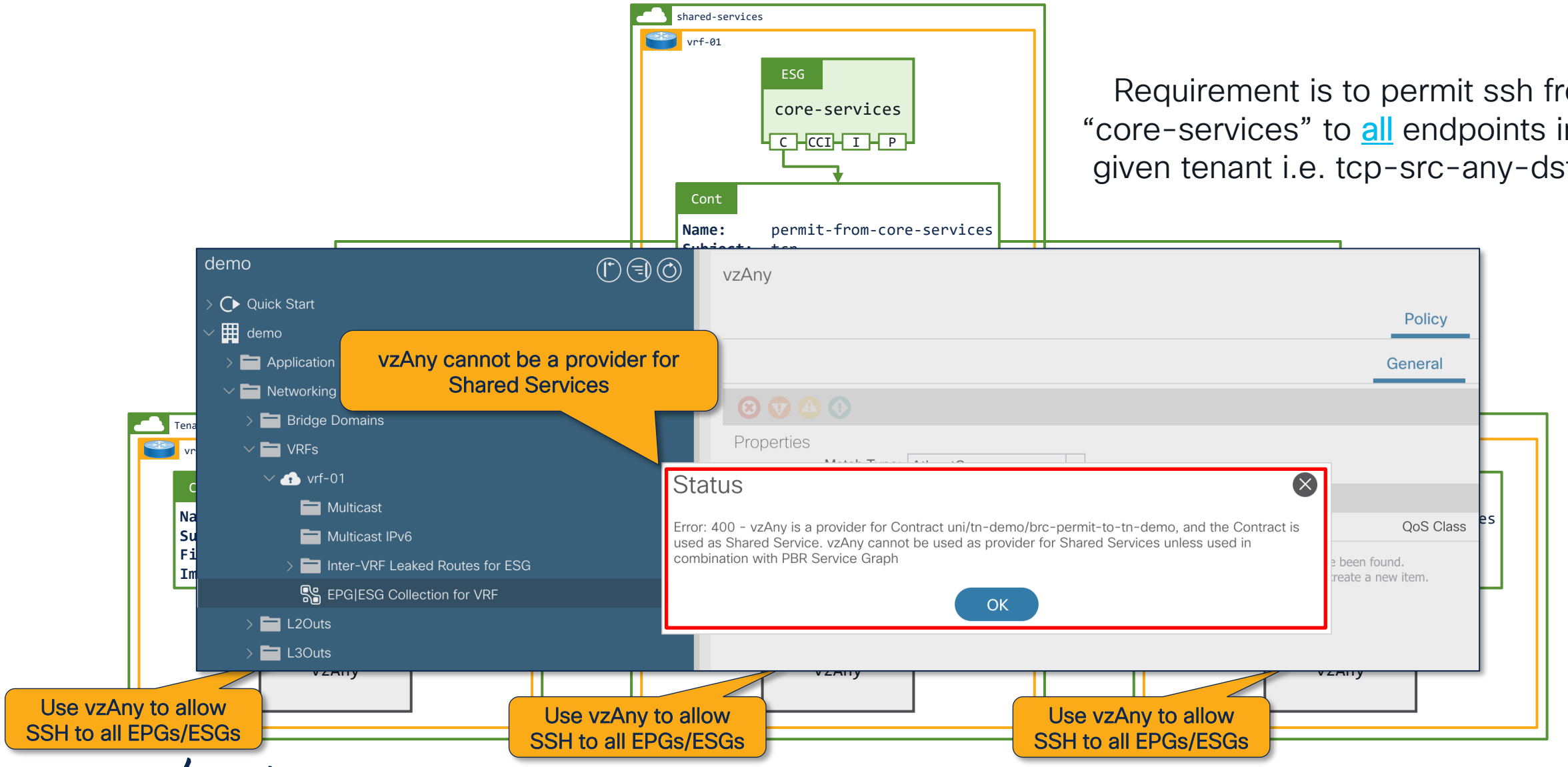
vzAny cannot be a Provider for Shared Services



Requirement is to permit ssh from "core-services" to all endpoints in any given tenant i.e. tcp-src-any-dst-22

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vzAny can absolutely be your friend, but remember that vzAny contract relationships are applied to all EPGs, ESGs, extEPGs in the VRF…

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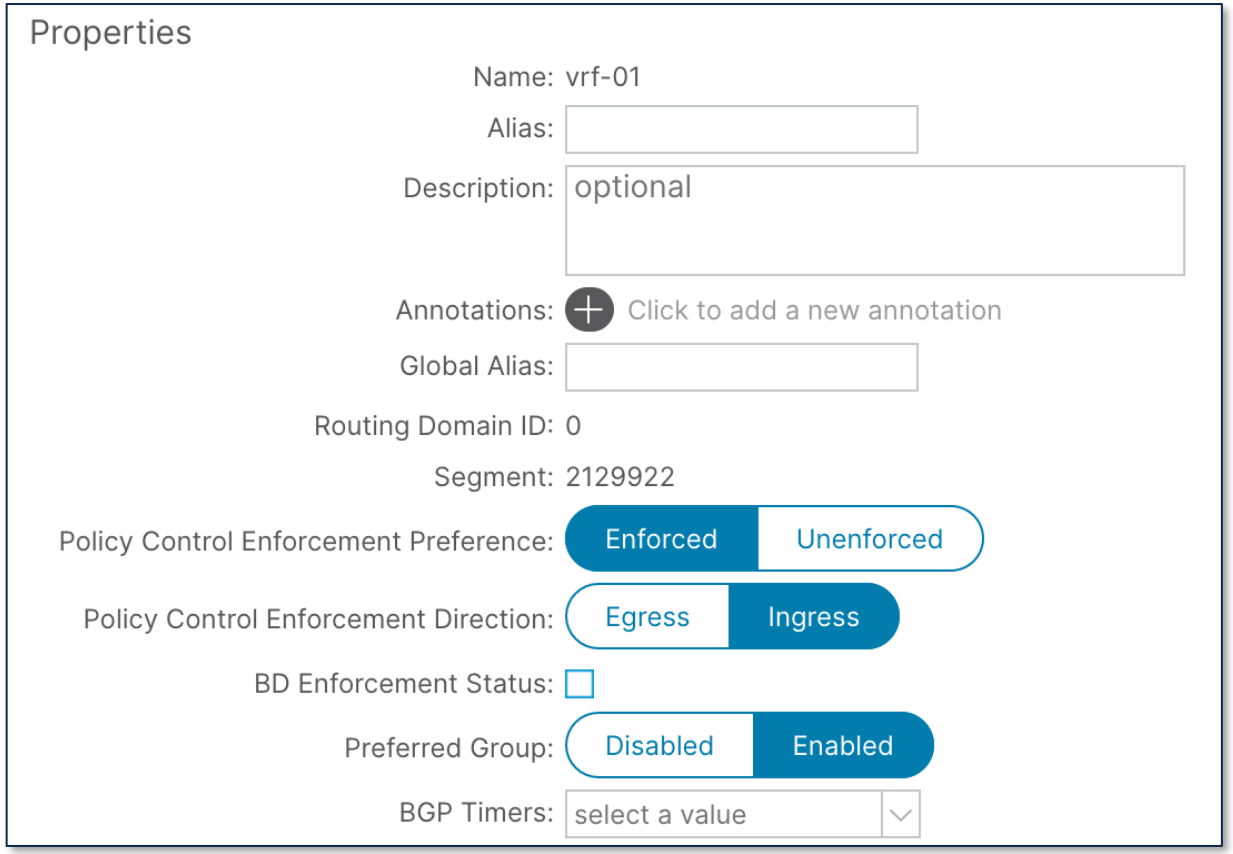
Preferred Groups



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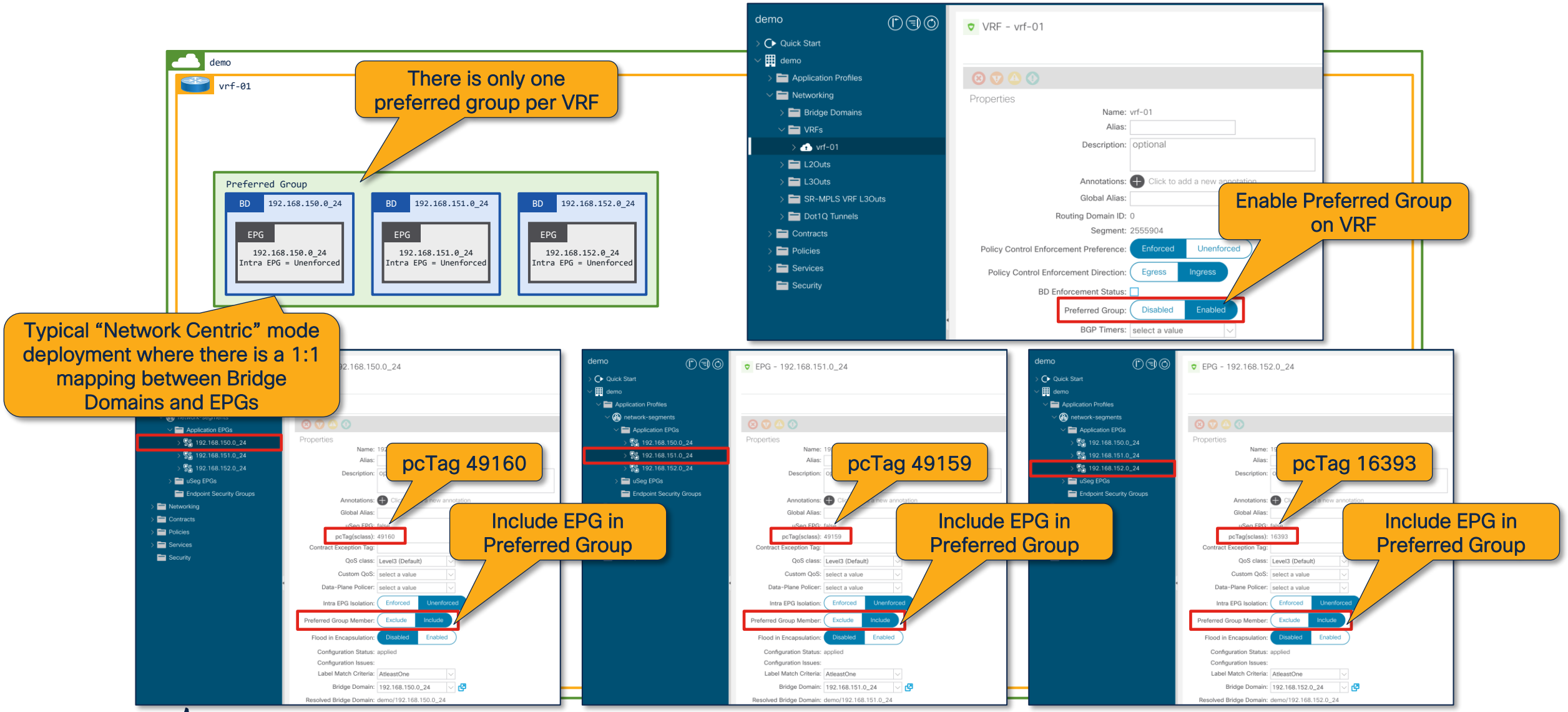
Preferred Groups

https://www.cisco.com/c/en/us/td/docs/switches/datacenter/aci/apic/sw/kb/b_KB_Use_vzAny_to_AutomaticallyApplyCommunicationRules_toEPGs.html



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There can only be one “Preferred Group” per VRF...

It is not possible to add Contract relationships to a “Preferred Group”

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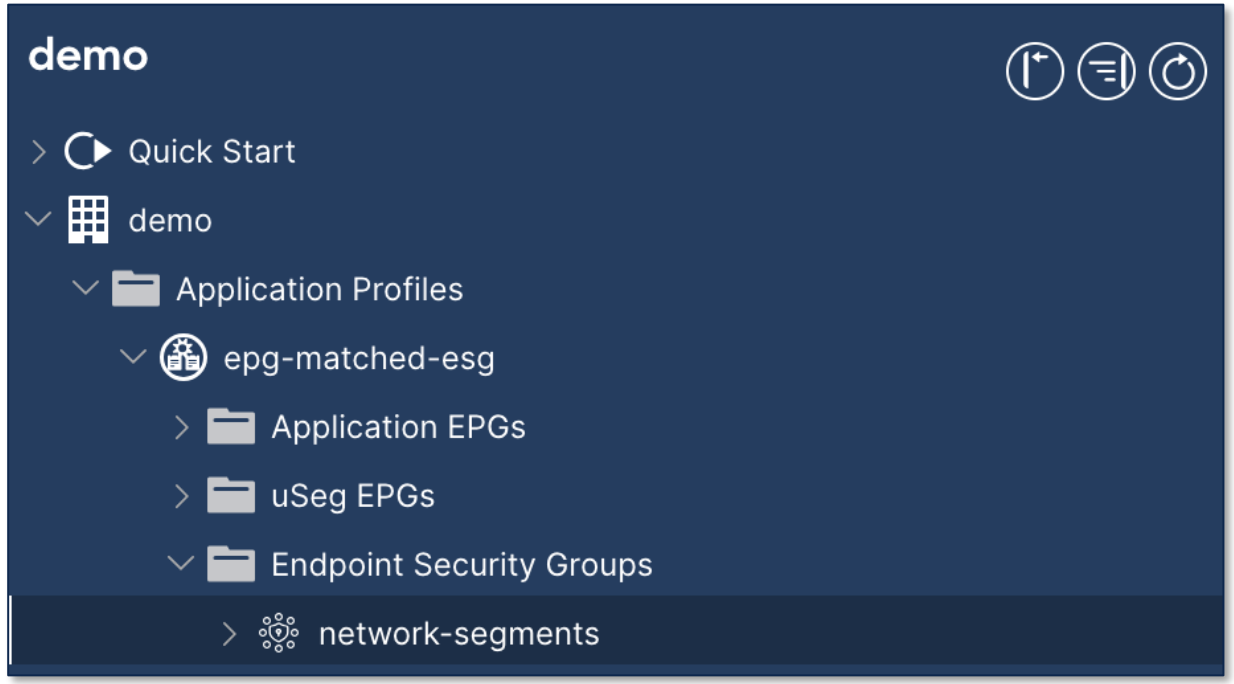
All EPGs mapped to a single ESG



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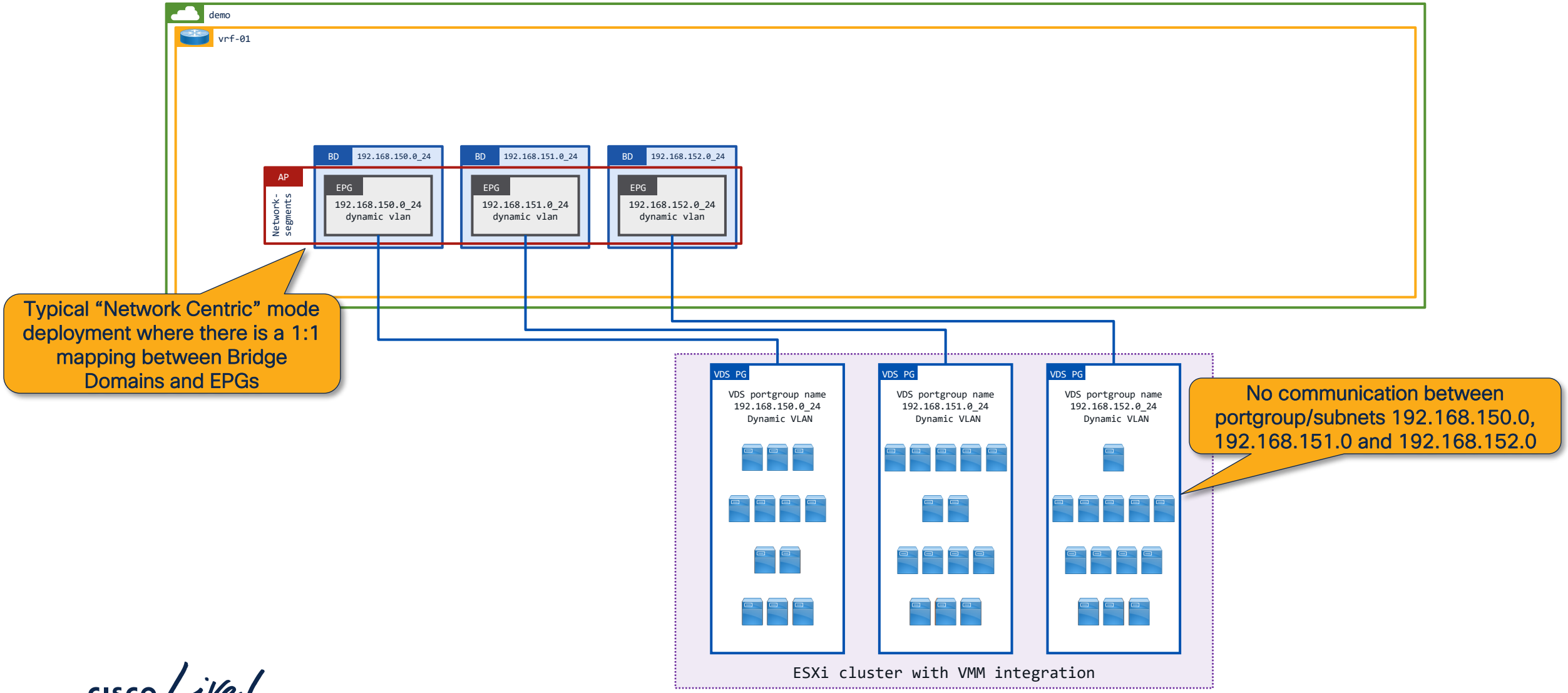
Initial state: Isolated groups of workloads



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Enable Endpoint Security Groups

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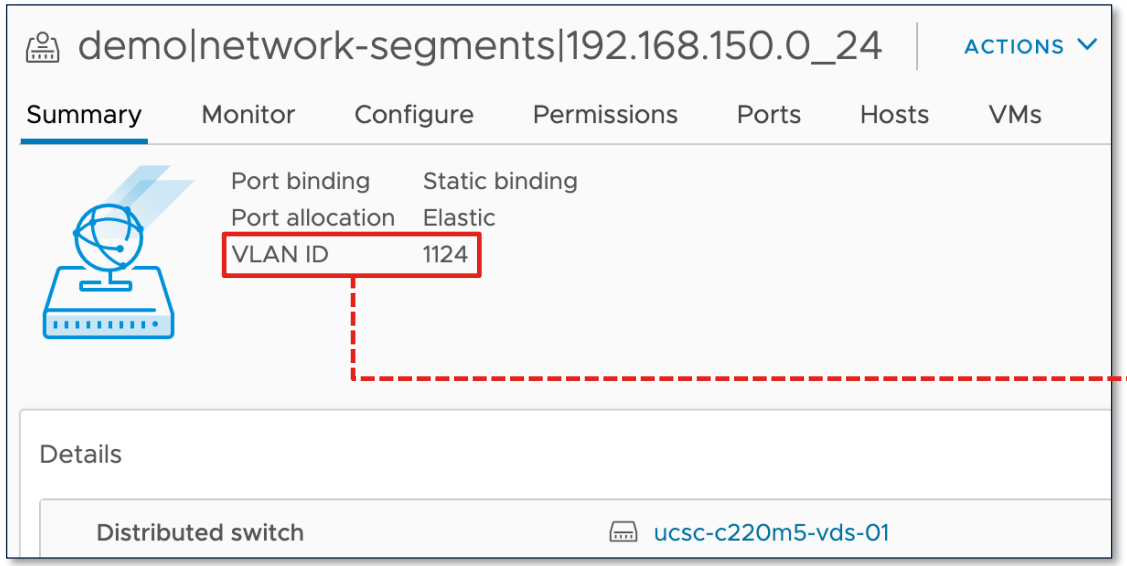
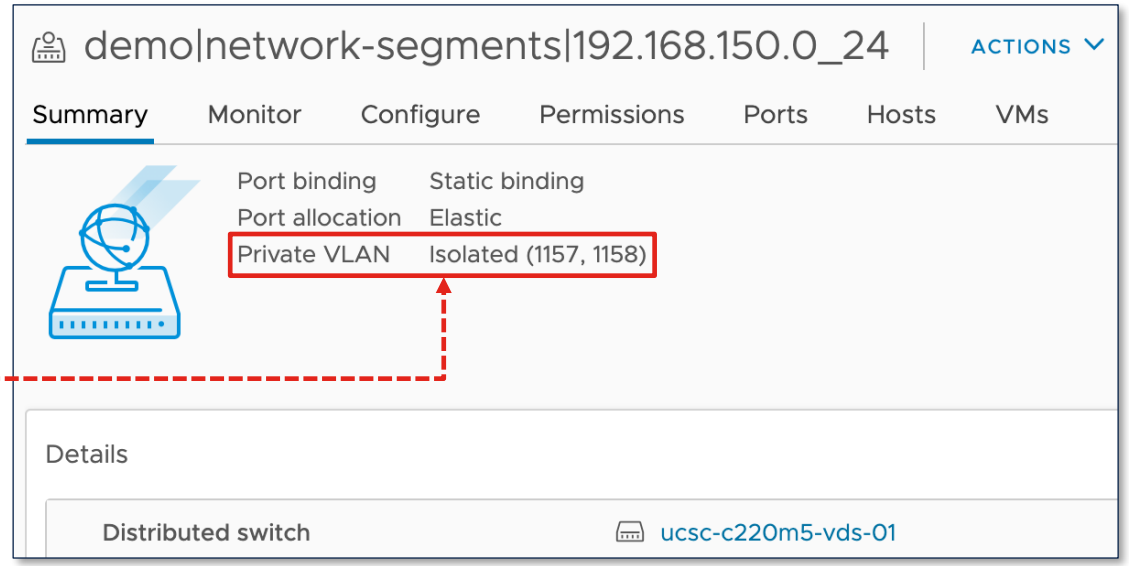
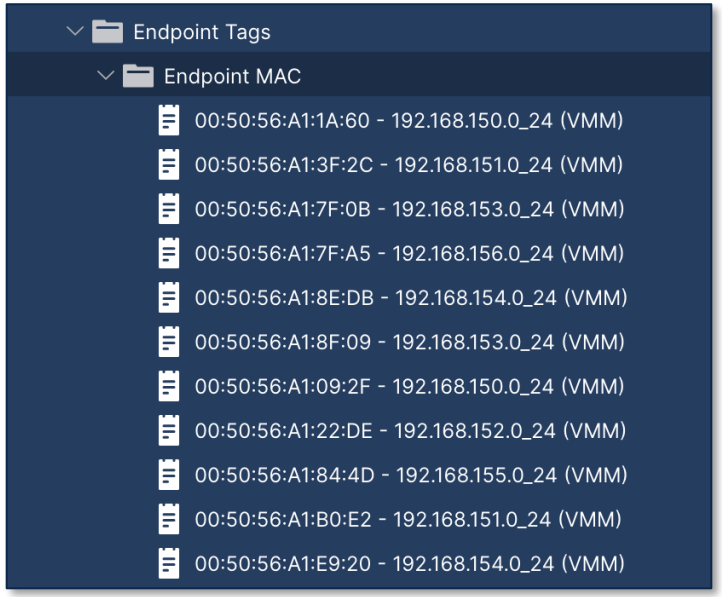
PVLAN and MAC Tagging







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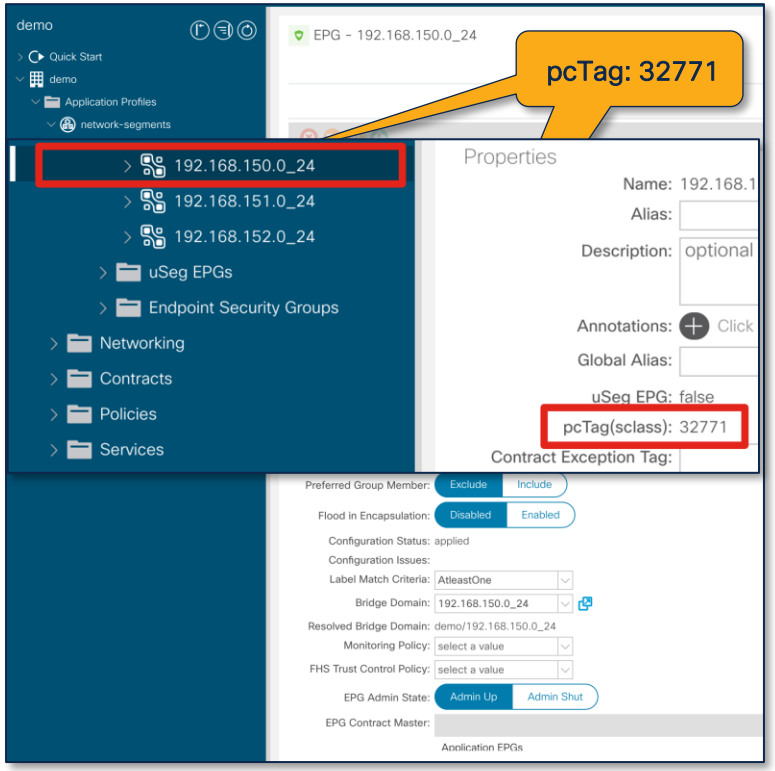
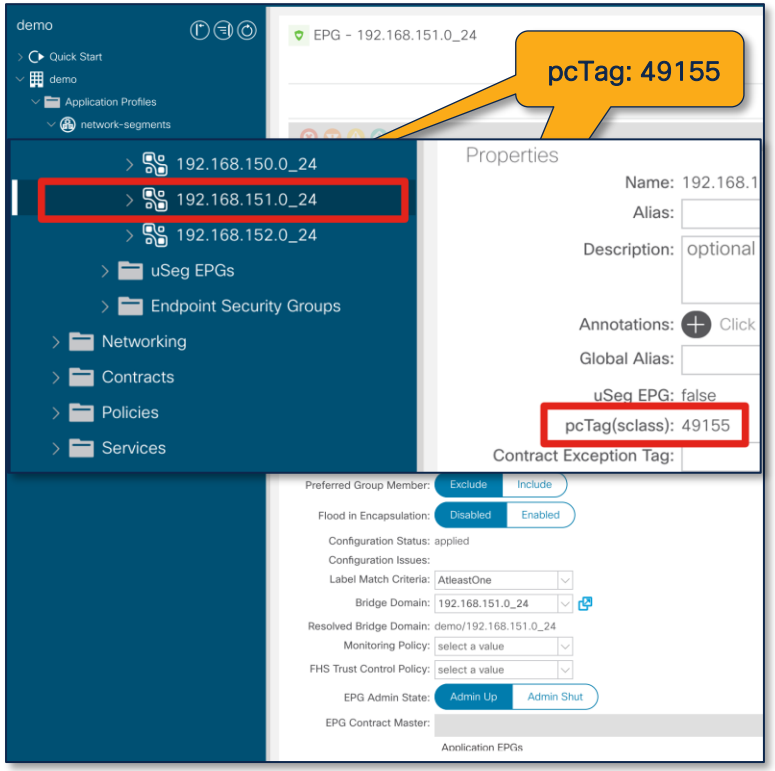
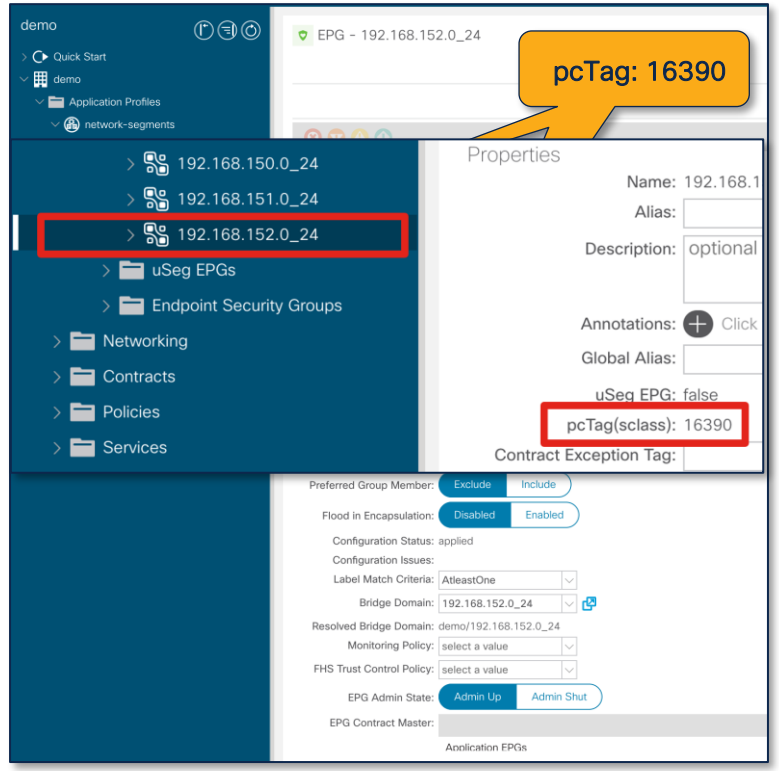
Each EPG has a unique security Tag (pcTag)







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Enabling ESG micro segmentation on a read/write VMM Domain enables PVLANs in the hypervisor to control East/West traffic…

plus, micro segmentation also enables Proxy ARP and dynamic endpoint MAC Tagging…

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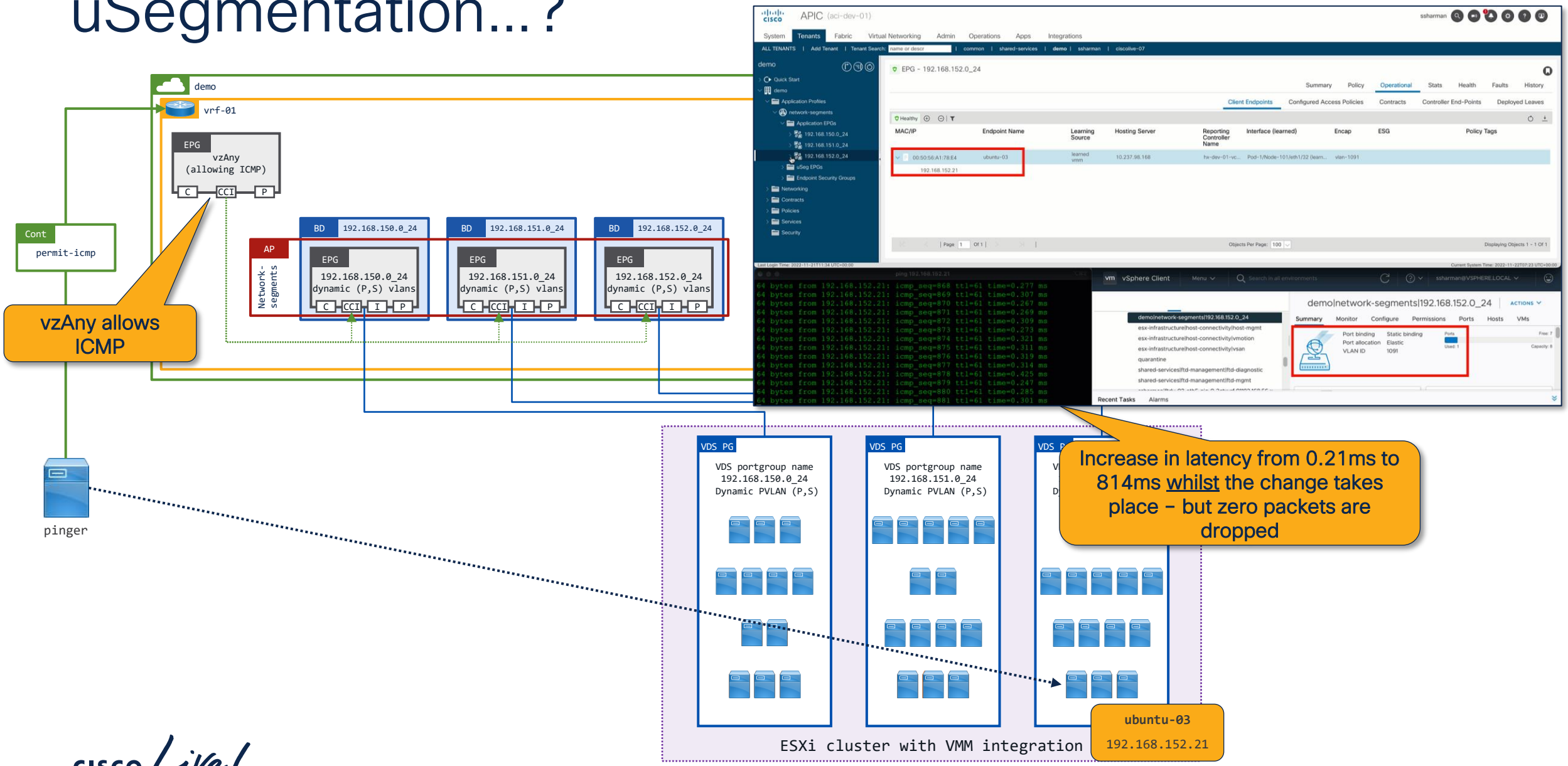
What's the impact to traffic when we enable uSegmentation...?



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Let’s map our EPGs to an ESG…

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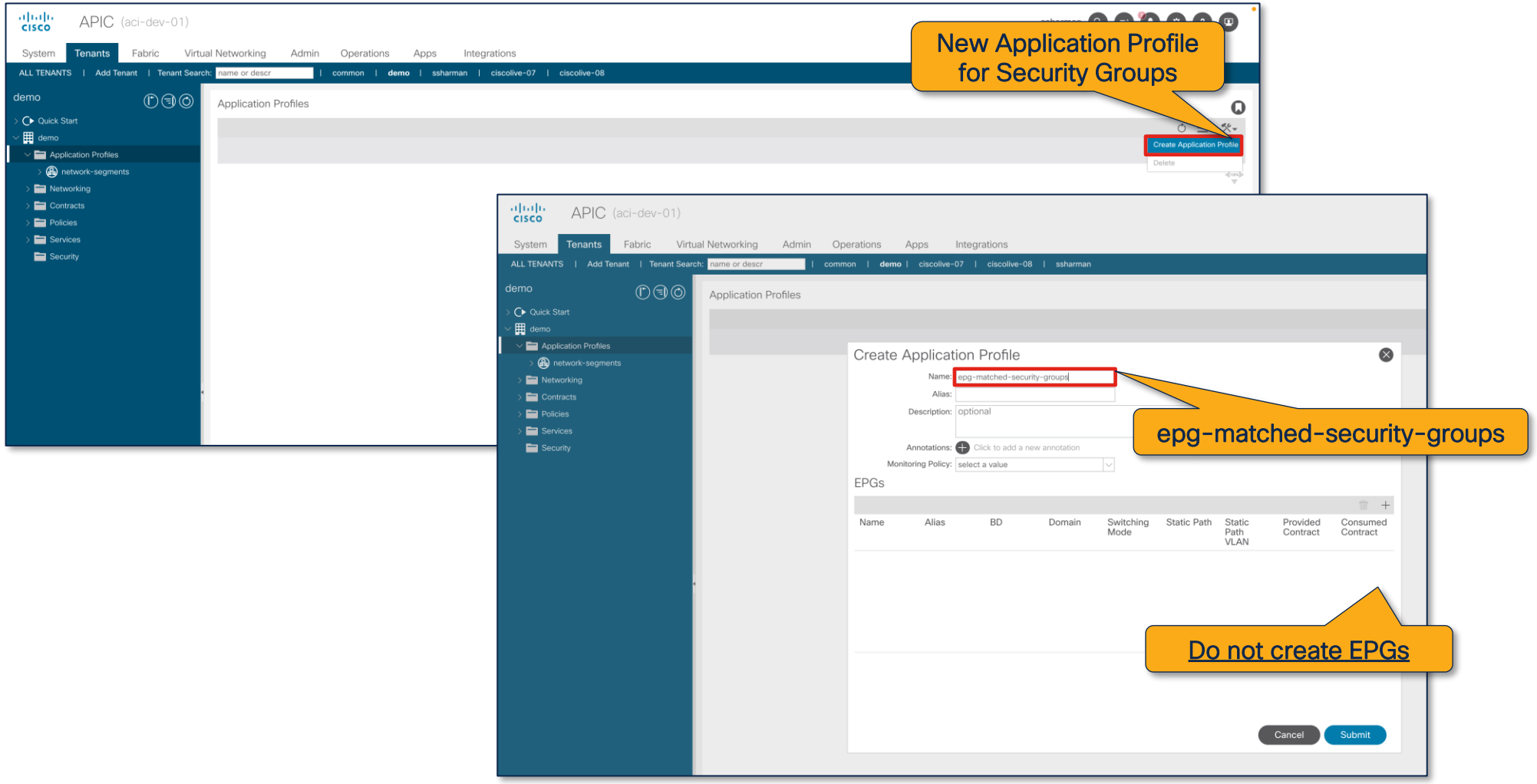
Create an Application Profile for Security Groups



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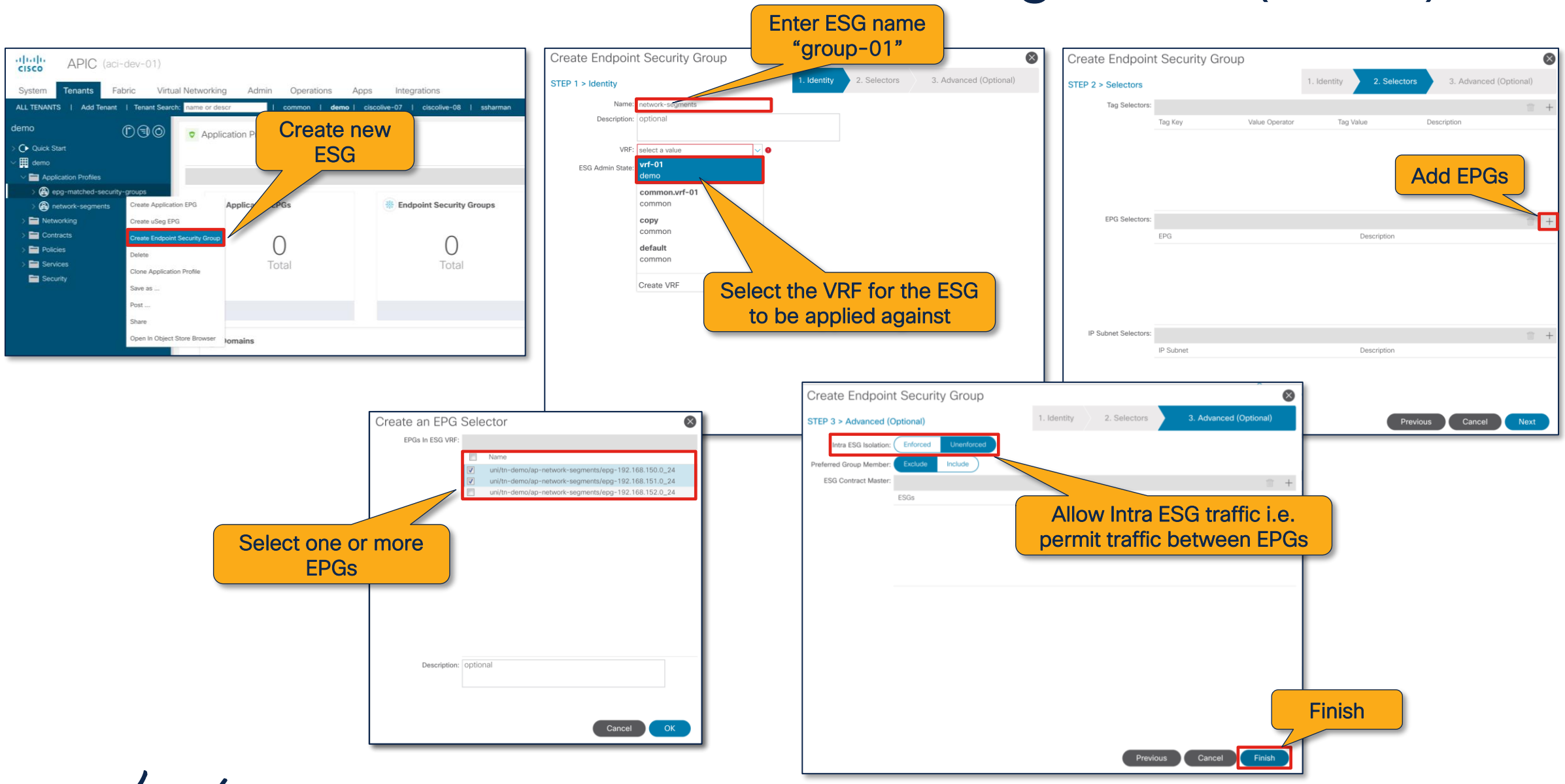
Create a new ESG for Network Segments (EPGs)



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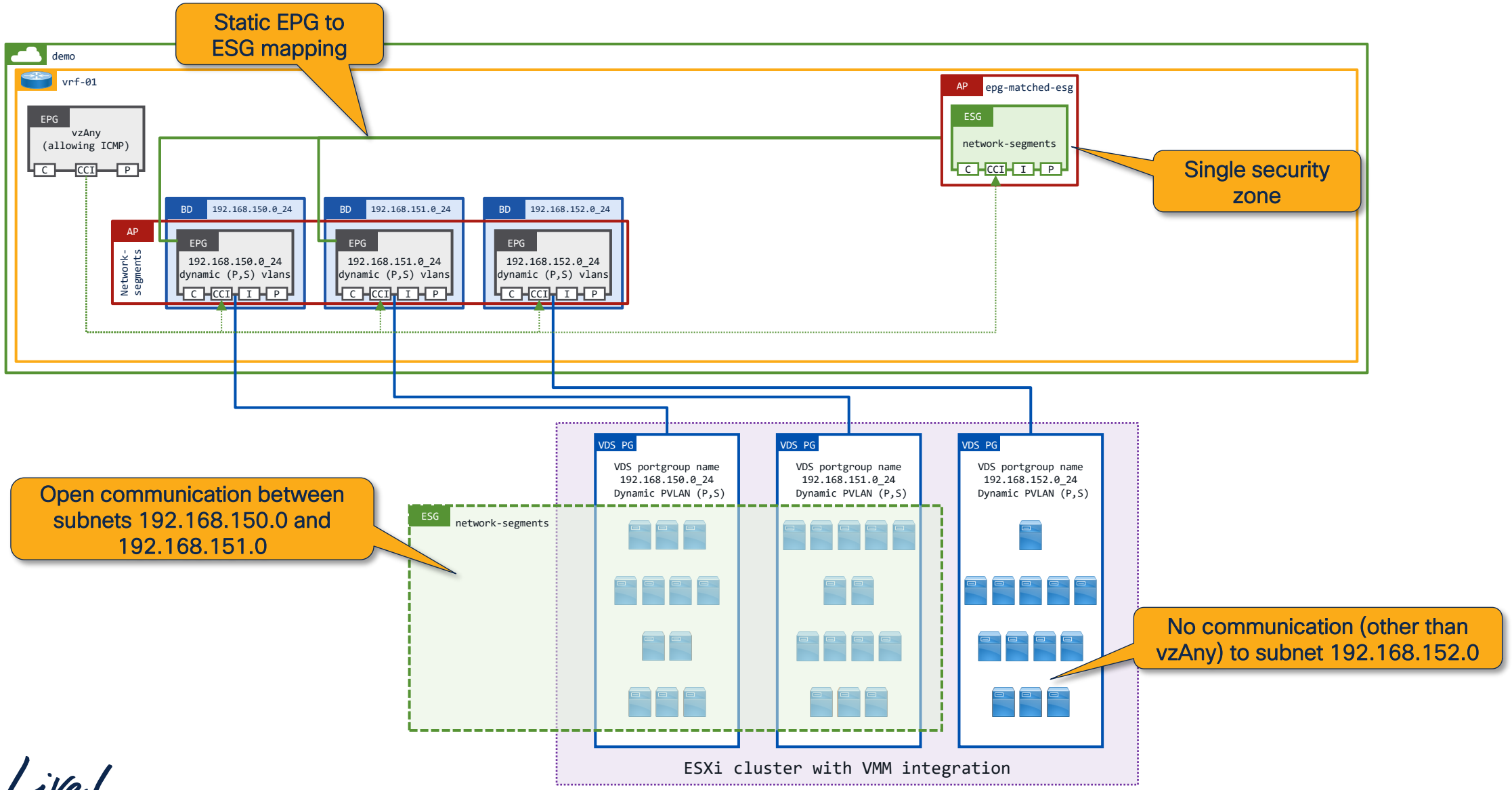
Open communication within the ESG...



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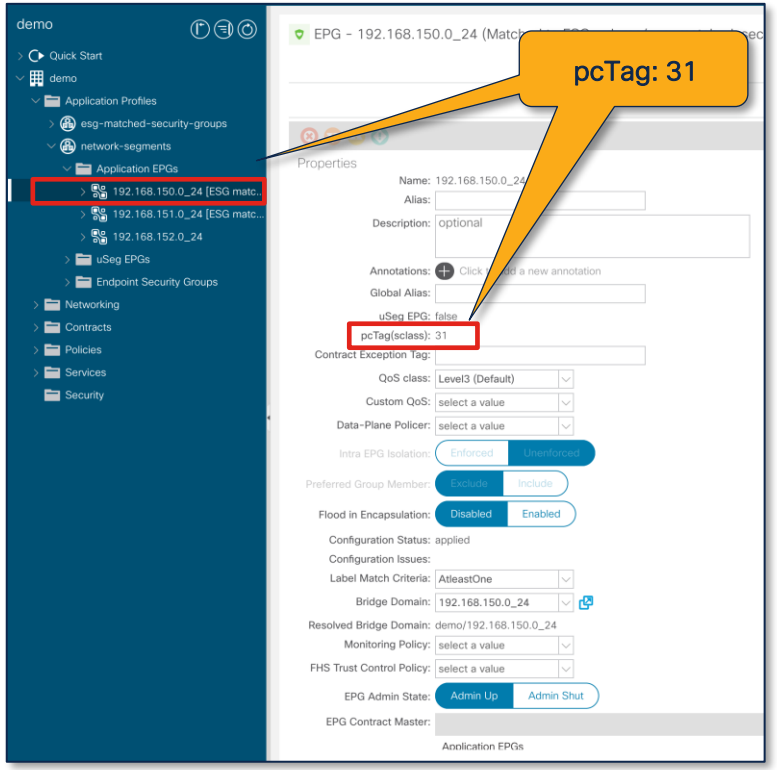
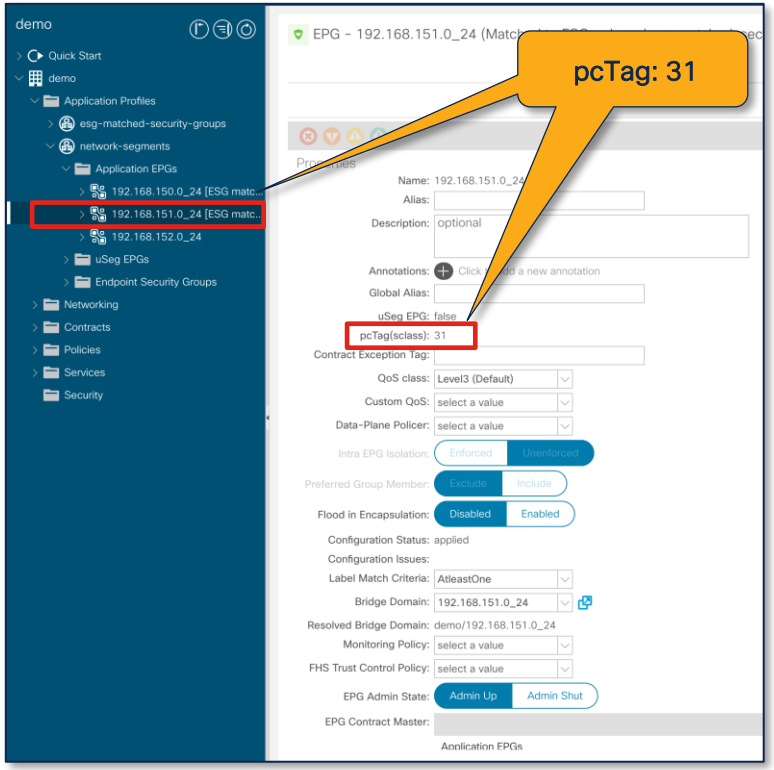
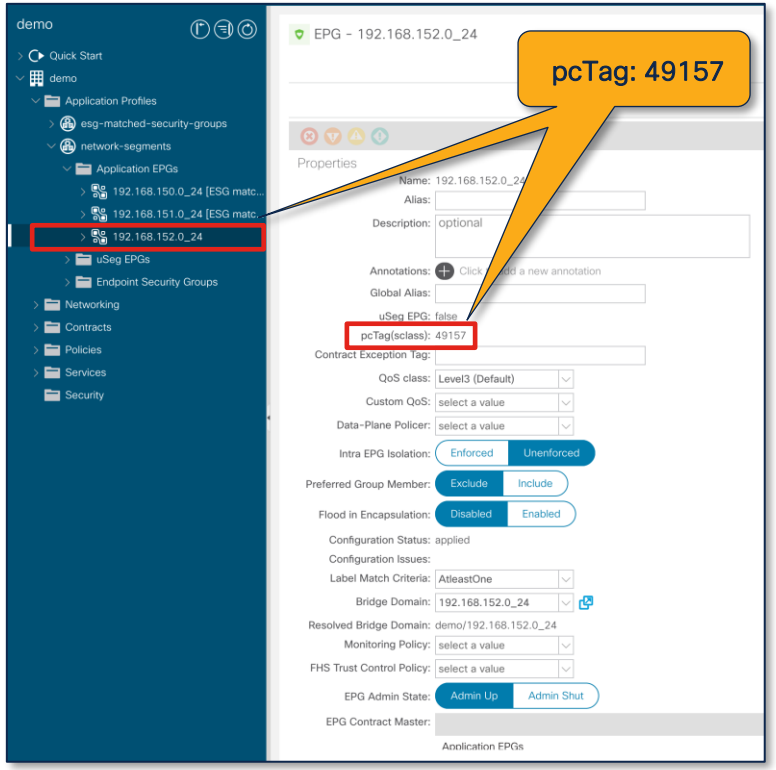
Matched EPGs now classified with a common pcTag







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Let’s consider any impact to traffic when adding the remaining EPG to the Security Group…

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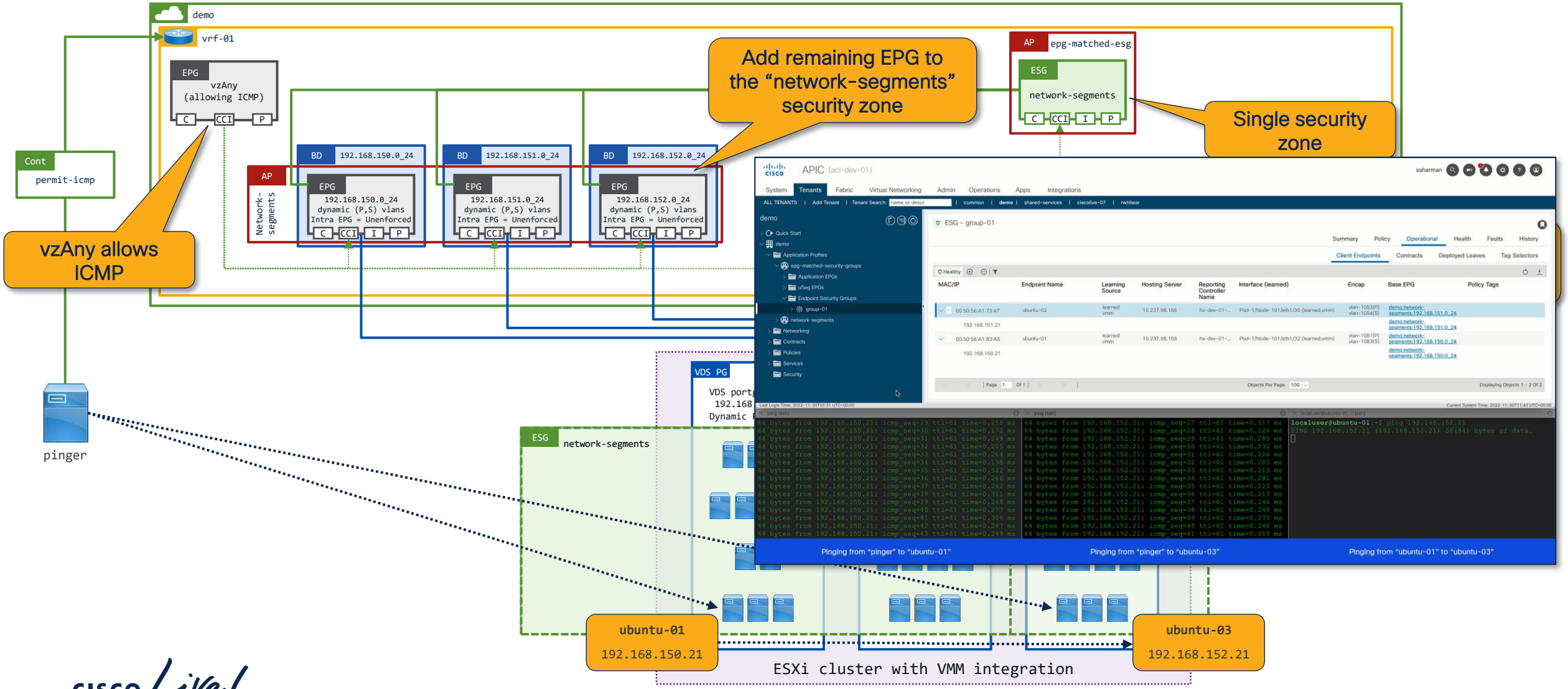
Add remaining EPG to Single Security Zone



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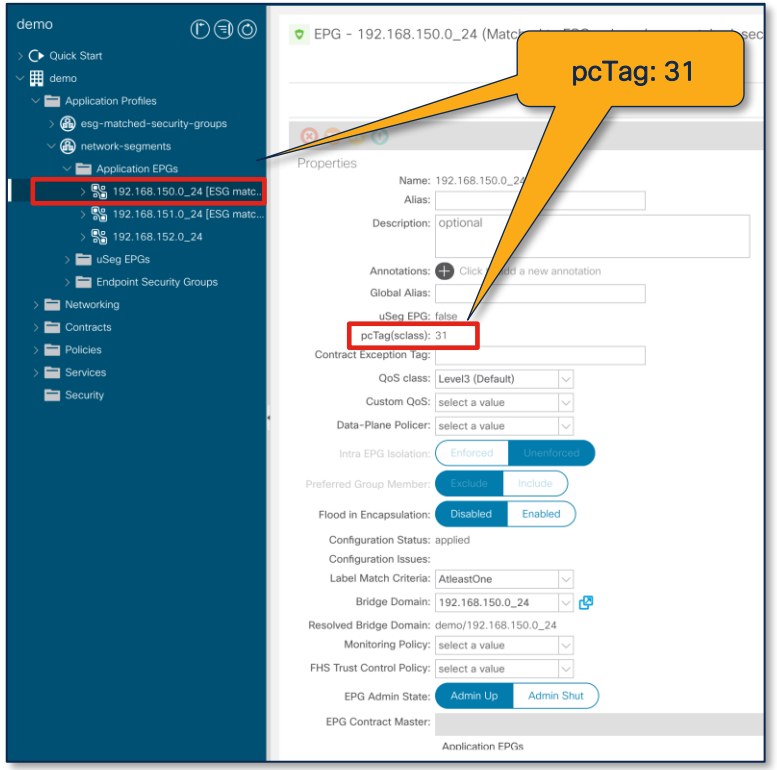
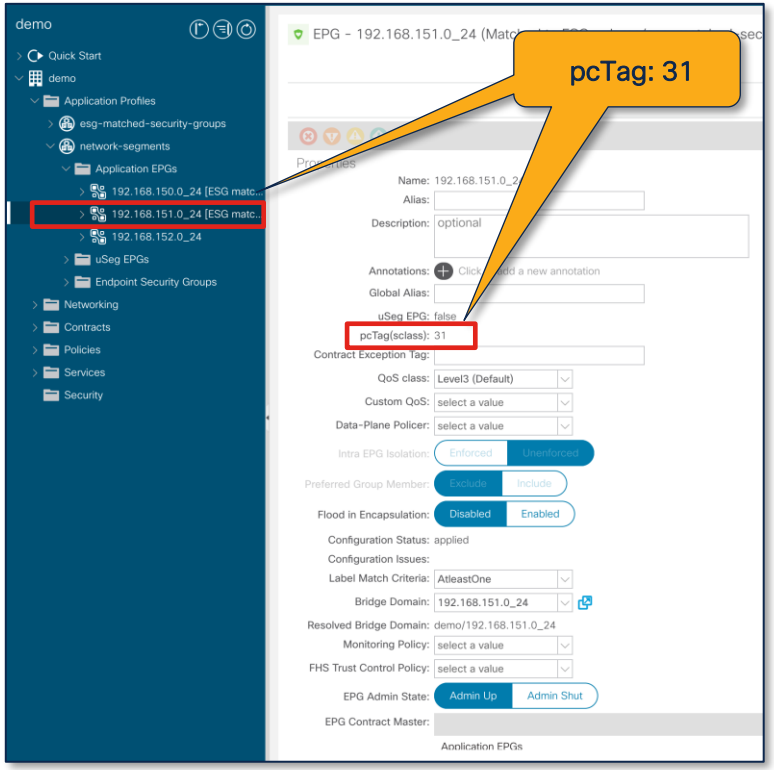
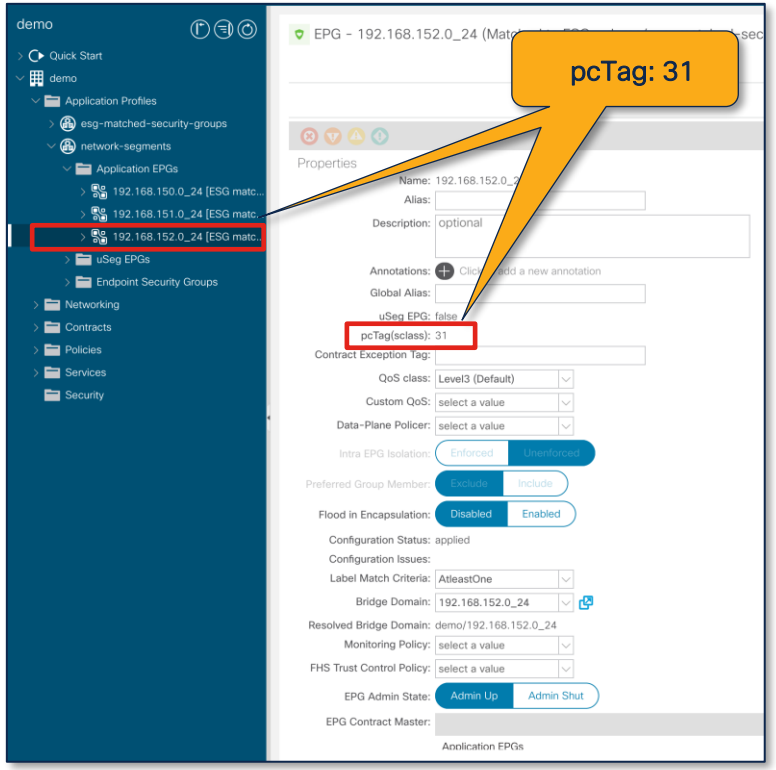
All EPGs now classified with a common pcTag







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Benefits of EPG to ESG Mapping

- More flexible than using vzAny as it is applied to specific EPGs to create one or more security groups based on subnets/vlans*
- More secure than vzAny as EPG/ESG mapping does not include the extEPG – a contract is required for external communication
- More integrated than vzAny as supports provider function for Shared Services
- More flexible than Preferred Groups as you can multiple ESG groups vs a single preferred group
- More integrated than Preferred Groups as you can create a contract to the whole ESG

* Assumes 1:1 mapping between Bridge Domain and EPG. ESGs can mapping can also be performed on IP subnets

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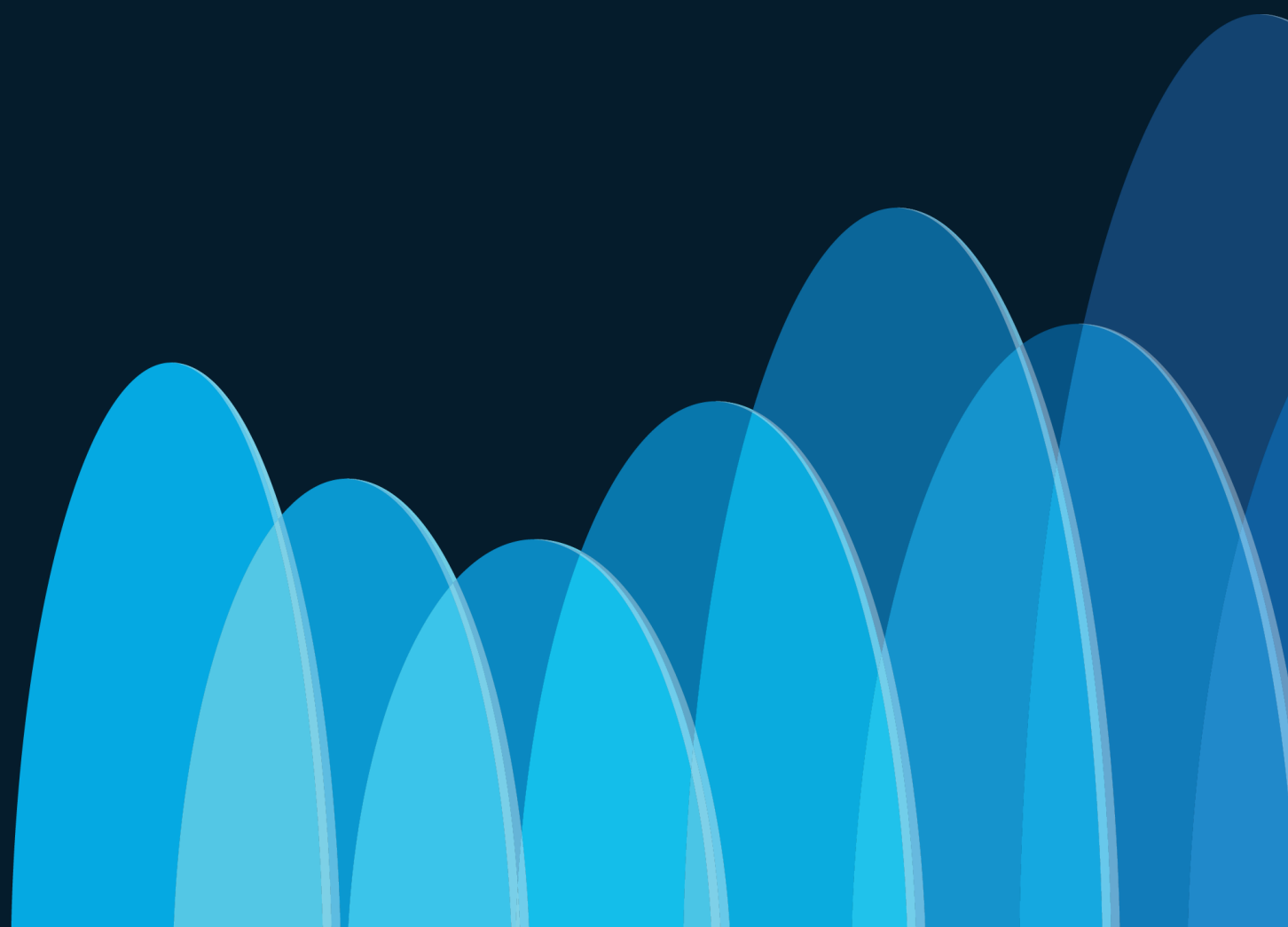
Allowing restricted communication...



Let’s check our understanding on how contracts work...

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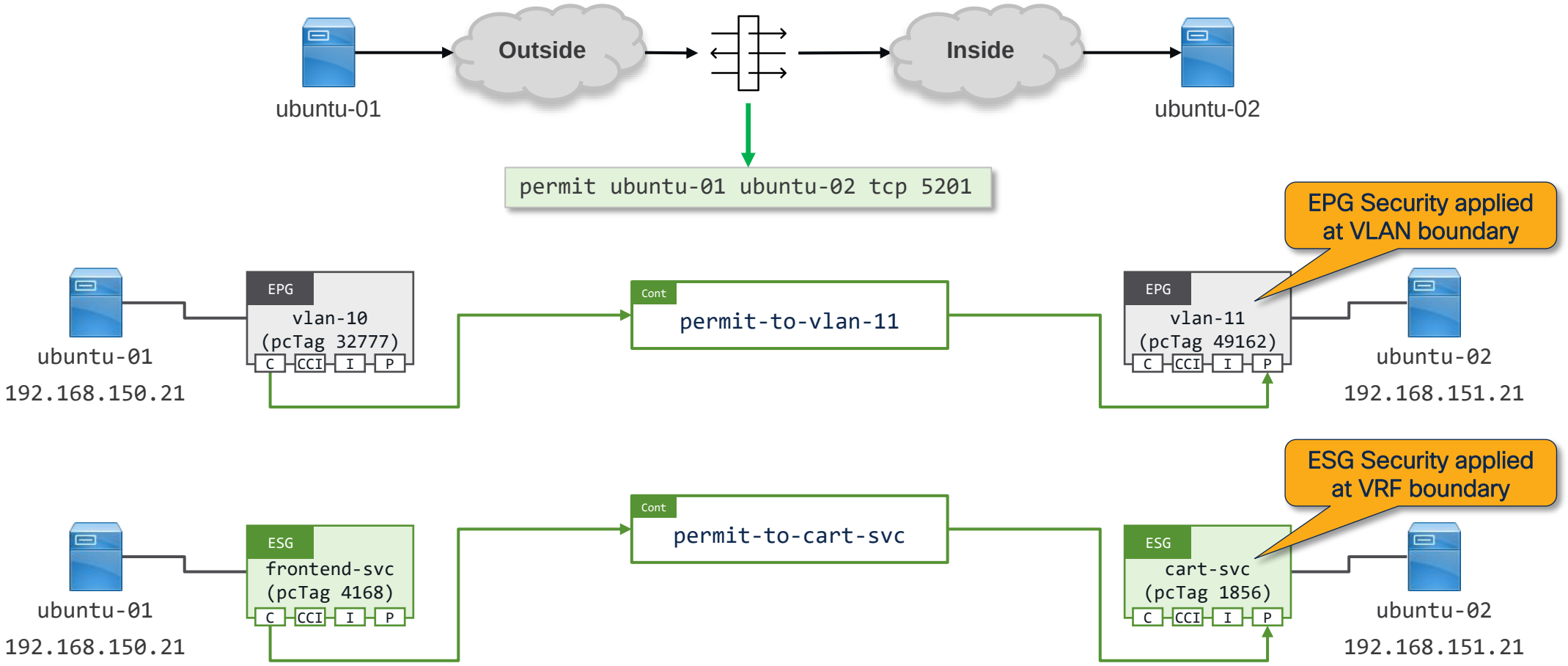
How do contracts work...?



*arrows indicate expected direction of connection i.e. from consumer to provider

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Consumer and Provider relationships are there to help you visualize the traffic flow direction

i.e. (typically) from the consumer to the provider

Consumer and Provider relationships do not (by default) prevent TCP connections being established from the Provider to the Consumer

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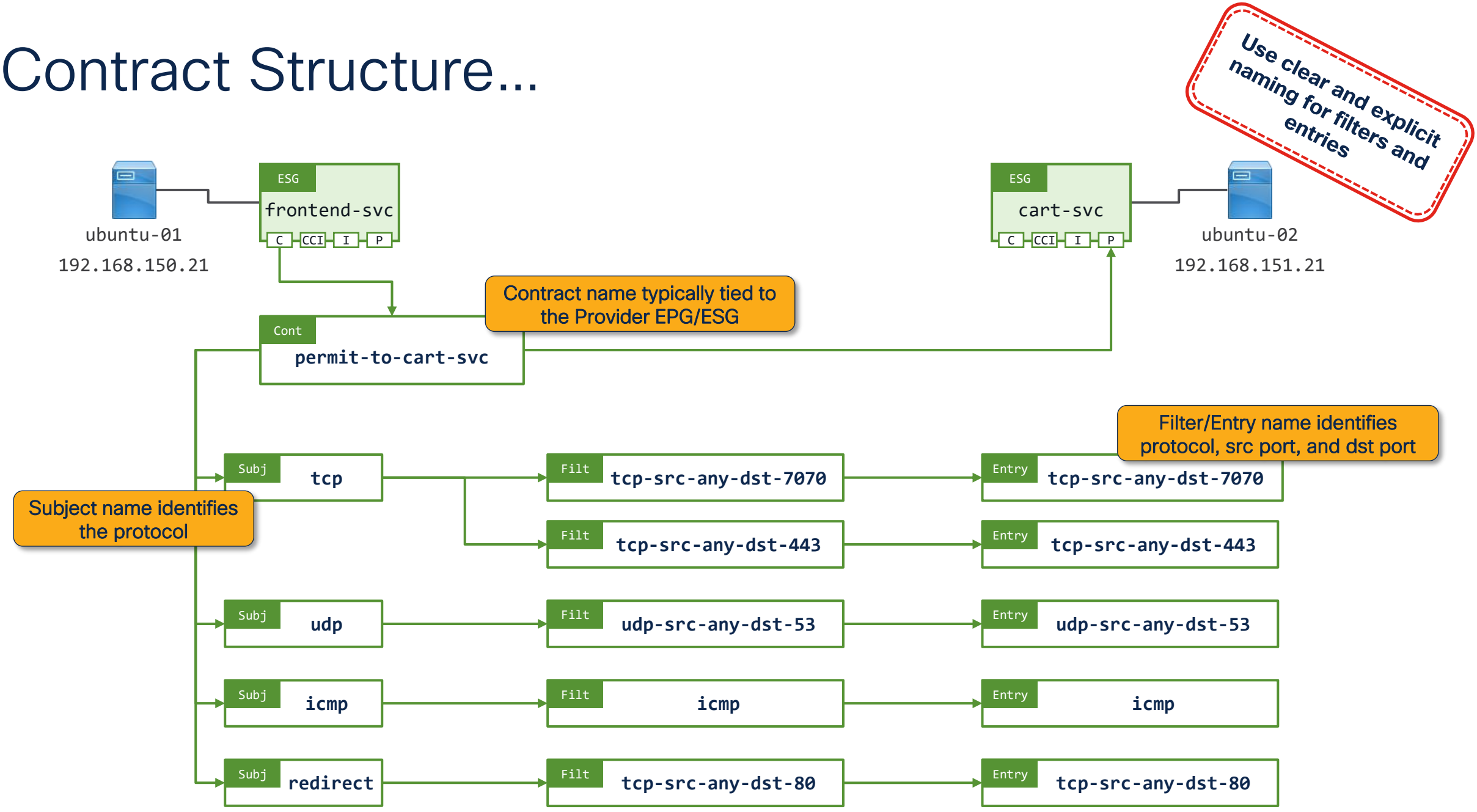
Contract Structure...



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Who hasn’t simply done this...

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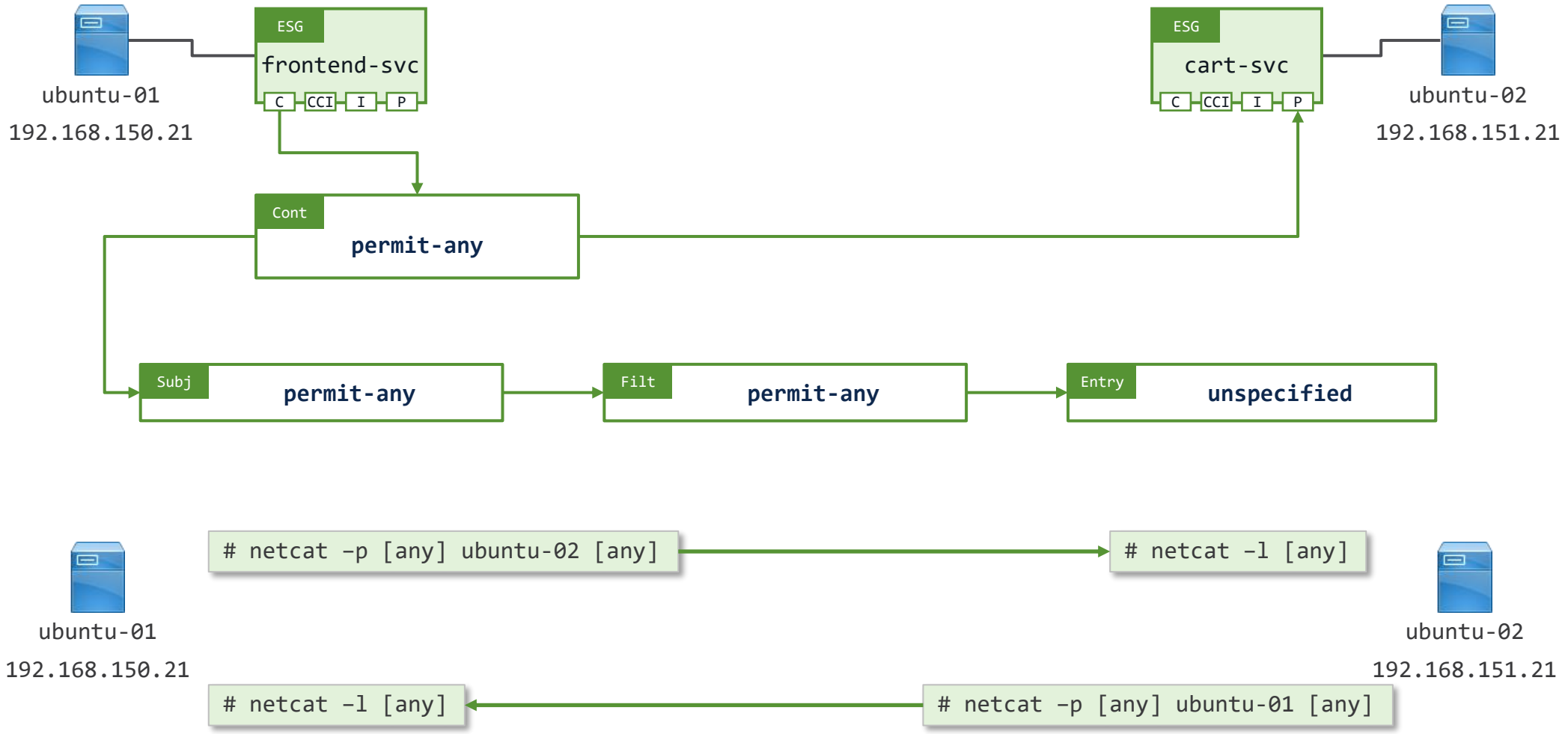
permit any/any



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Contracts also trigger route leaking for EPGs...

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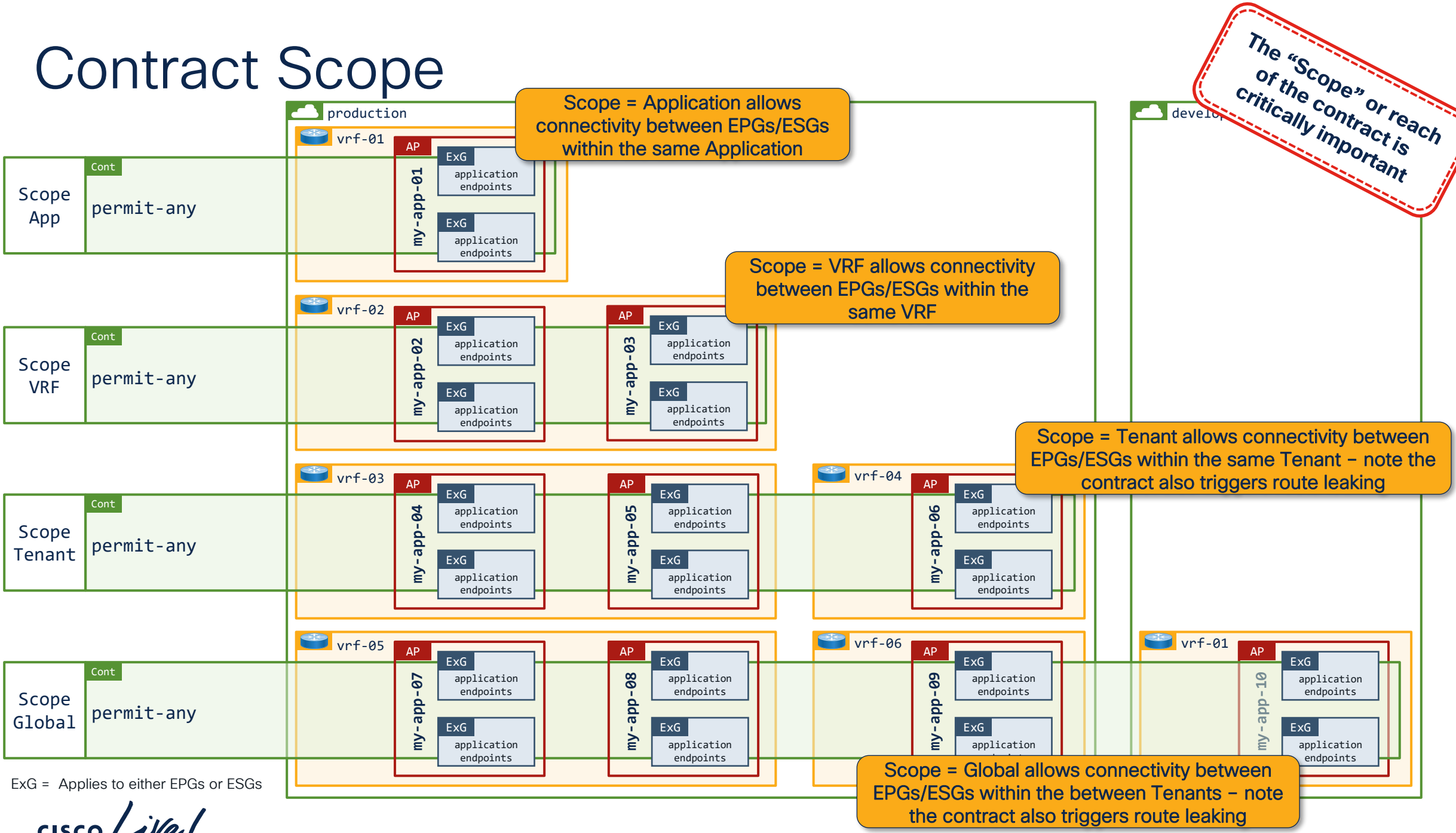
Contract Scope



ExG = Applies to either EPGs or ESGs

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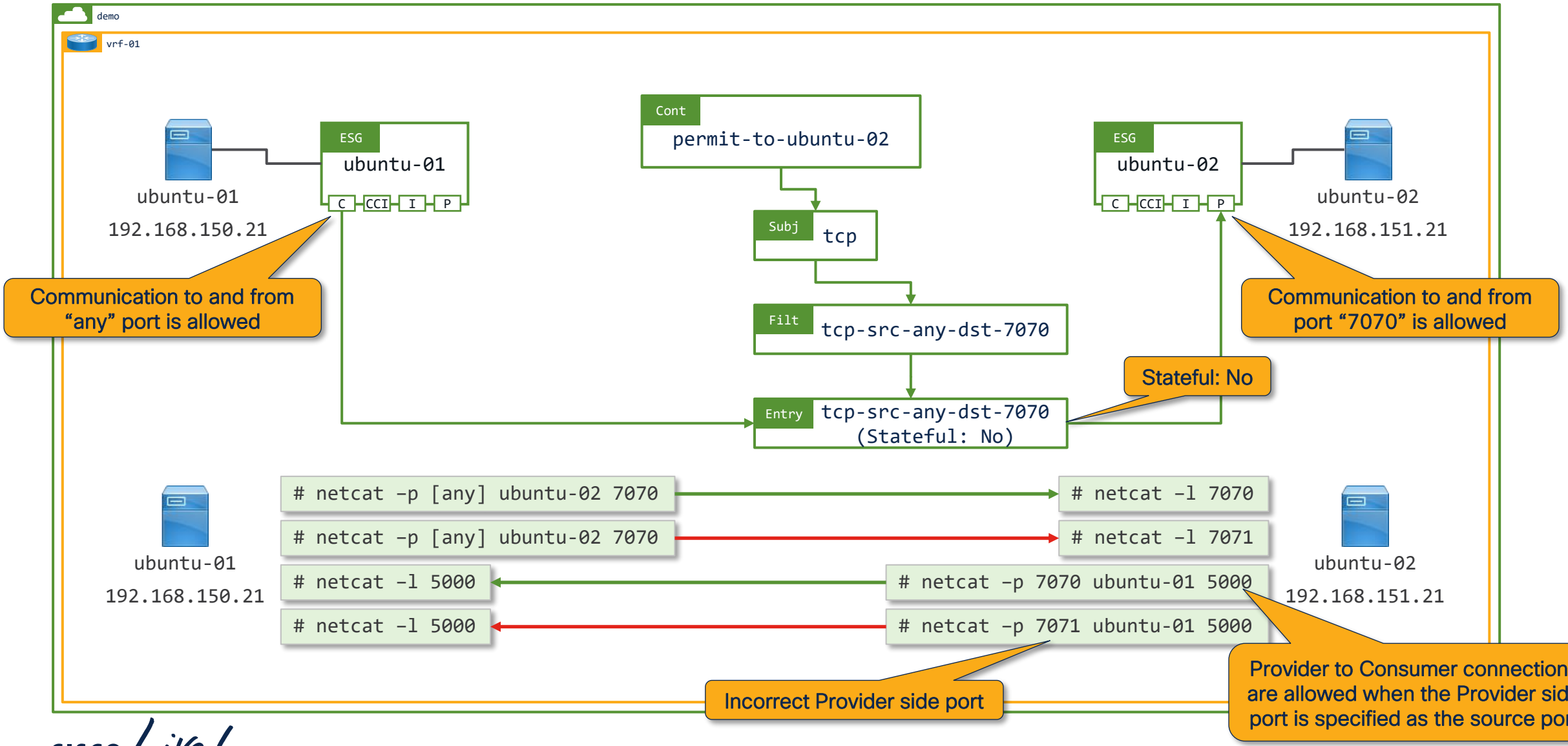
Verifying Contract operation with netcat – Stateful = No



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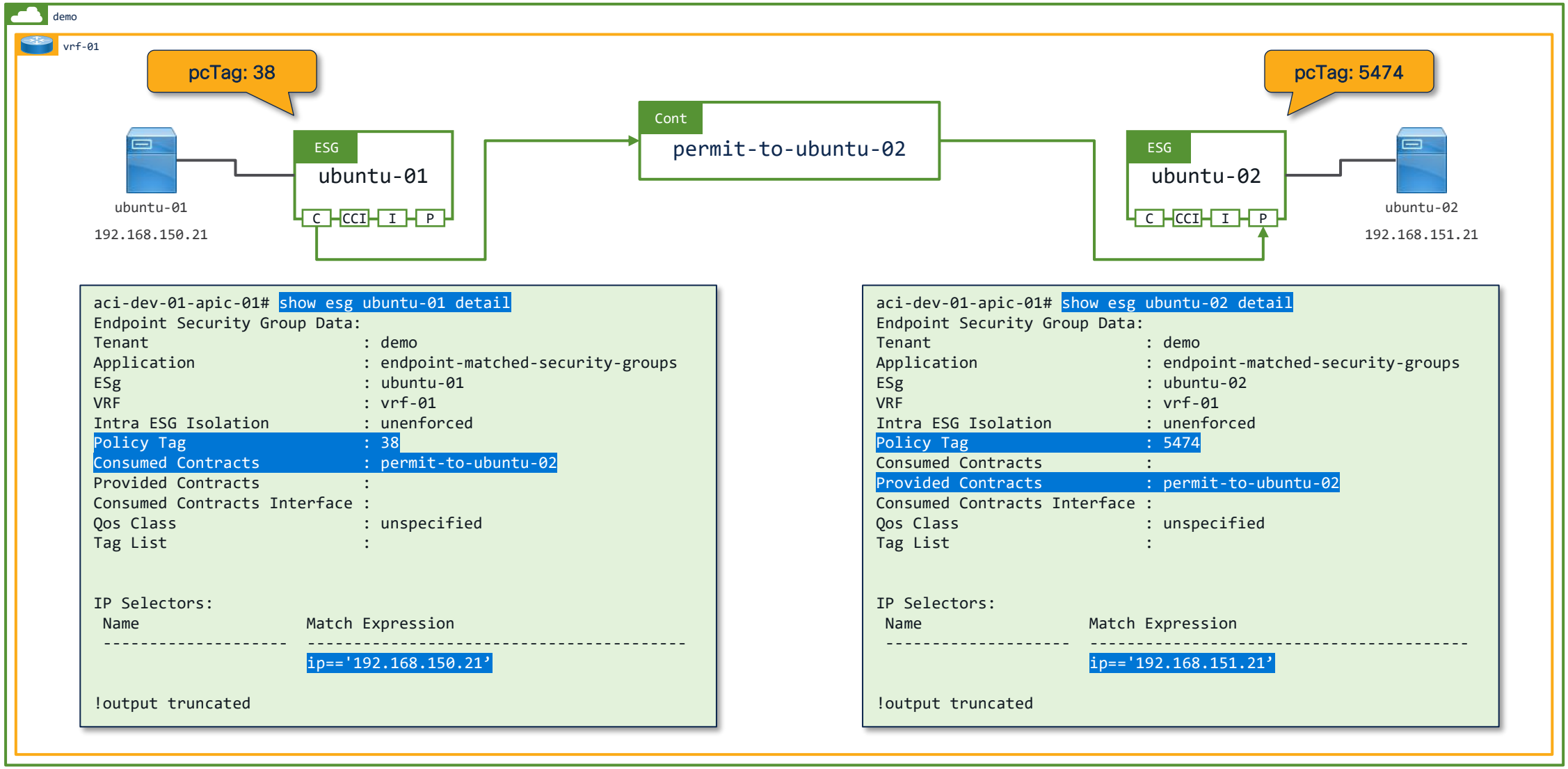
Verifying Contract Operation: EPG/ESG details




```
aci-dev-01-apic-01# show esg ubuntu-01 detail
Endpoint Security Group Data:
Tenant                          : demo
Application                     : endpoint-matched-security-groups
ESg                             : ubuntu-01
VRF                             : vrf-01
Intra ESG Isolation             : unenforced
Policy Tag                      : 38
Consumed Contracts              : permit-to-ubuntu-02
Provided Contracts              :
Consumed Contracts Interface    :
Qos Class                       : unspecified
Tag List                        :


IP Selectors:
 Name                   Match Expression
 --------------------   ----------------------------------------
                        ip=='192.168.150.21'

!output truncated
```

```
aci-dev-01-apic-01# show esg ubuntu-02 detail
Endpoint Security Group Data:
Tenant                          : demo
Application                     : endpoint-matched-security-groups
ESg                             : ubuntu-02
VRF                             : vrf-01
Intra ESG Isolation             : unenforced
Policy Tag                      : 5474
Consumed Contracts              :
Provided Contracts              : permit-to-ubuntu-02
Consumed Contracts Interface    :
Qos Class                       : unspecified
Tag List                        :


IP Selectors:
 Name                   Match Expression
 --------------------   ----------------------------------------
                        ip=='192.168.151.21'

!output truncated
```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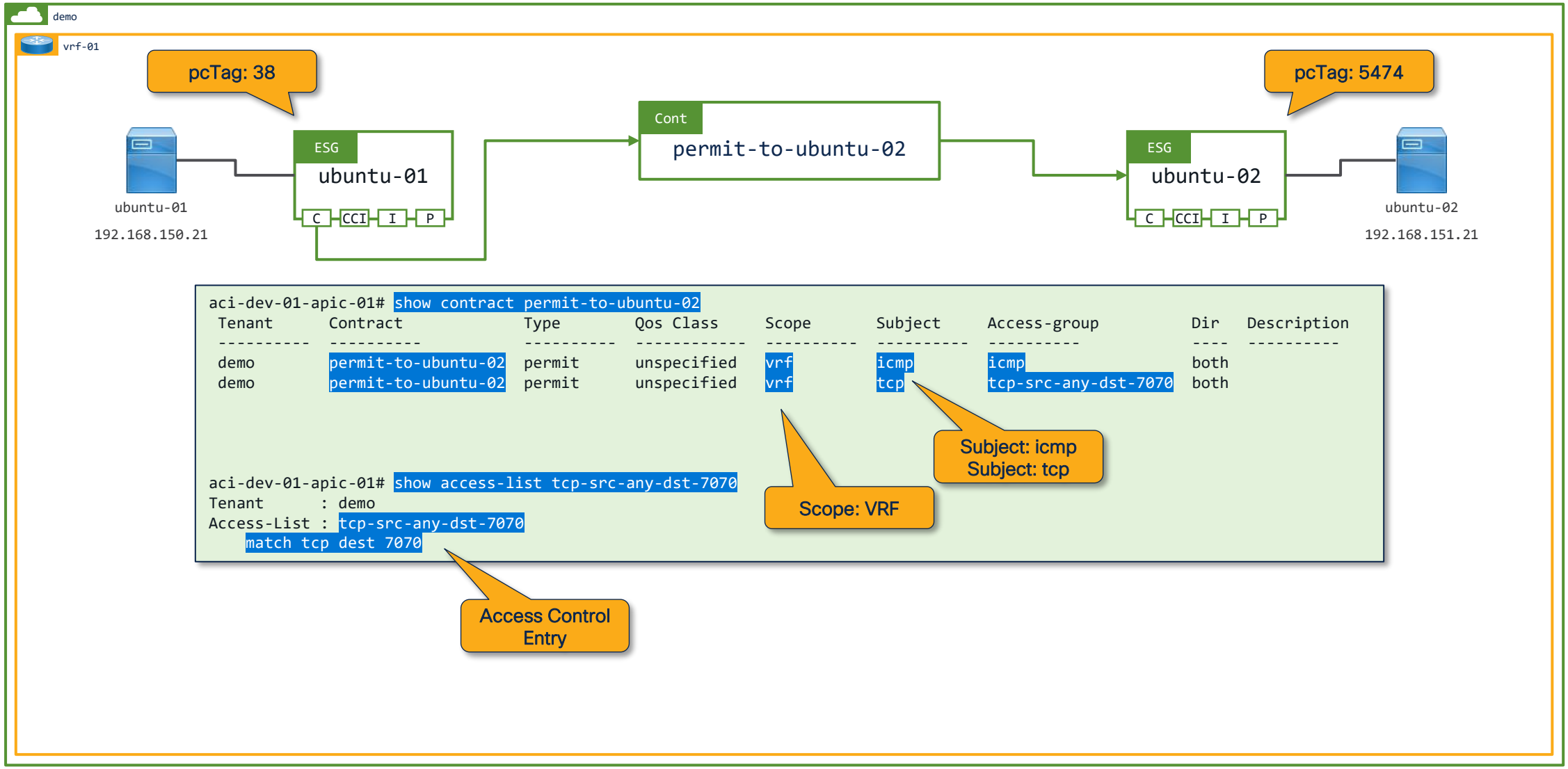
Verifying Contract Operation: Contract details



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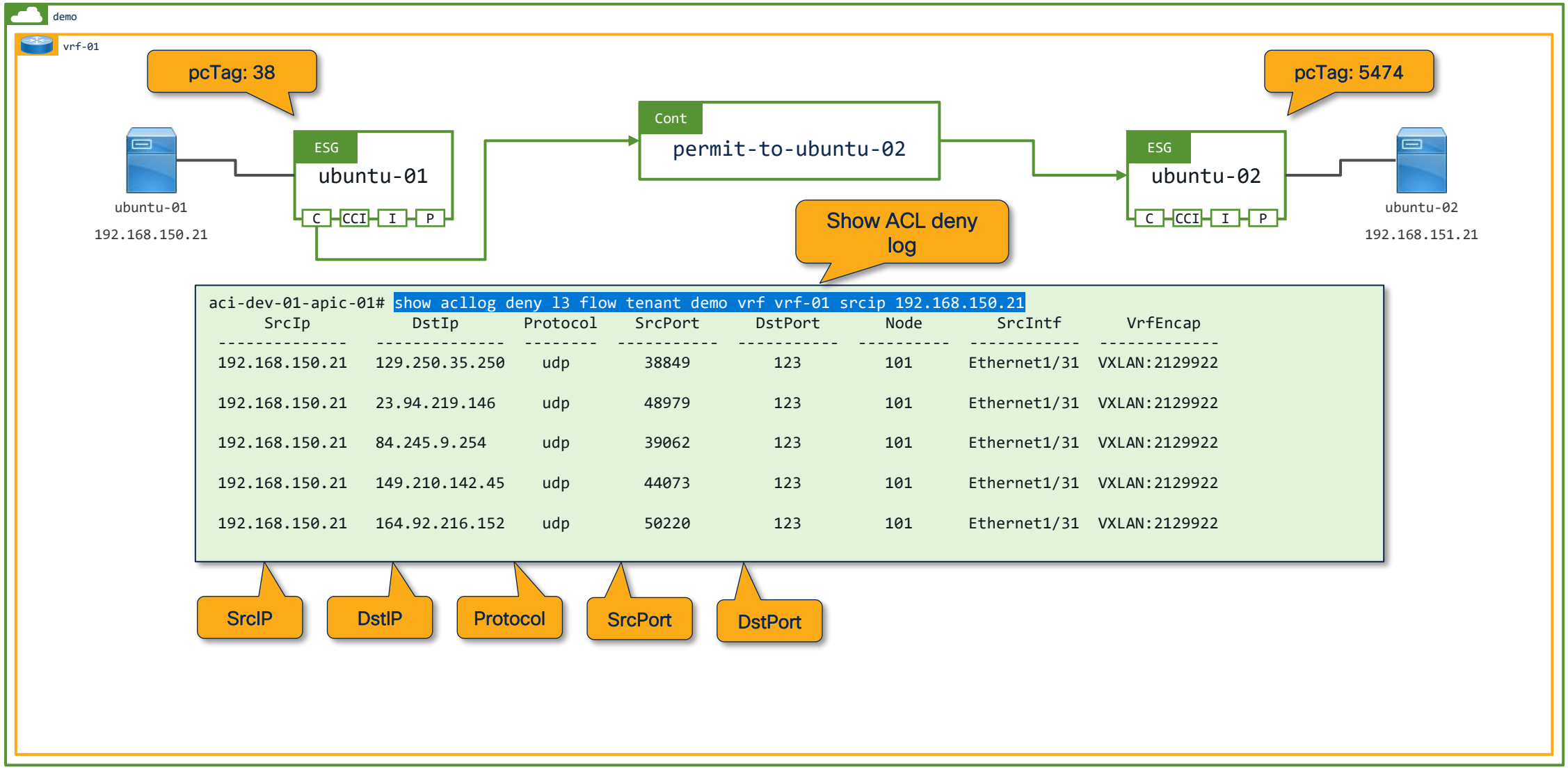
Verifying Contract Operation: Drop details



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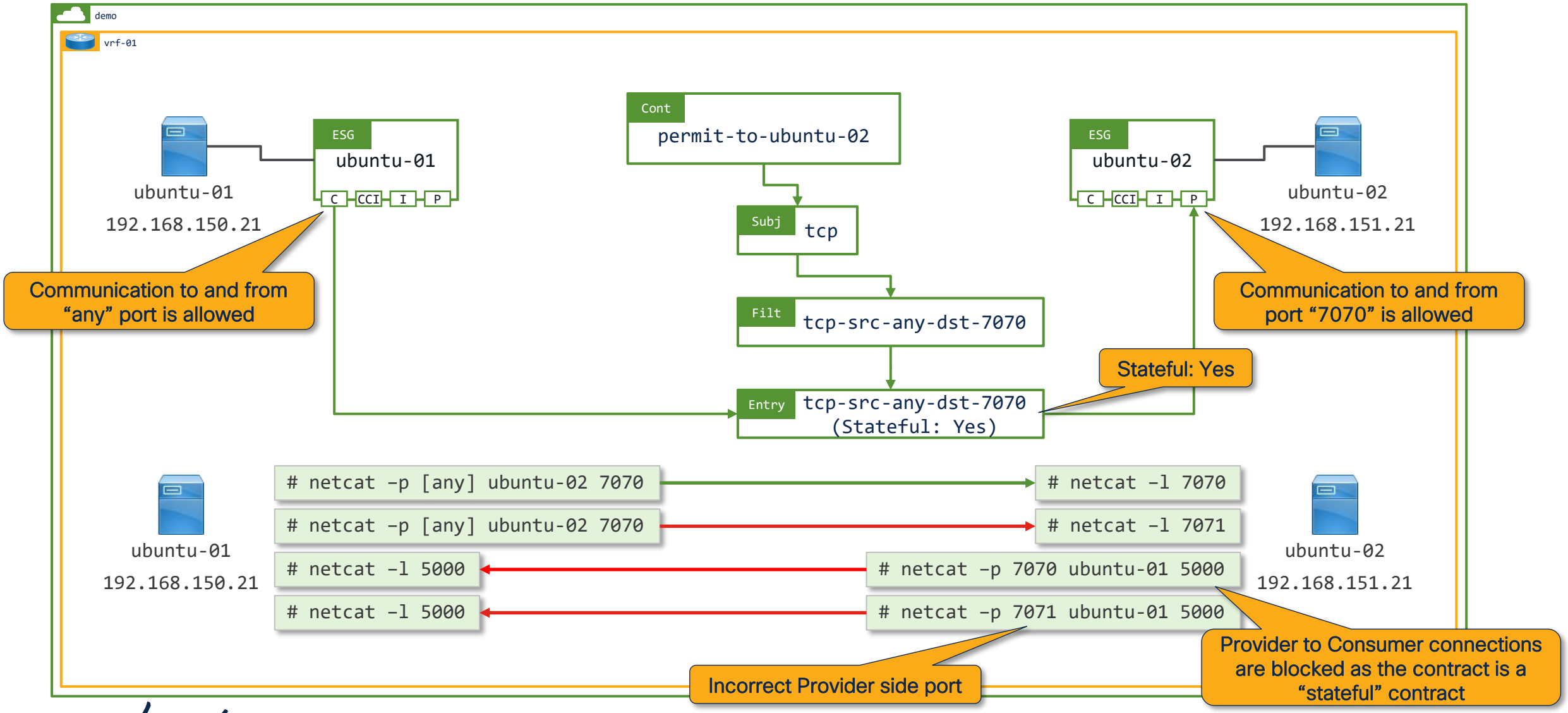
Verifying Contract operation with netcat – Stateful = Yes



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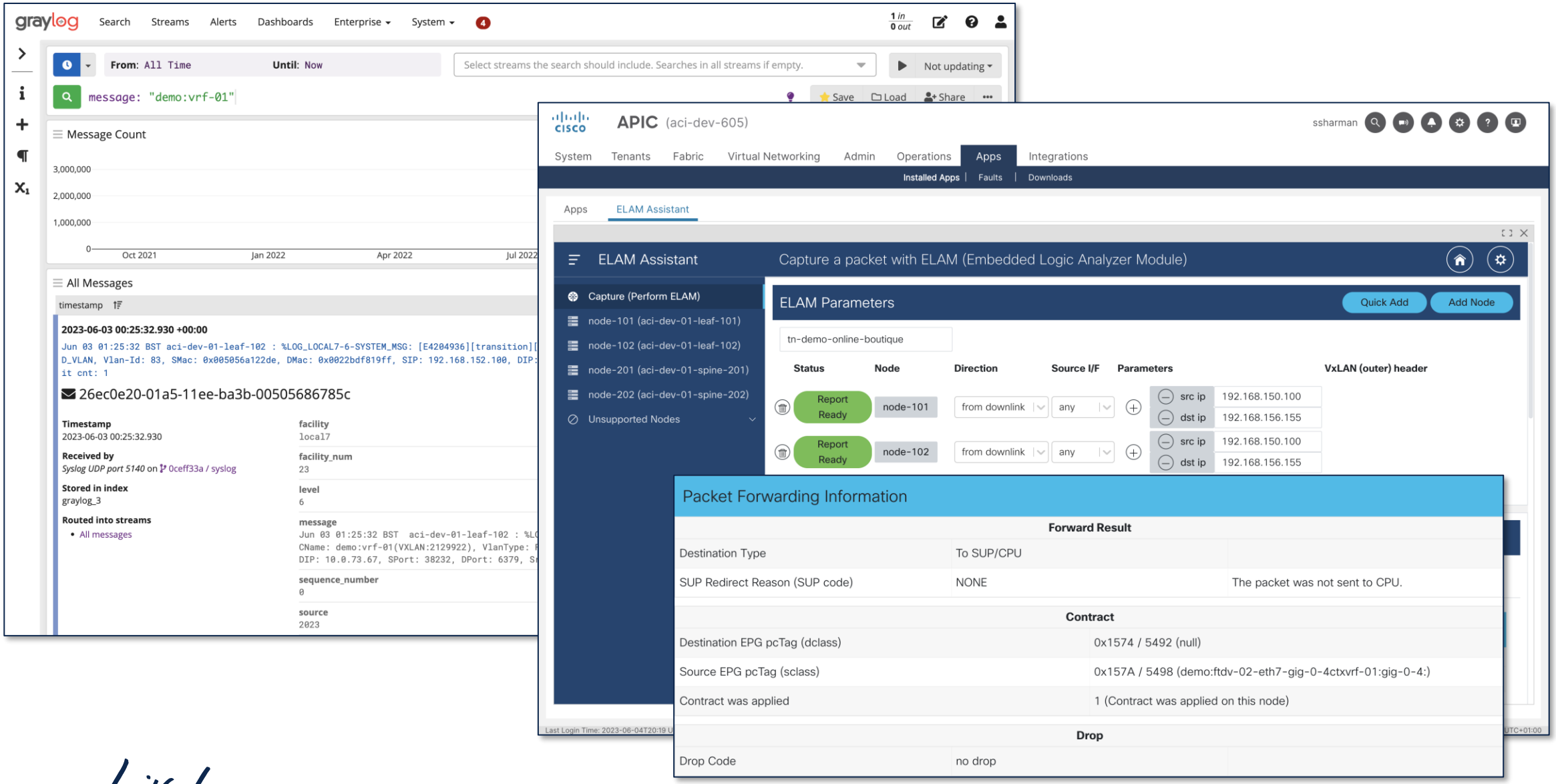
Verifying Contracts with Syslog and ELAM



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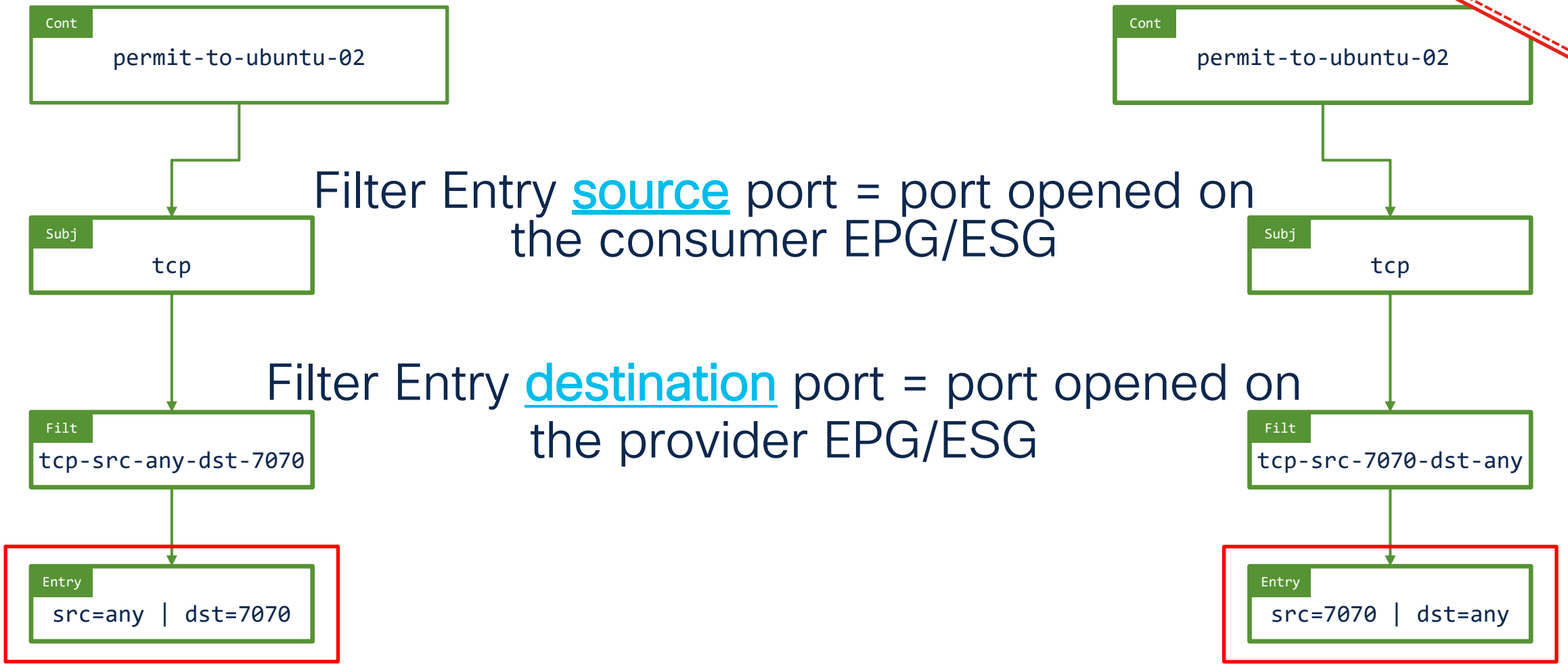

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Getting into the weeds...!

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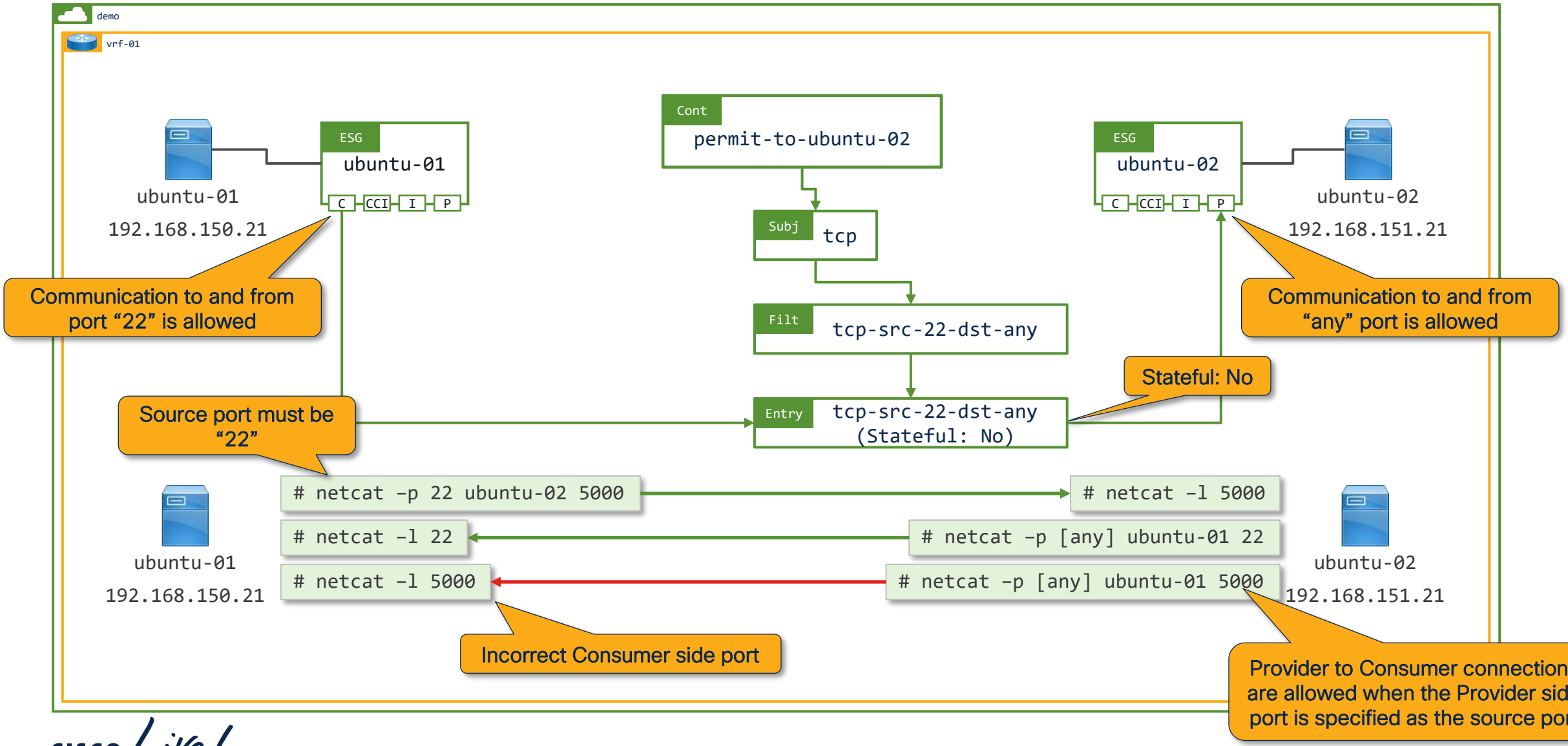
Reversing the Filter ports – Stateful = No



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Why would you want to reverse the Consumer and Provider Filters...?

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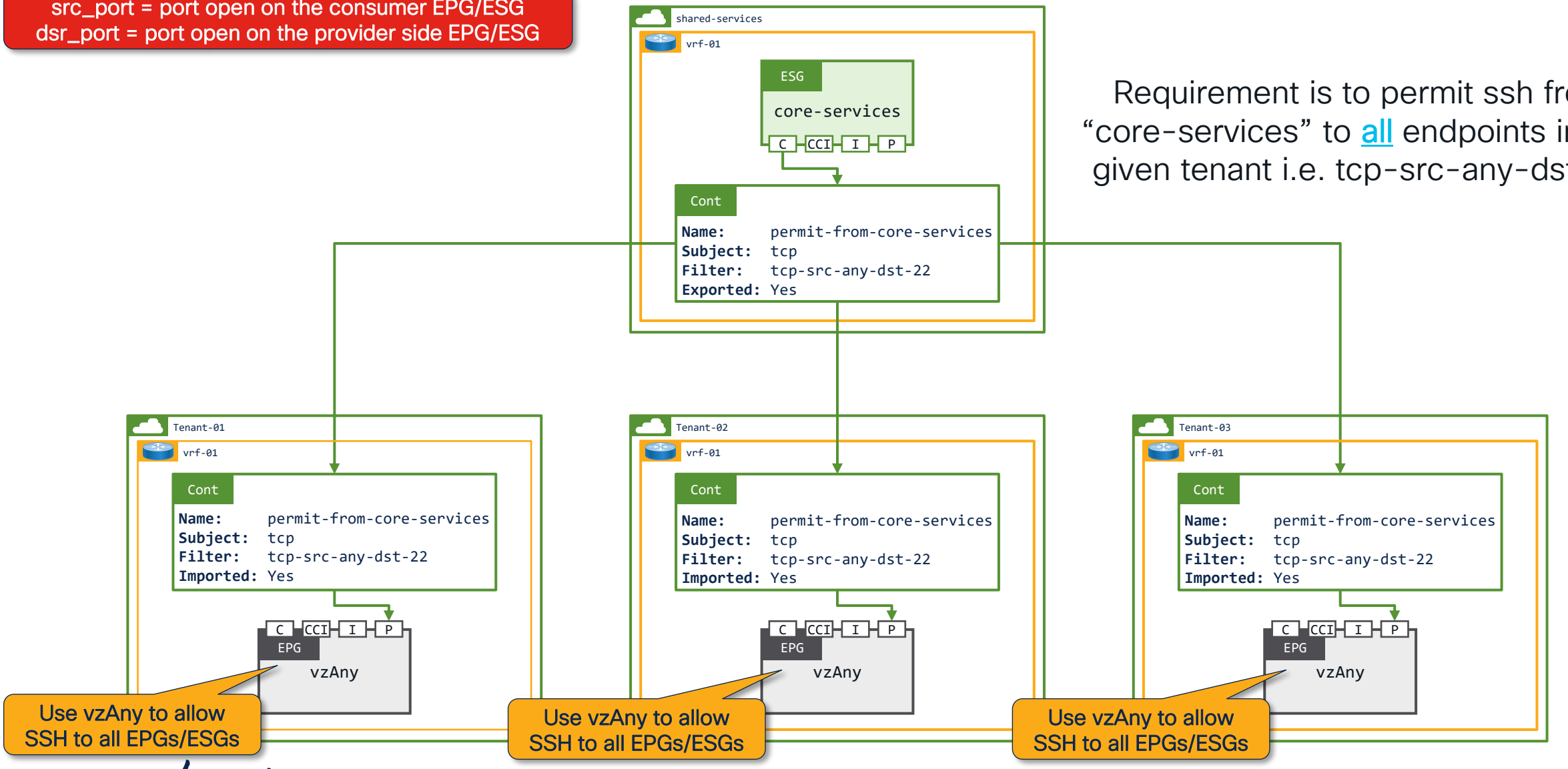
vzAny as a contract Provider

src_port = port open on the consumer EPG/ESG
dsr_port = port open on the provider side EPG/ESG



Requirement is to permit ssh from "core-services" to all endpoints in any given tenant i.e. tcp-src-any-dst-22

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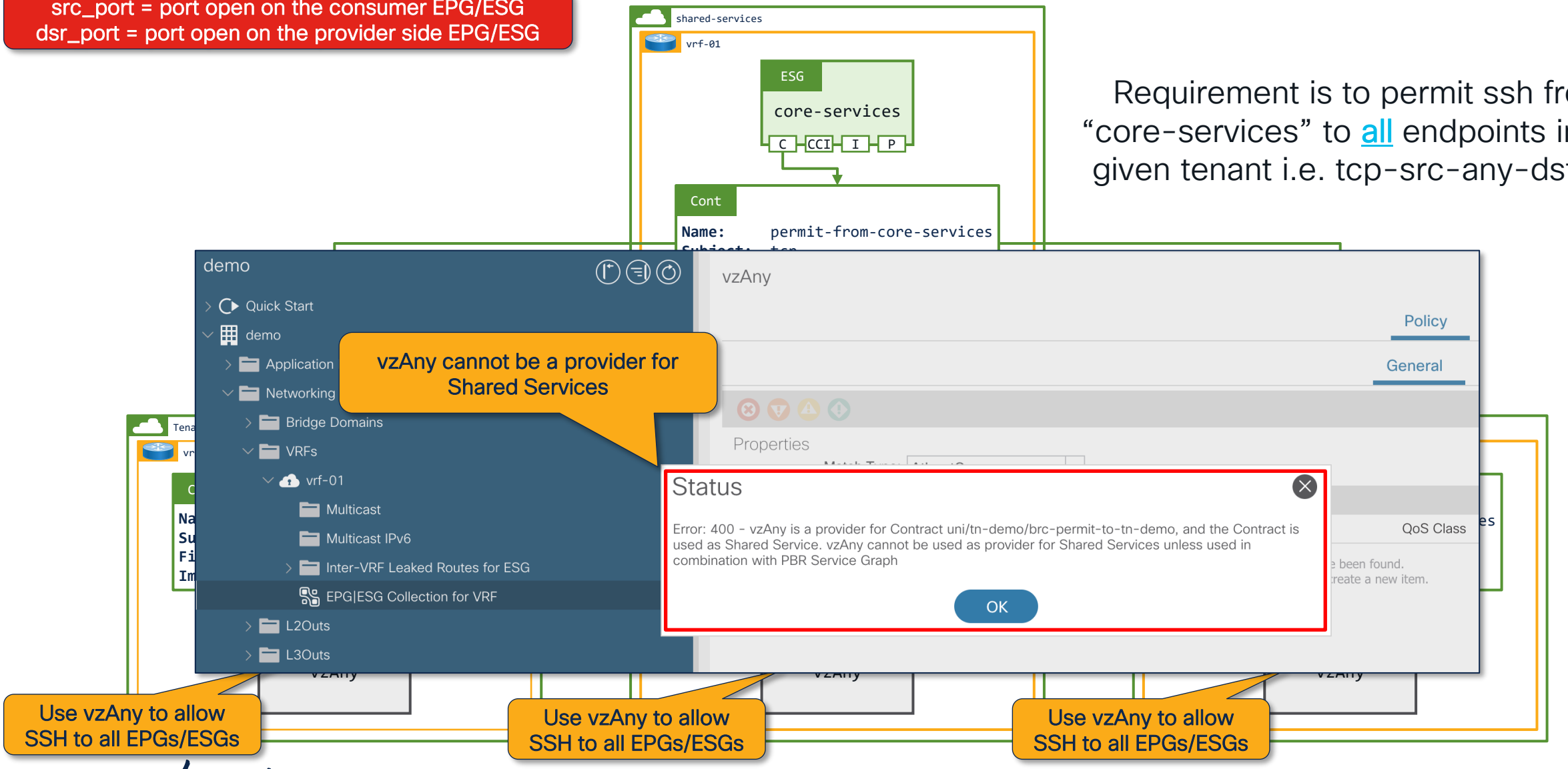
vzAny as a contract Provider

src_port = port open on the consumer EPG/ESG
dsr_port = port open on the provider side EPG/ESG



Requirement is to permit ssh from “core-services” to all endpoints in any given tenant i.e. tcp-src-any-dst-22

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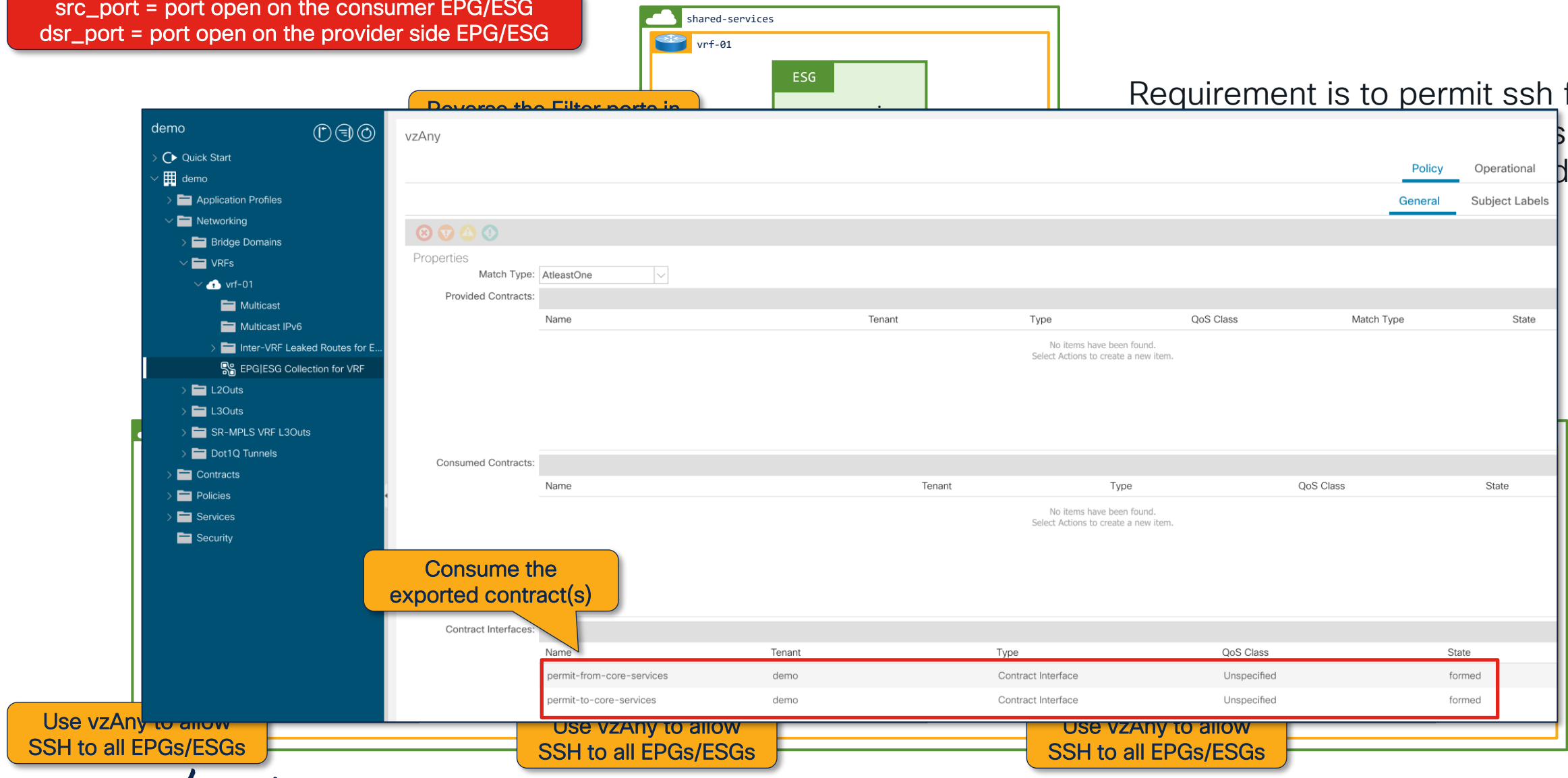
vzAny as a contract Consumer – Filters Reversed

src_port = port open on the consumer EPG/ESG
dsr_port = port open on the provider side EPG/ESG



Requirement is to permit ssh from
s in any
dst-22

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Setting the scene...

Designing your Tenants...

Switching to Application Centric mode...

Working with ESGs...

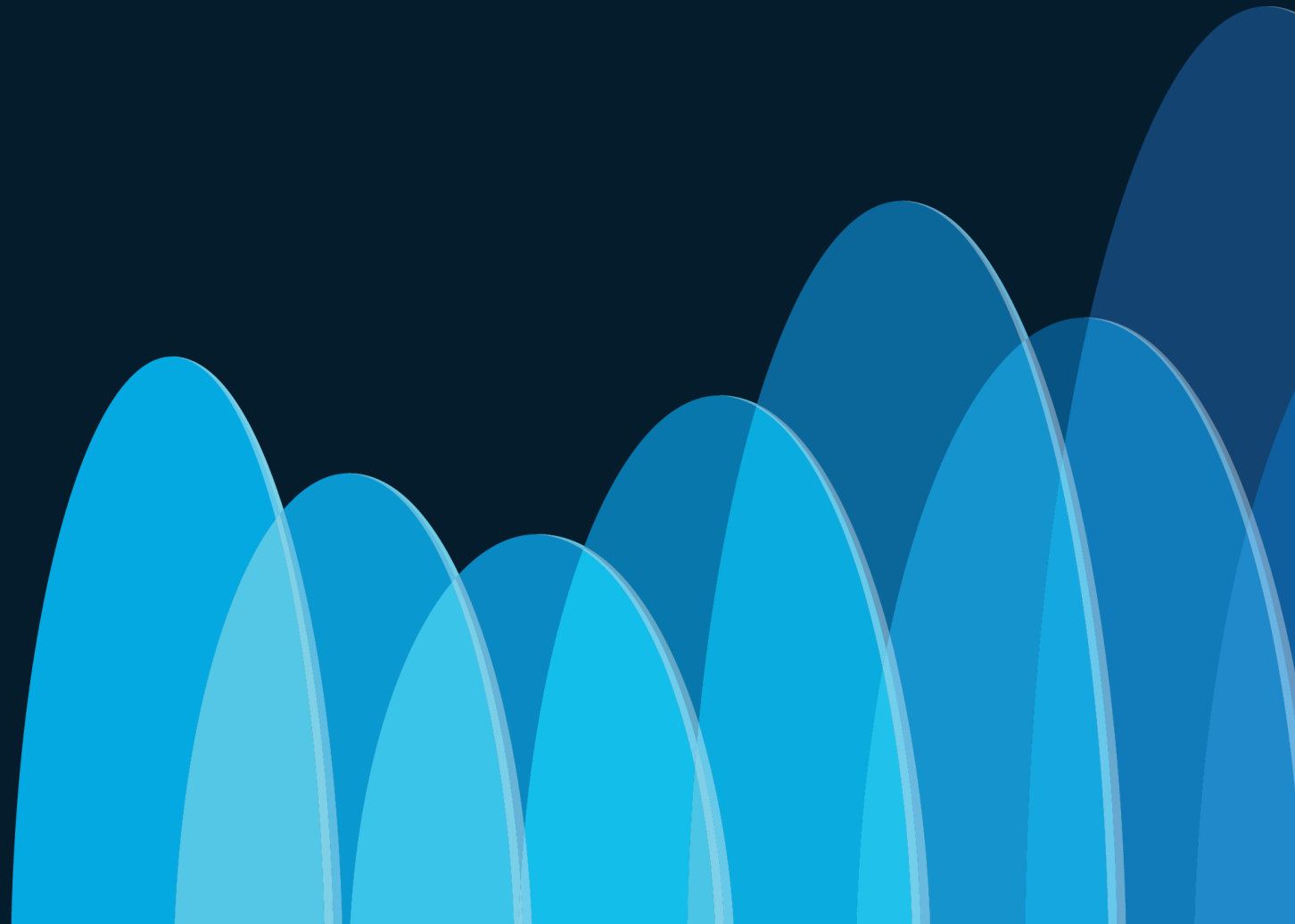
Understanding ACI security...

External Connectivity...

Increasing Security...

Automation Blueprints...

Wrapping up...



Where should you place your L3outs…?

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tenant “common”, “shared-services”, or in the “workload/user” tenant…

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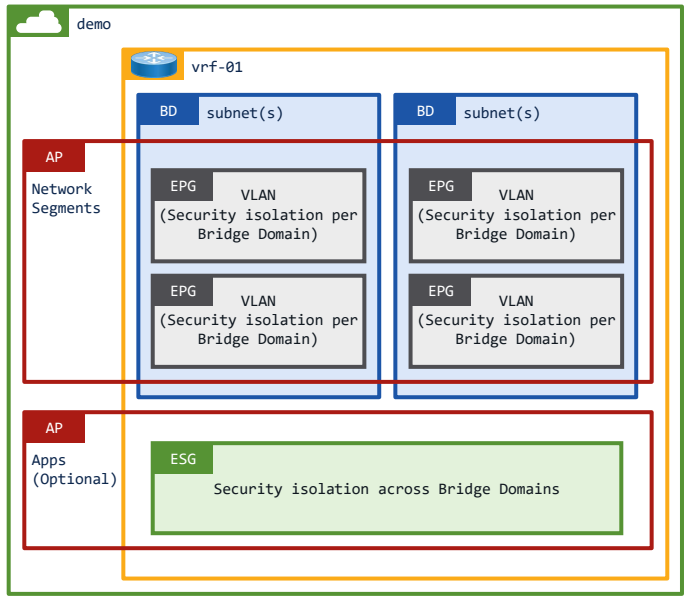
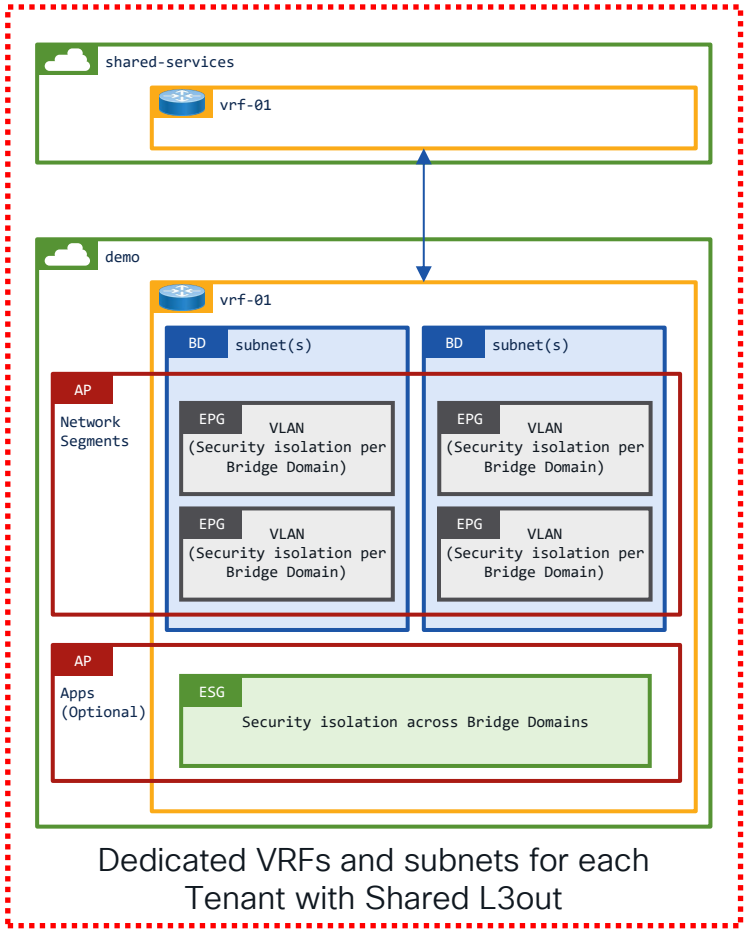
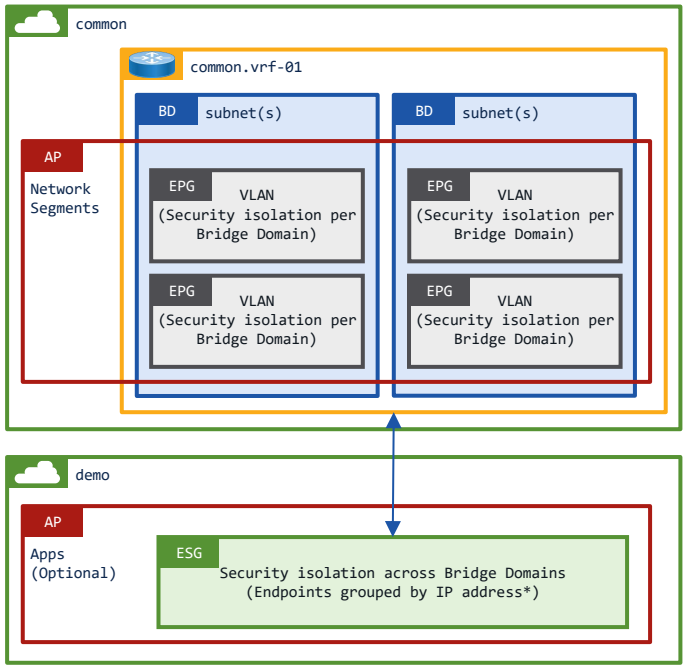
External Connectivity



Dedicated VRFs and subnets for each Tenant with Dedicated L3outs



Dedicated VRFs and subnets for each Tenant with Shared L3out



Shared networking with isolated security

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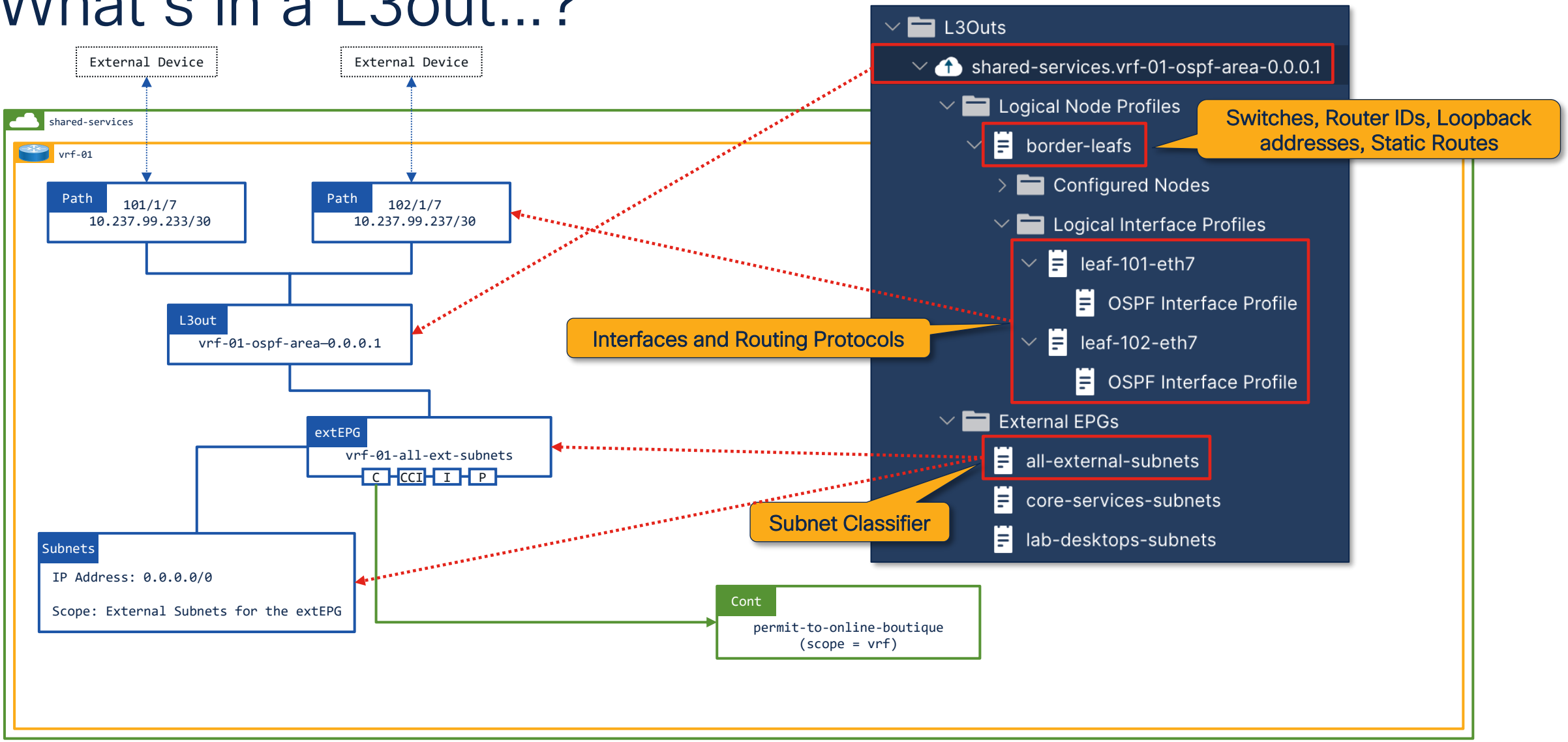
What's in a L3out...?



*arrows indicates direction of traffic flow i.e. from consumer to provider

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Option 1 – Dedicated L3out per Tenant

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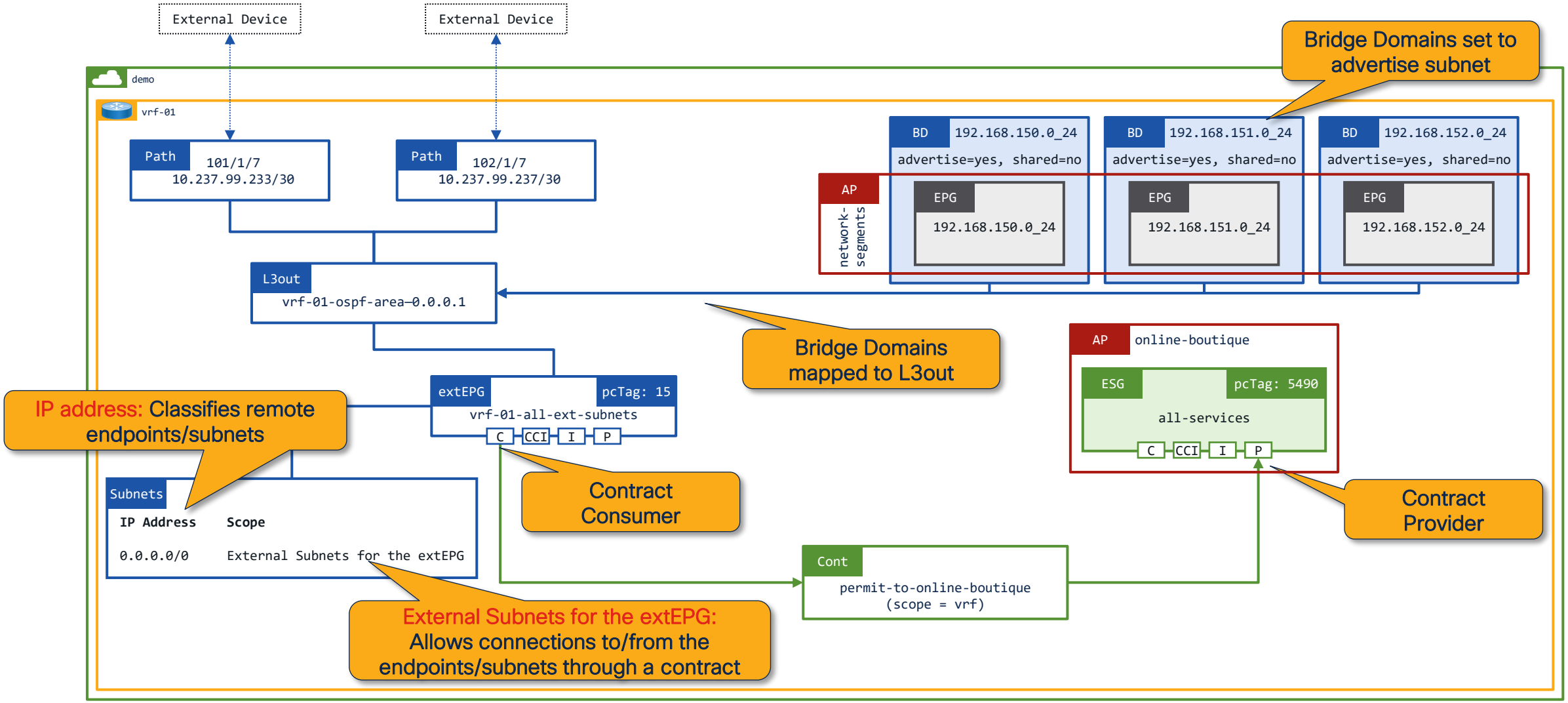
Dedicated L3out



*arrows indicate expected direction of connection i.e. from consumer to provider

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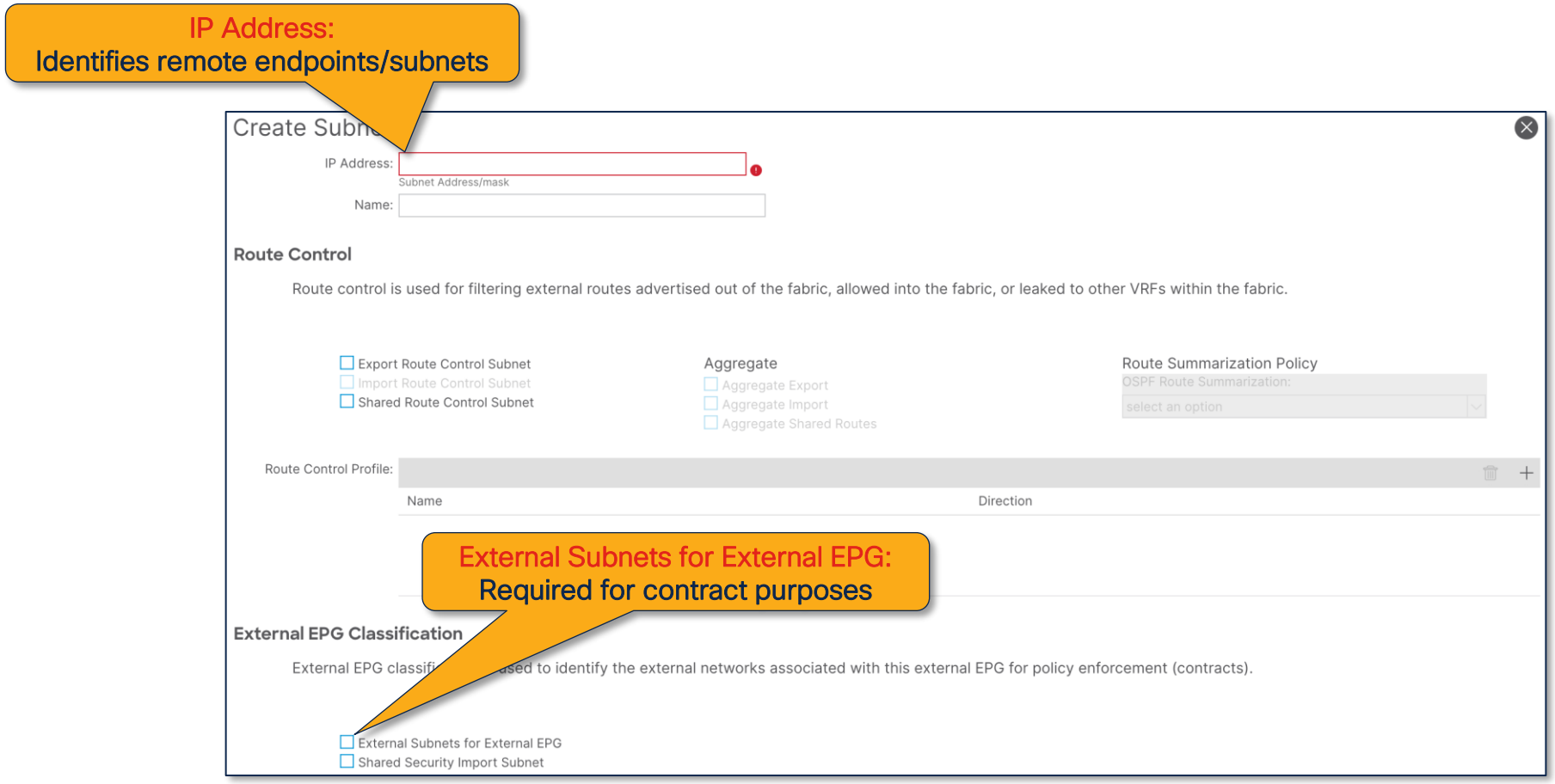
External Classification



- **IP Address:** identifies remote endpoints/subnets
- **External Subnets for External EPG:** allows packets to/from the L3out with a contract

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Option 2 – Shared L3out

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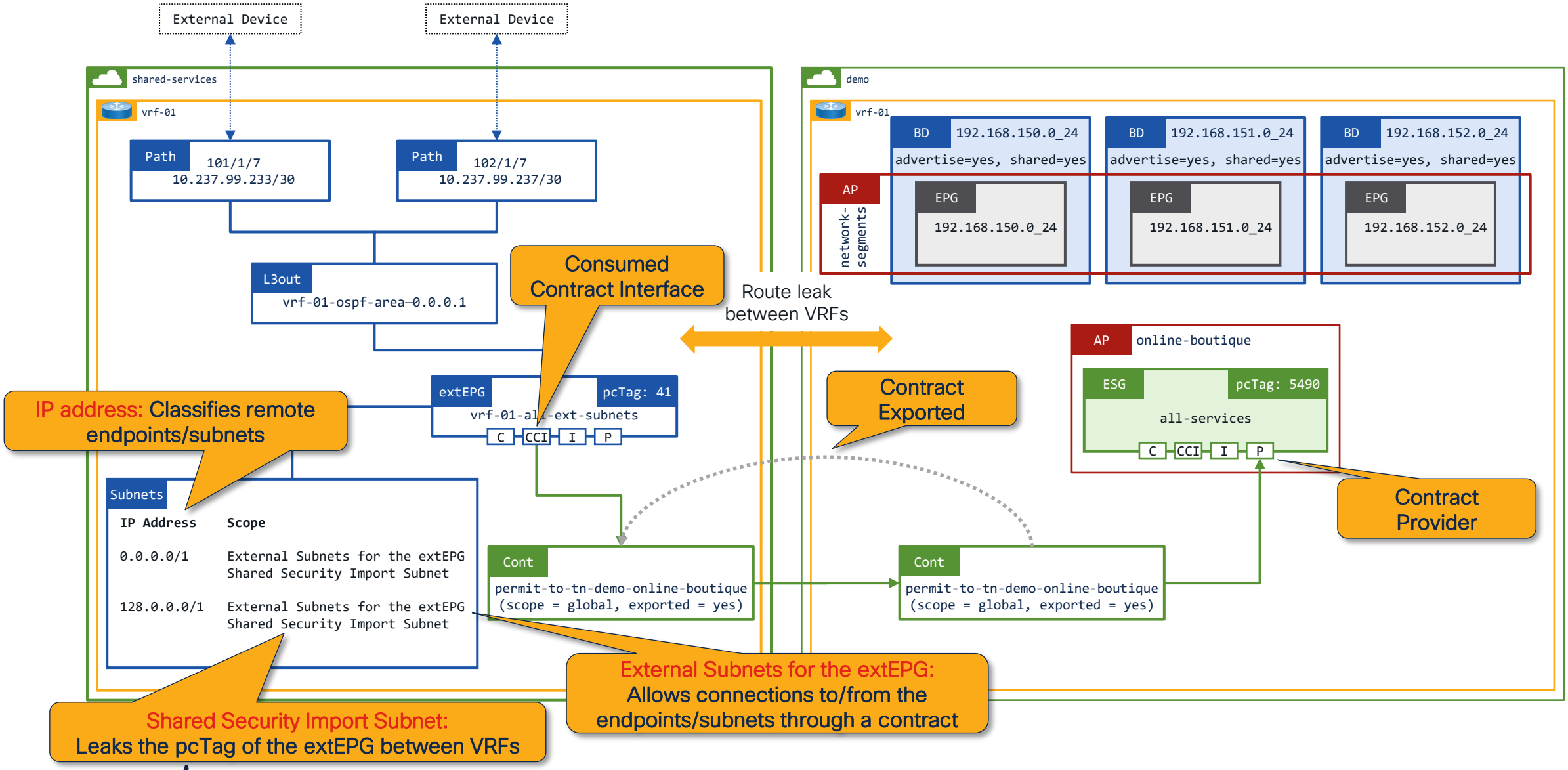
Shared L3out – Route Leaking between VRFs (ESGs)



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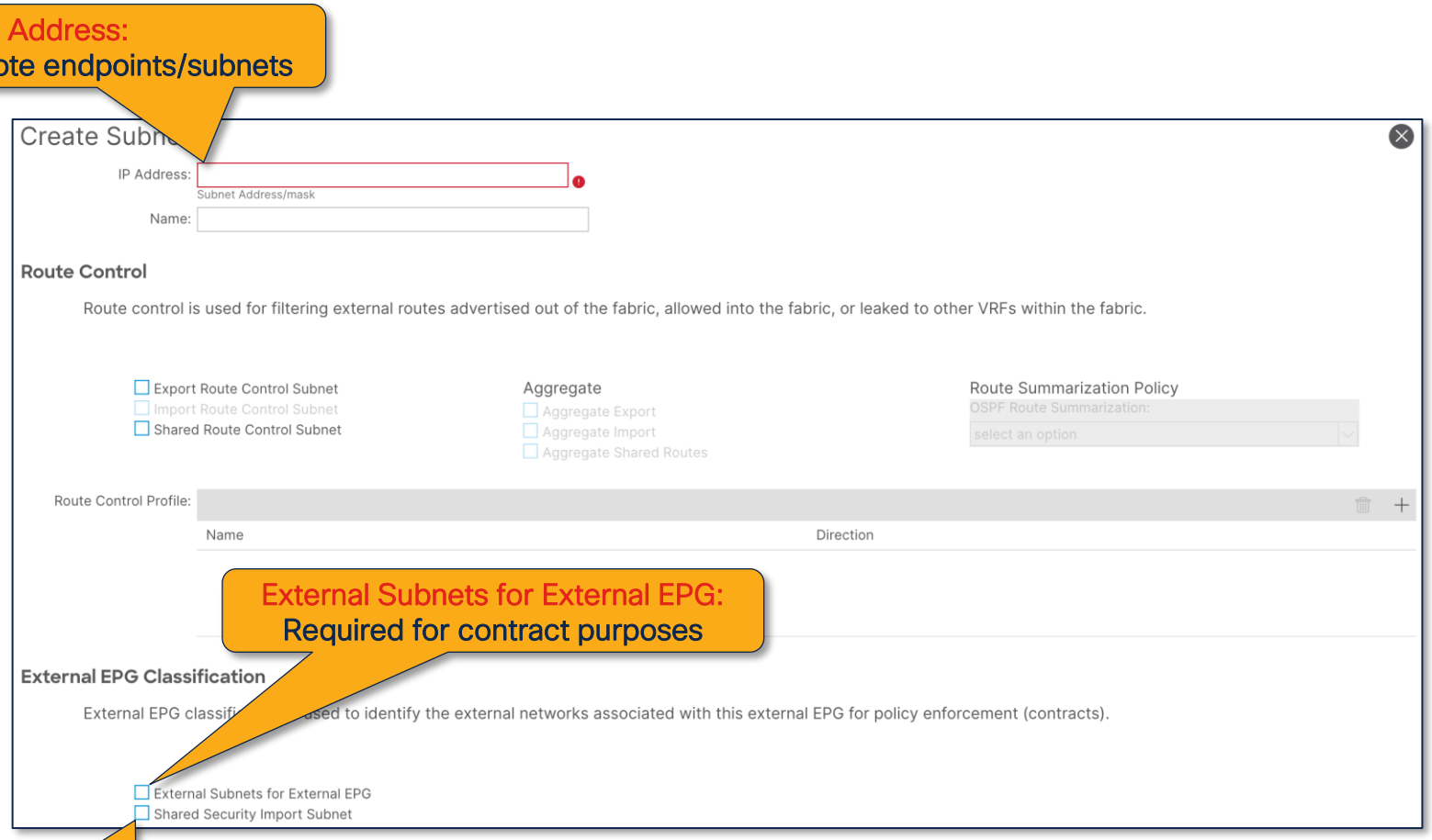
External Classification and Route Leaking



- **IP Address:** identifies remote endpoints/subnets, **must** match a received route for route leaking purposes
- **External Subnets for External EPG:** allows packets to/from the L3out with a contract
- **Shared Security Import Subnet:** is **always** required as it leaks the extEPG pcTag to the target VRF

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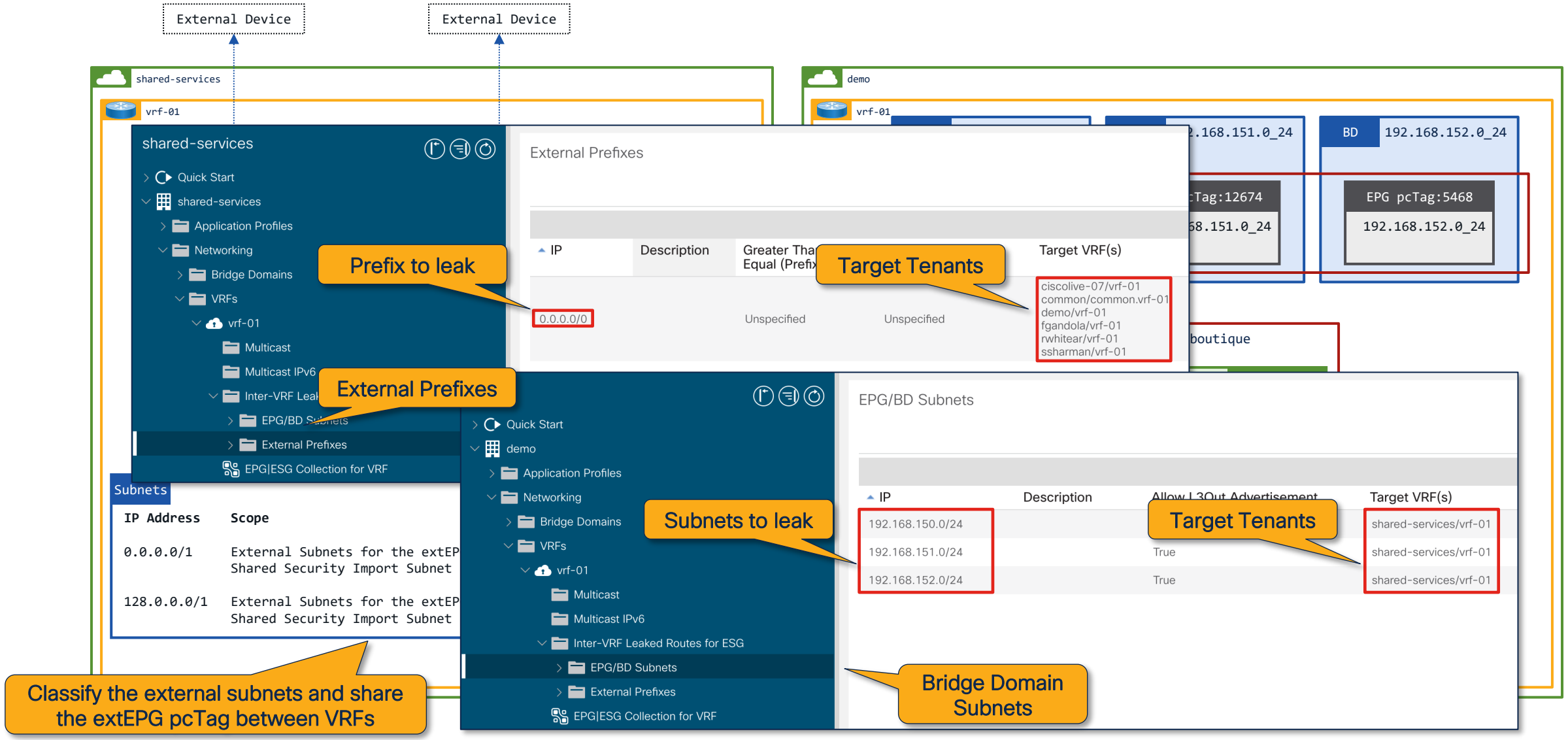
Shared L3out – Route Leaking between VRFs (ESGs)



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Getting into the weeds...!

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How does ACI Route Leaking work for EPGs...?

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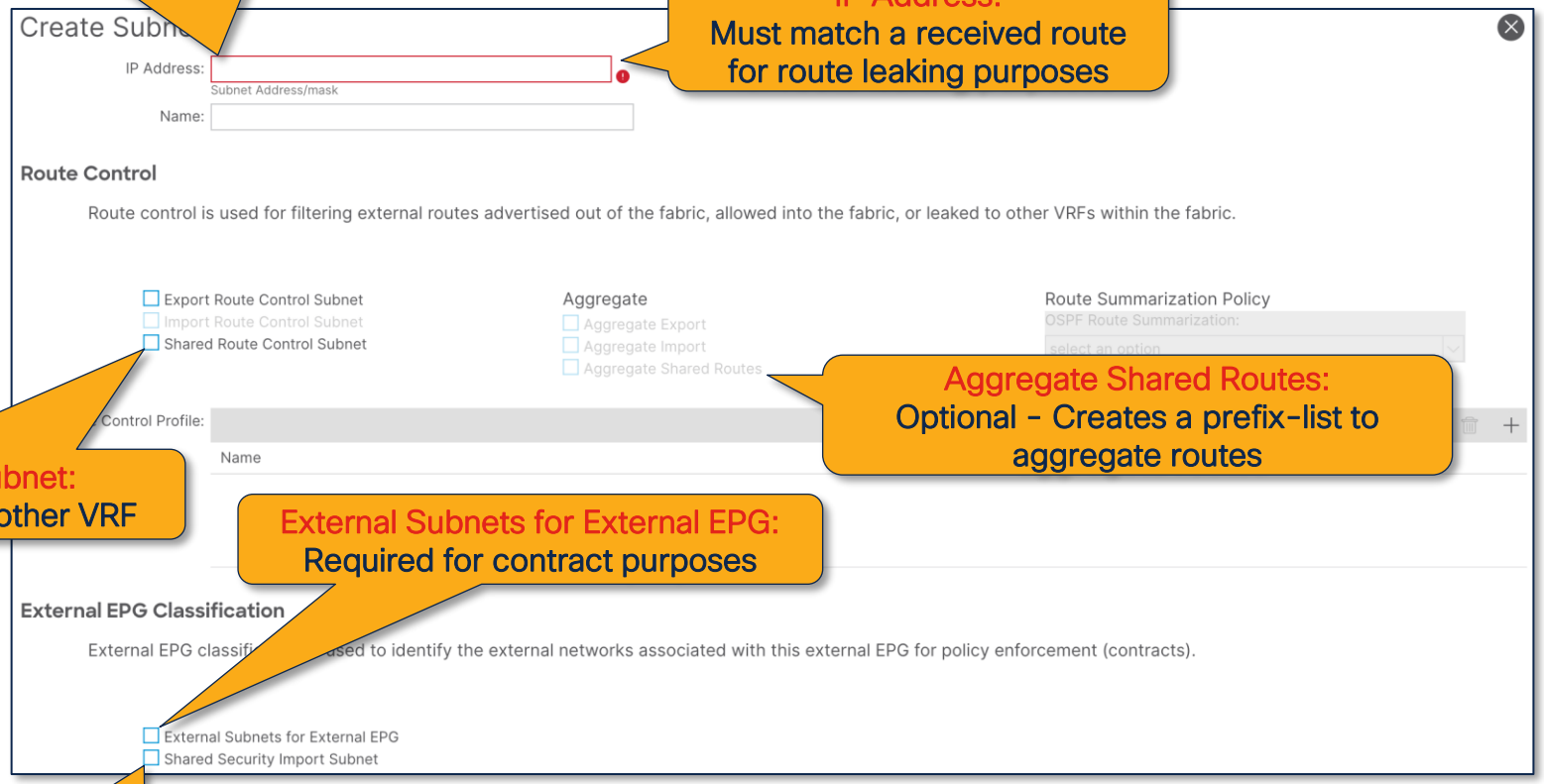
External Classification and Route Leaking



- **IP Address:** identifies remote endpoints/subnets, **must** match a received route for route leaking purposes
- **External Subnets for External EPG:** allows packets to/from the L3out with a contract
- **Shared Security Import Subnet:** is **always** required as it leaks the extEPG pcTag to the target VRF

- **Shared Route Control Subnet:** **not** required when route leaking is configured under the VRF
- **Aggregate Shared Routes:** creates a prefix-list to aggregate routes

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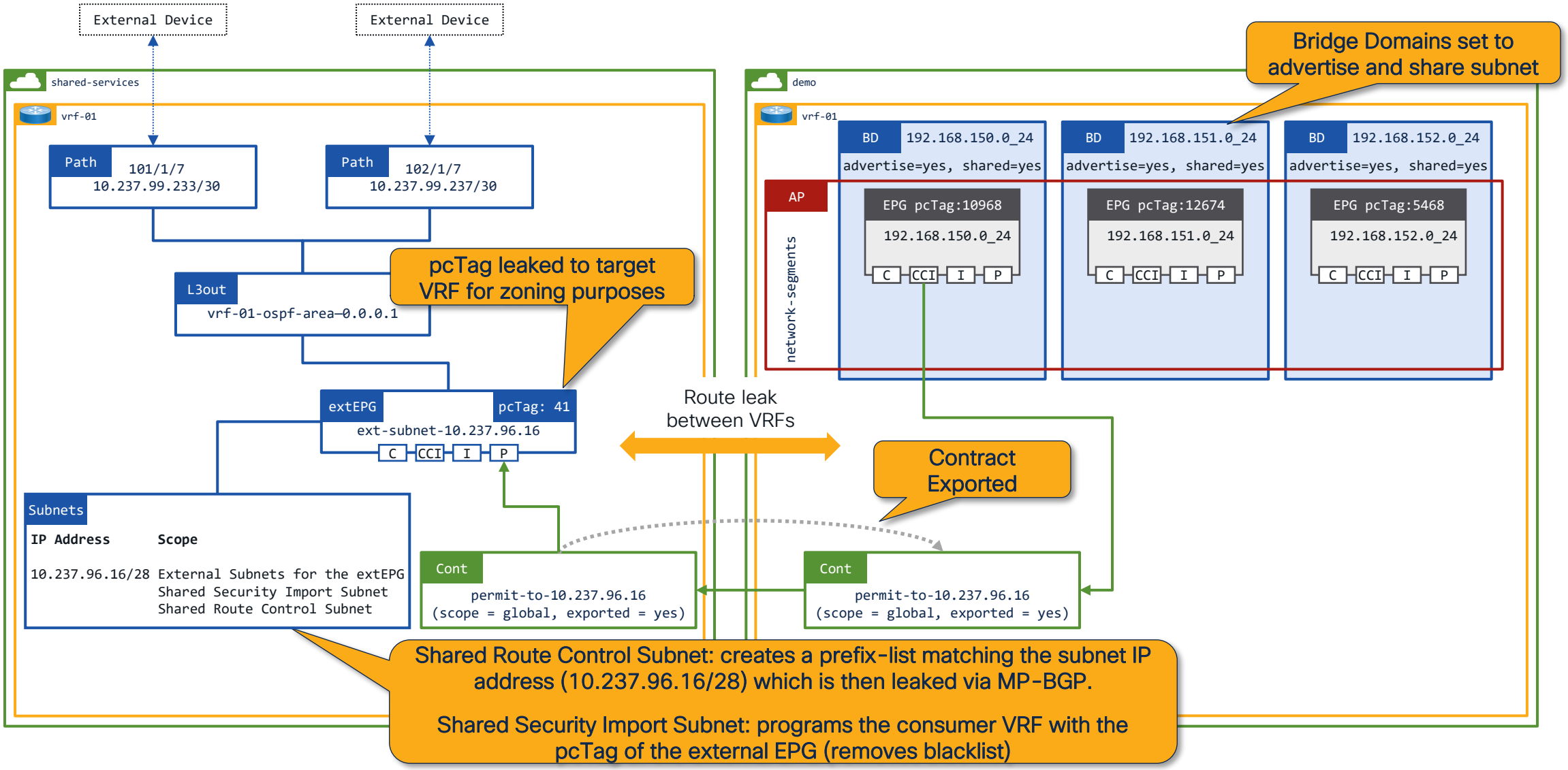
EPG Route Leaking – L3out is the Provider



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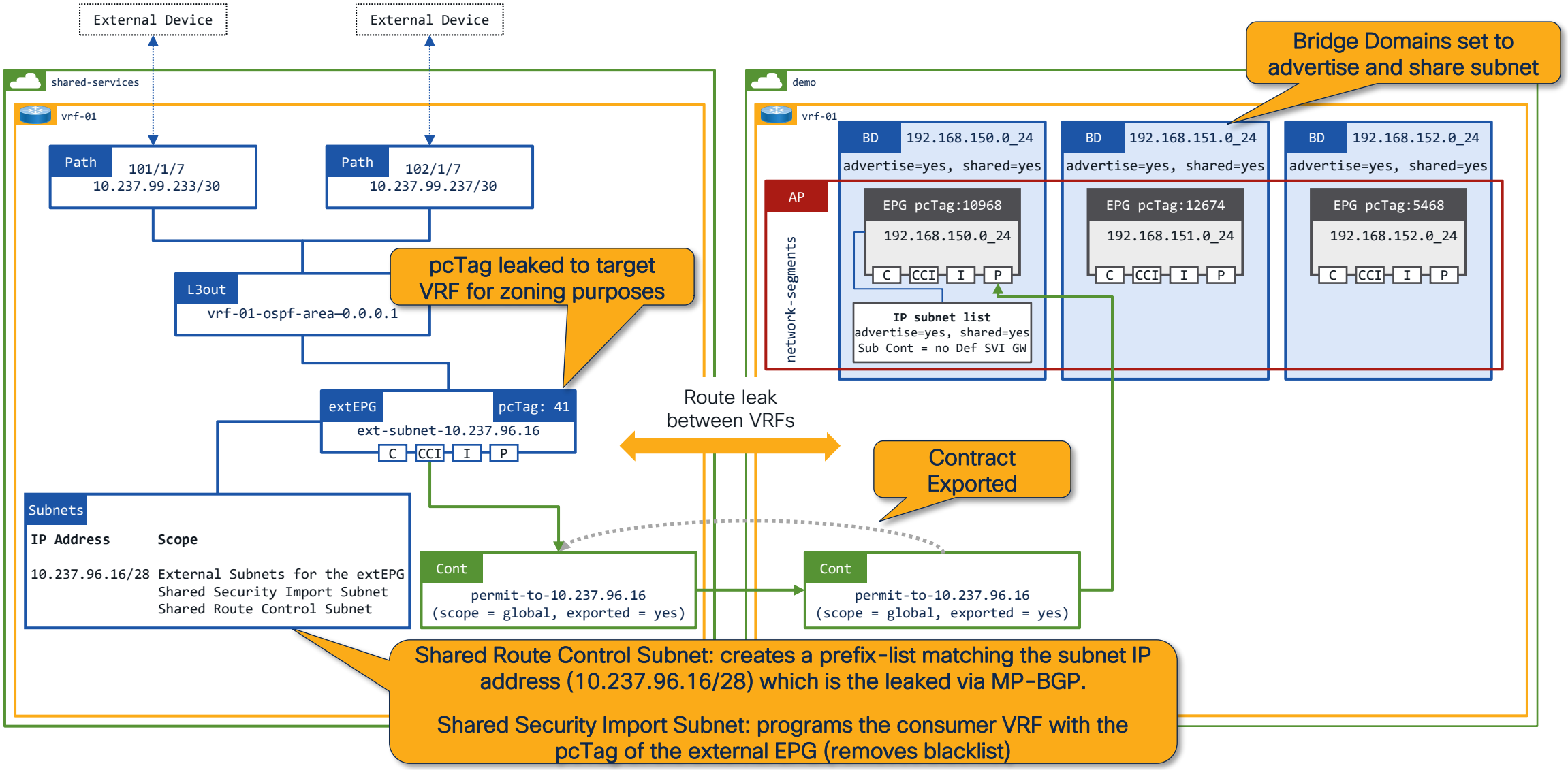
EPG Route Leaking – L3out is the Consumer



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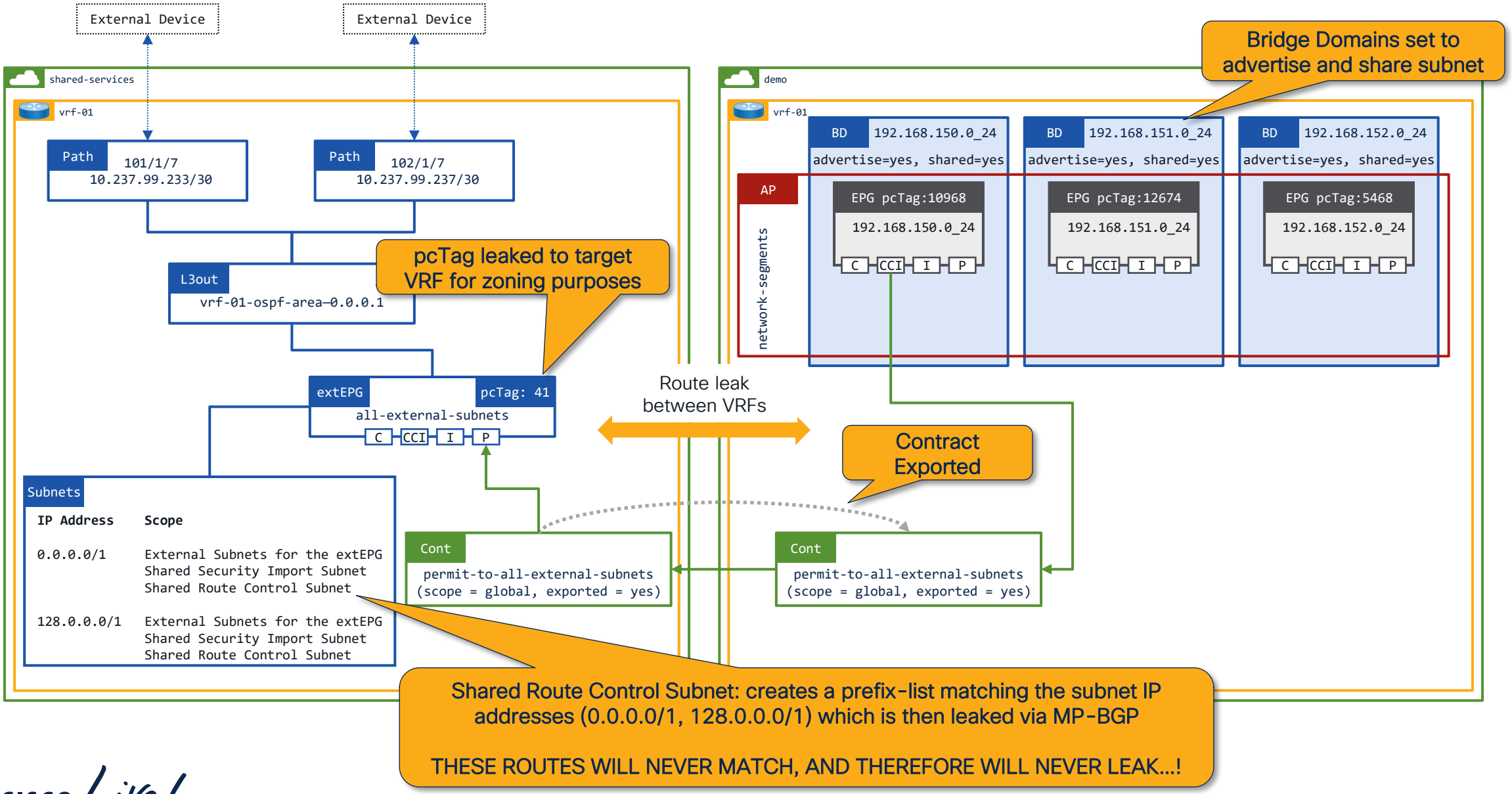
“Shared Route Control Subnet” **must** match a received route



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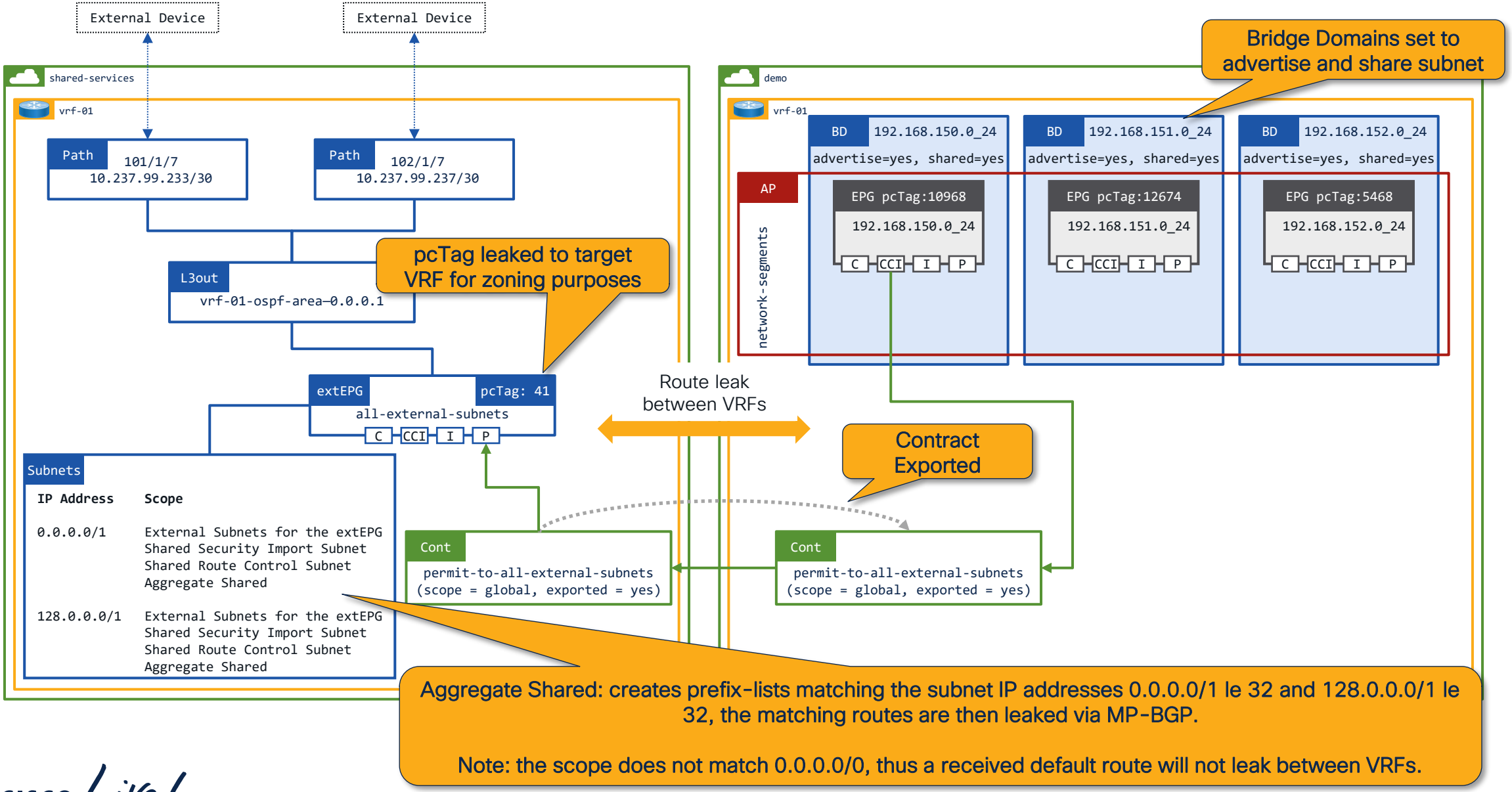
Leaking all received routes



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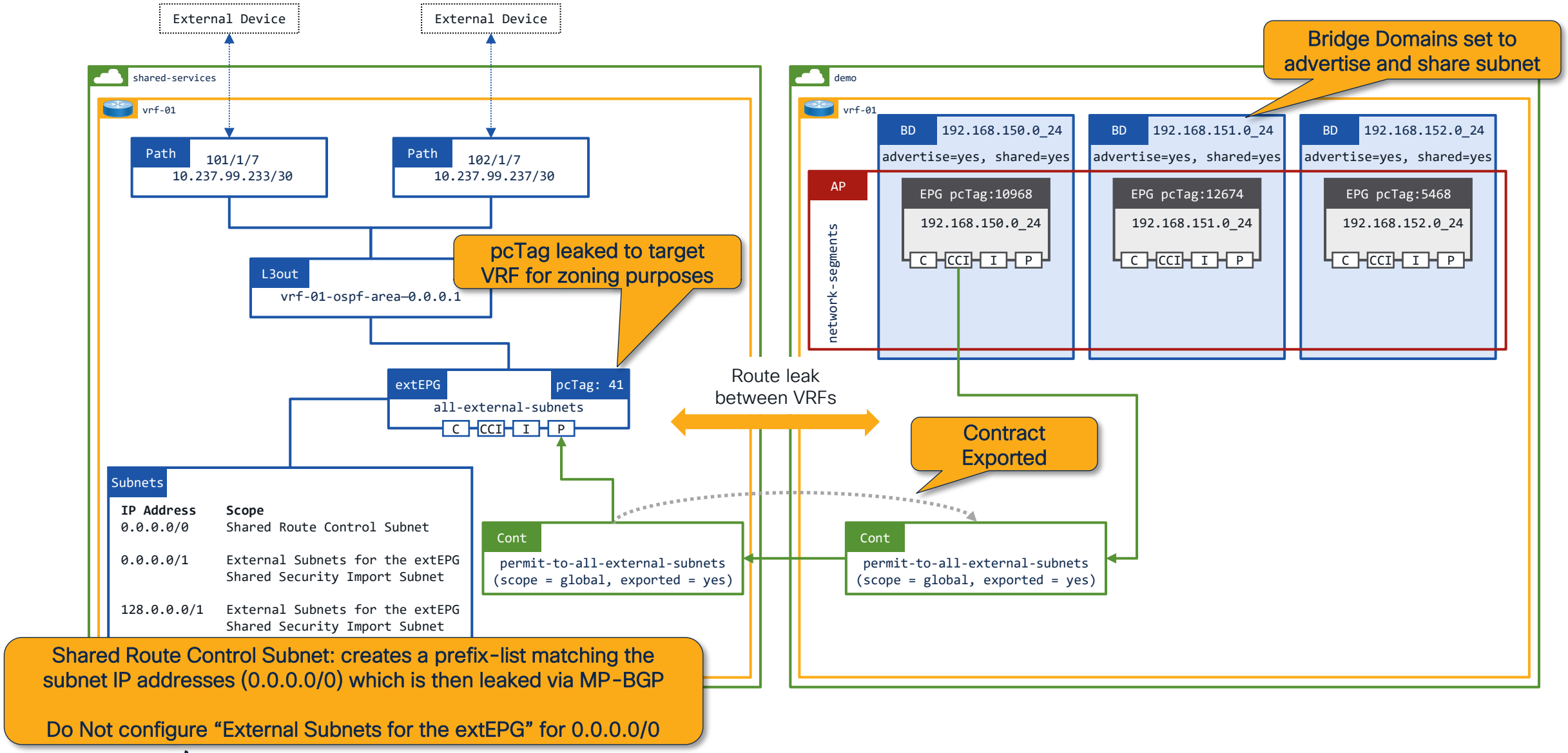
Leaking a default route



Shared Route Control Subnet: creates a prefix-list matching the subnet IP addresses (0.0.0.0/0) which is then leaked via MP-BGP

Do Not configure “External Subnets for the extEPG” for 0.0.0.0/0

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Why are we classifying with 0.0.0.0/1 and 128.0.0.0/1…?

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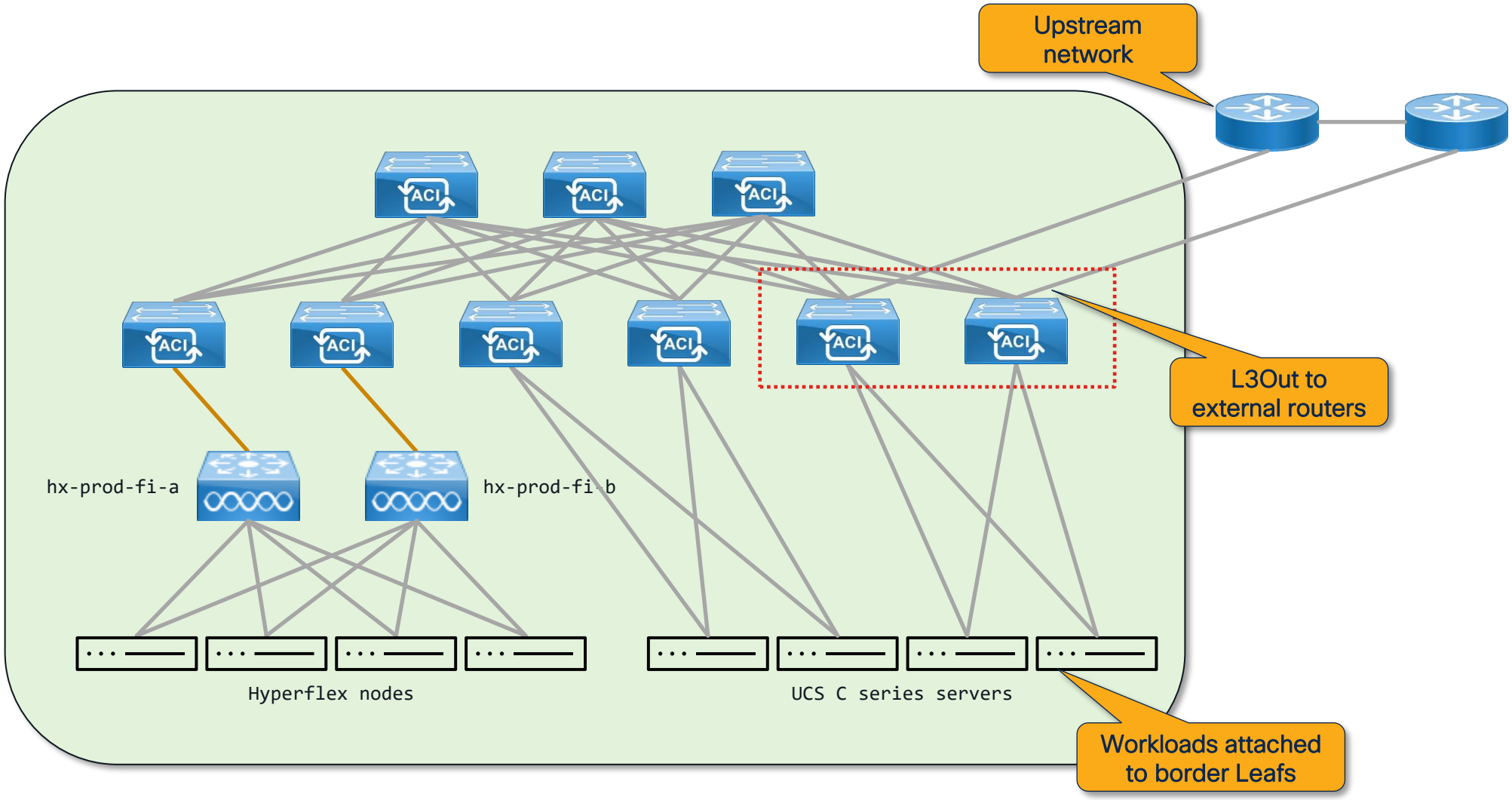
Non dedicated border Leafs



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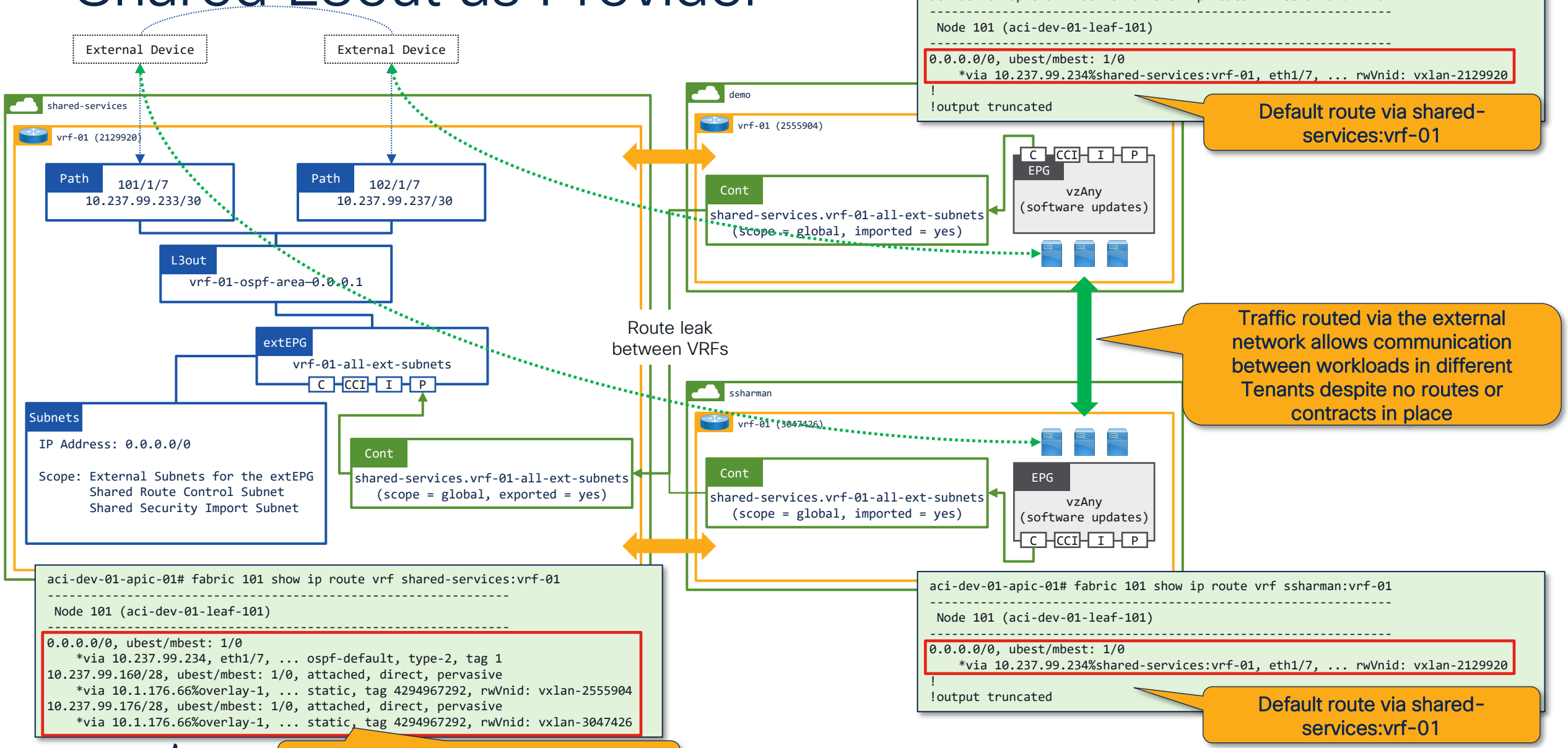
Shared L3out as Provider




```
aci-dev-01-apic-01# fabric 101 show ip route vrf ssharman:vrf-01
------------------------------------------------------------------
 Node 101 (aci-dev-01-leaf-101)
------------------------------------------------------------------
0.0.0.0/0, ubest/mbest: 1/0
    *via 10.237.99.234%shared-services:vrf-01, eth1/7, ... rwVnid: vxlan-2129920
!
!output truncated
```

Default route via shared-services:vrf-01

Traffic routed via the external network allows communication between workloads in different Tenants despite no routes or contracts in place

```
aci-dev-01-apic-01# fabric 101 show ip route vrf shared-services:vrf-01
------------------------------------------------------------------
 Node 101 (aci-dev-01-leaf-101)
------------------------------------------------------------------
0.0.0.0/0, ubest/mbest: 1/0
    *via 10.237.99.234, eth1/7, ... ospf-default, type-2, tag 1
10.237.99.160/28, ubest/mbest: 1/0, attached, direct, pervasive
    *via 10.1.176.66%overlay-1, ... static, tag 4294967292, rwVnid: vxlan-2555904
10.237.99.176/28, ubest/mbest: 1/0, attached, direct, pervasive
    *via 10.1.176.66%overlay-1, ... static, tag 4294967292, rwVnid: vxlan-3047426
```

Default route to external network. Routes to Tenant subnets via overlay-1

```
aci-dev-01-apic-01# fabric 101 show ip route vrf ssharman:vrf-01
------------------------------------------------------------------
 Node 101 (aci-dev-01-leaf-101)
------------------------------------------------------------------
0.0.0.0/0, ubest/mbest: 1/0
    *via 10.237.99.234%shared-services:vrf-01, eth1/7, ... rwVnid: vxlan-2129920
!
!output truncated
```

Default route via shared-services:vrf-01

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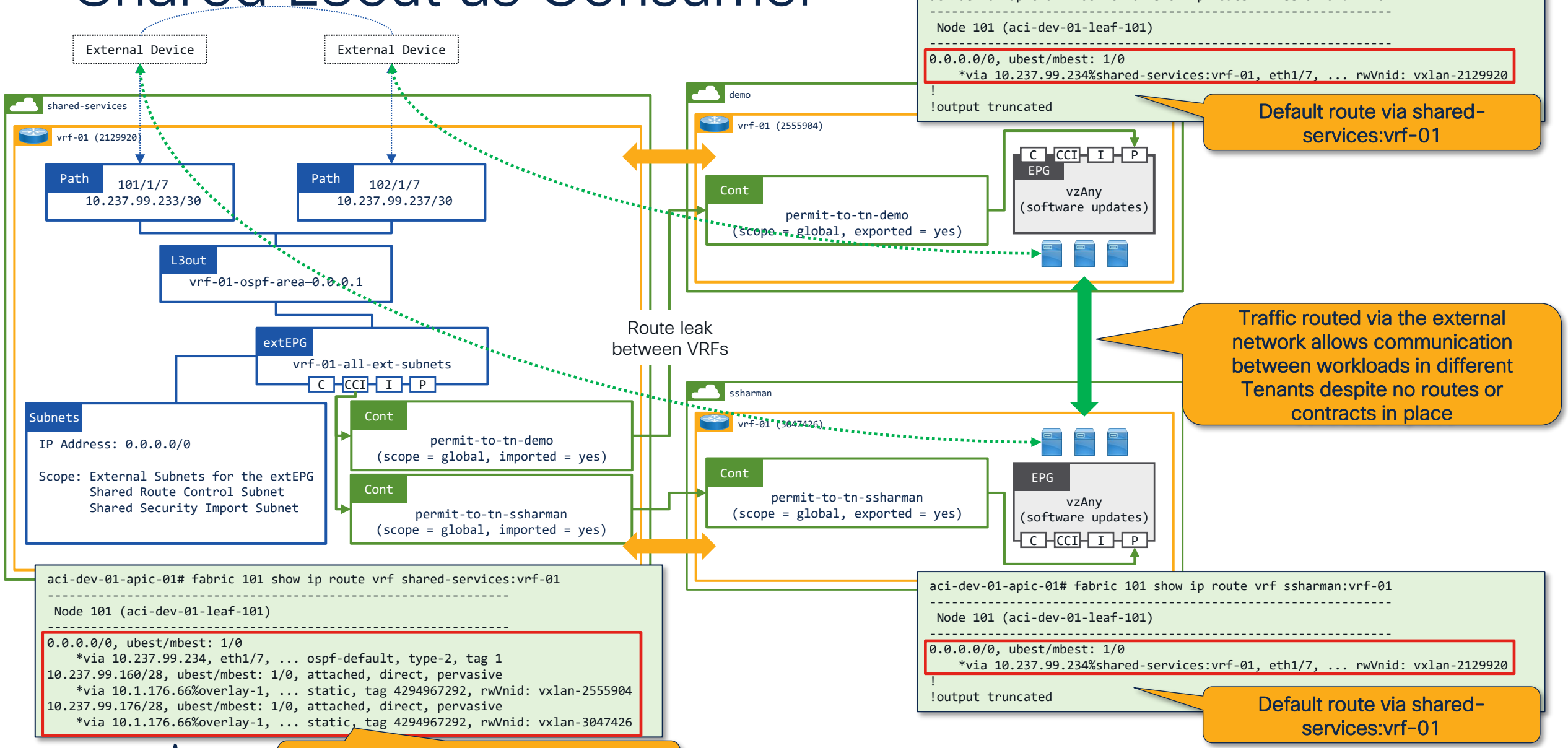
Shared L3out as Consumer




```
aci-dev-01-apic-01# fabric 101 show ip route vrf ssharman:vrf-01
------------------------------------------------------------------
 Node 101 (aci-dev-01-leaf-101)
------------------------------------------------------------------
0.0.0.0/0, ubest/mbest: 1/0
    *via 10.237.99.234%shared-services:vrf-01, eth1/7, ... rwVnid: vxlan-2129920
!
!output truncated
```

Default route via shared-services:vrf-01

Traffic routed via the external network allows communication between workloads in different Tenants despite no routes or contracts in place

```
aci-dev-01-apic-01# fabric 101 show ip route vrf shared-services:vrf-01
------------------------------------------------------------------
 Node 101 (aci-dev-01-leaf-101)
------------------------------------------------------------------
0.0.0.0/0, ubest/mbest: 1/0
    *via 10.237.99.234, eth1/7, ... ospf-default, type-2, tag 1
10.237.99.160/28, ubest/mbest: 1/0, attached, direct, pervasive
    *via 10.1.176.66%overlay-1, ... static, tag 4294967292, rwVnid: vxlan-2555904
10.237.99.176/28, ubest/mbest: 1/0, attached, direct, pervasive
    *via 10.1.176.66%overlay-1, ... static, tag 4294967292, rwVnid: vxlan-3047426
```

Default route to external network. Routes to Tenant subnets via overlay-1

```
aci-dev-01-apic-01# fabric 101 show ip route vrf ssharman:vrf-01
------------------------------------------------------------------
 Node 101 (aci-dev-01-leaf-101)
------------------------------------------------------------------
0.0.0.0/0, ubest/mbest: 1/0
    *via 10.237.99.234%shared-services:vrf-01, eth1/7, ... rwVnid: vxlan-2129920
!
!output truncated
```

Default route via shared-services:vrf-01

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Recommendation

Do not use 0.0.0.0/0 in route leaking design...!

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Setting the scene...

Designing your Tenants...

Switching to Application Centric mode...

Working with ESGs...

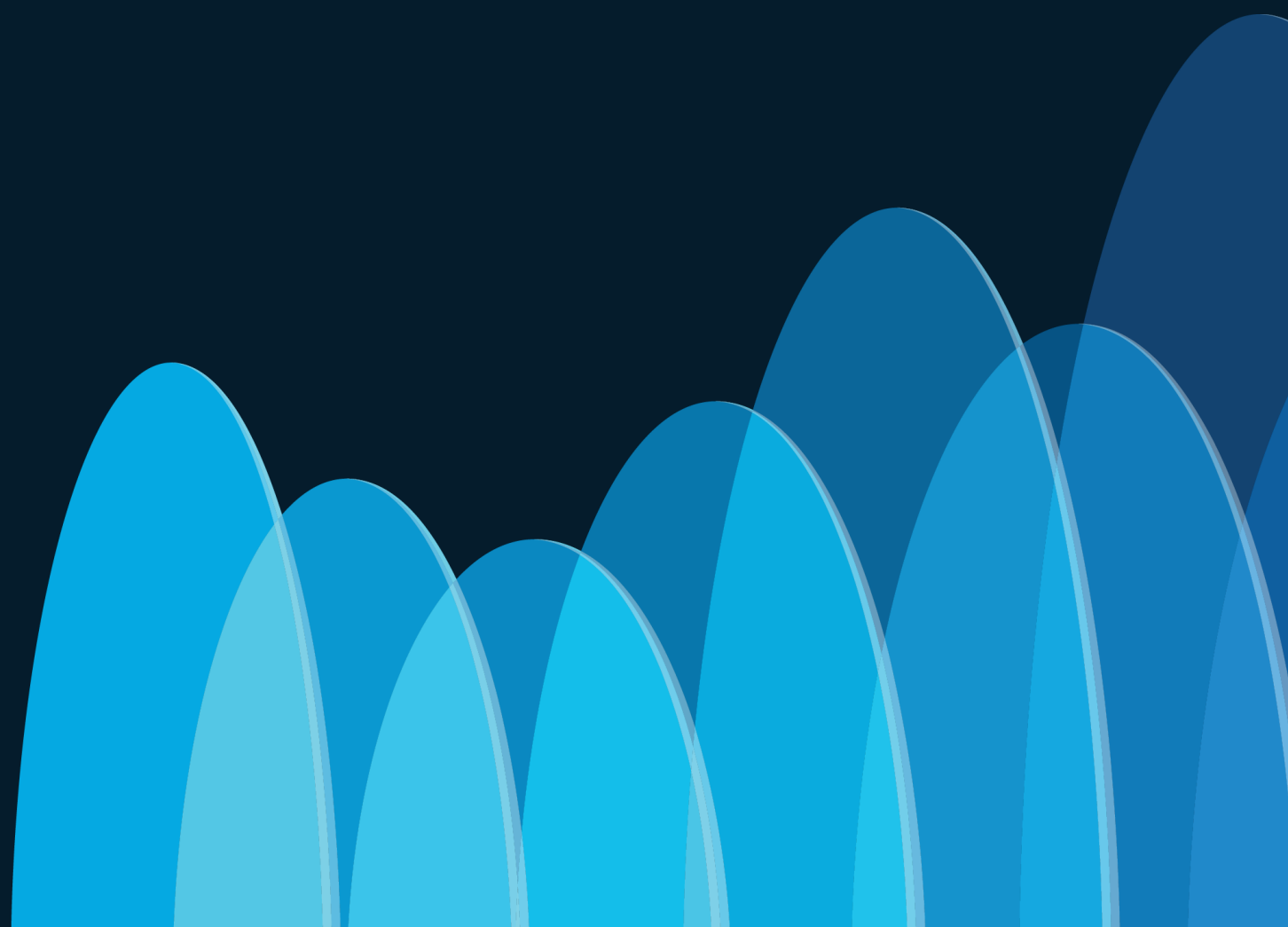
Understanding ACI security...

External Connectivity...

Increasing Security...

Automation Blueprints...

Wrapping up...



cisco Live!

Where should you place your L4-7 devices...?

Do you want to use Layer 2 or Layer 3 redirects for service insertion...?

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tenant “common”, “shared-services”, or in the “workload/user” tenant…

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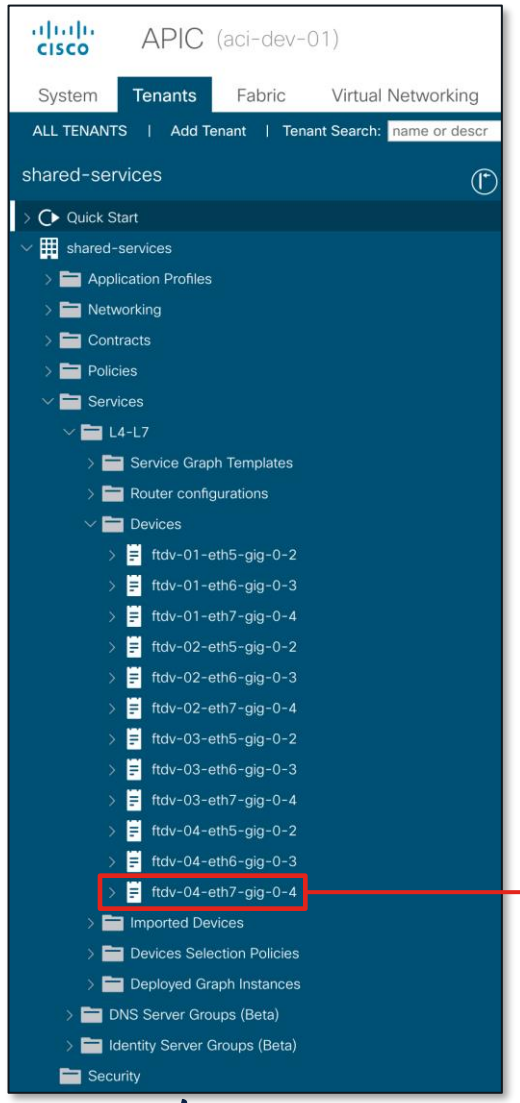
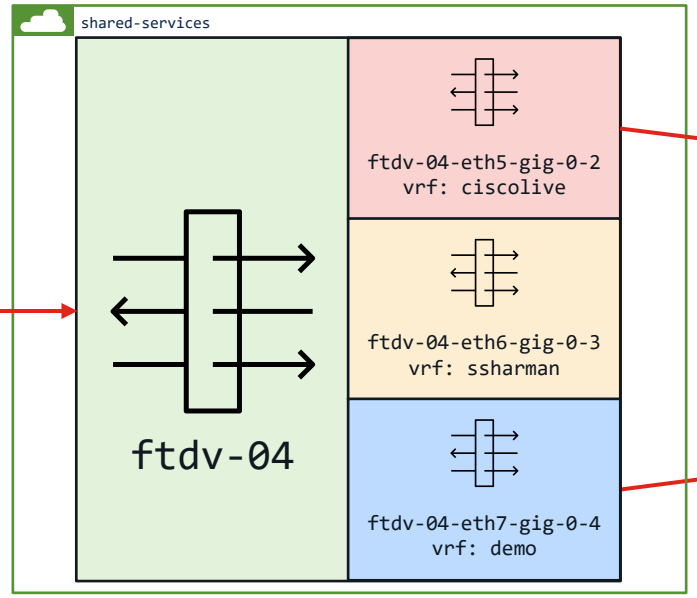
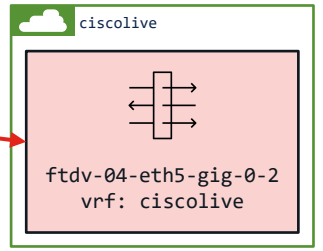
Virtual firewall deployment

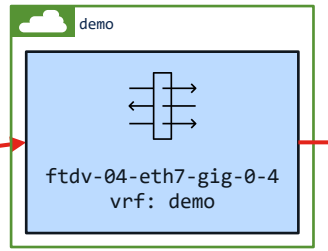




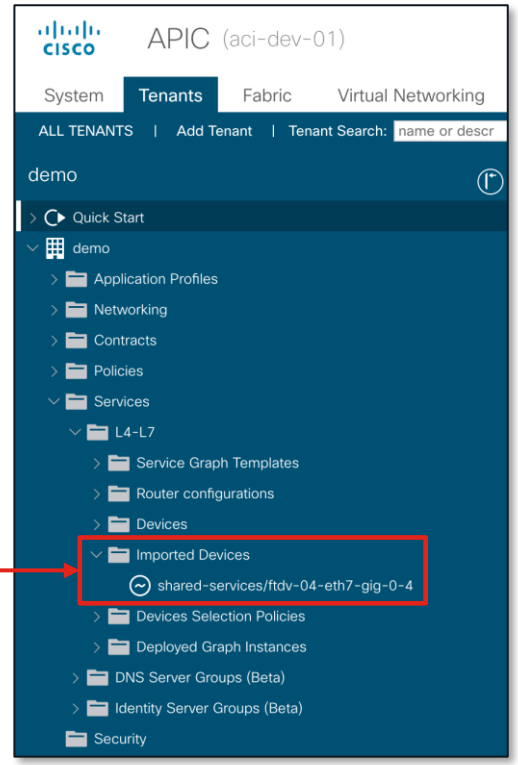
VRF aware firewalls defined in “shared-services” and exported to “user” tenants



Imported firewall



Imported firewall



Benefits of virtual firewall / IPS

- One or more virtual firewalls exported to “user” tenants as required
- Virtual firewalls used for targeted service insertion
- Firewall throughput matches application requirements
- Firewall ruleset reduced to application requirements
- Firewall security group members pushed/pulled from APIC (where available)

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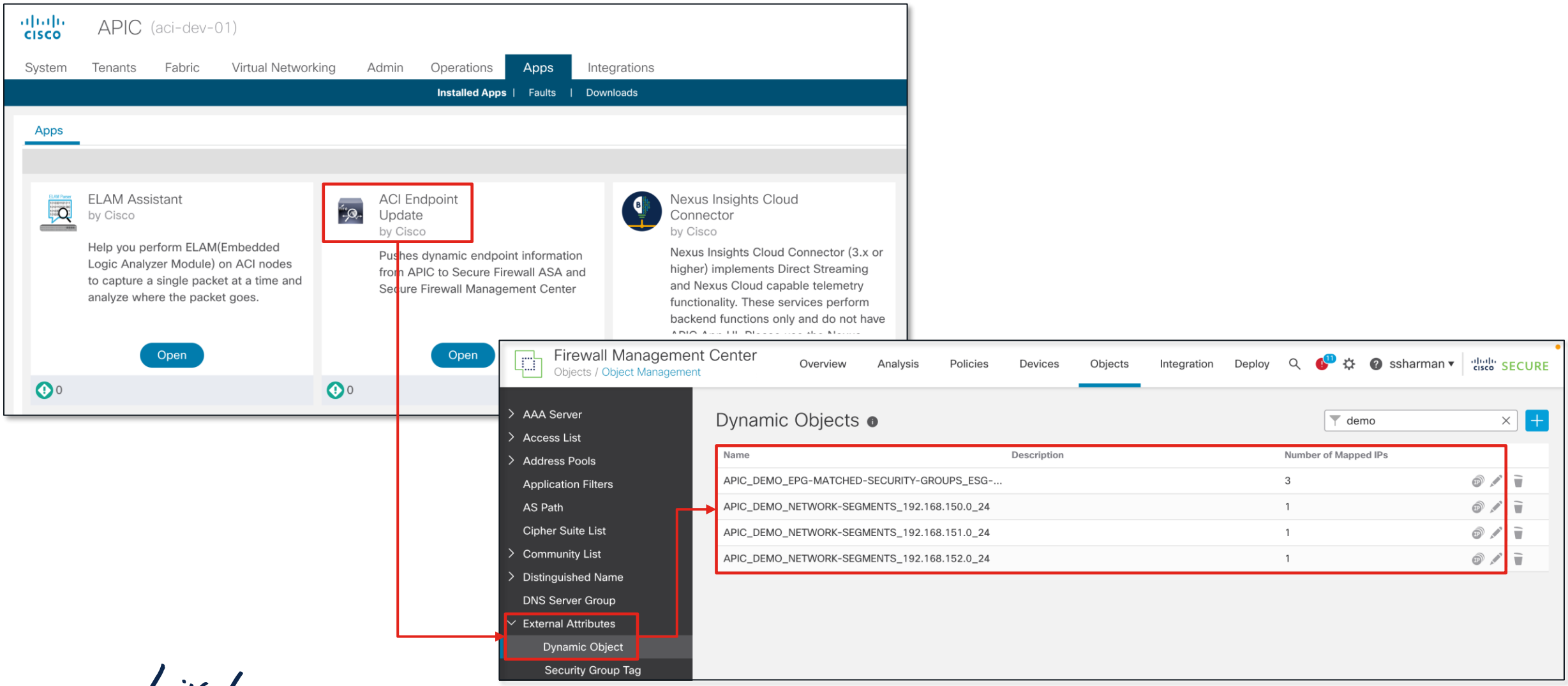
ACI Endpoint Update App (optional)

https://dcappcenter.cisco.com/aci-endpoint-update.html



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Setting up PBR to a one arm attached firewall...

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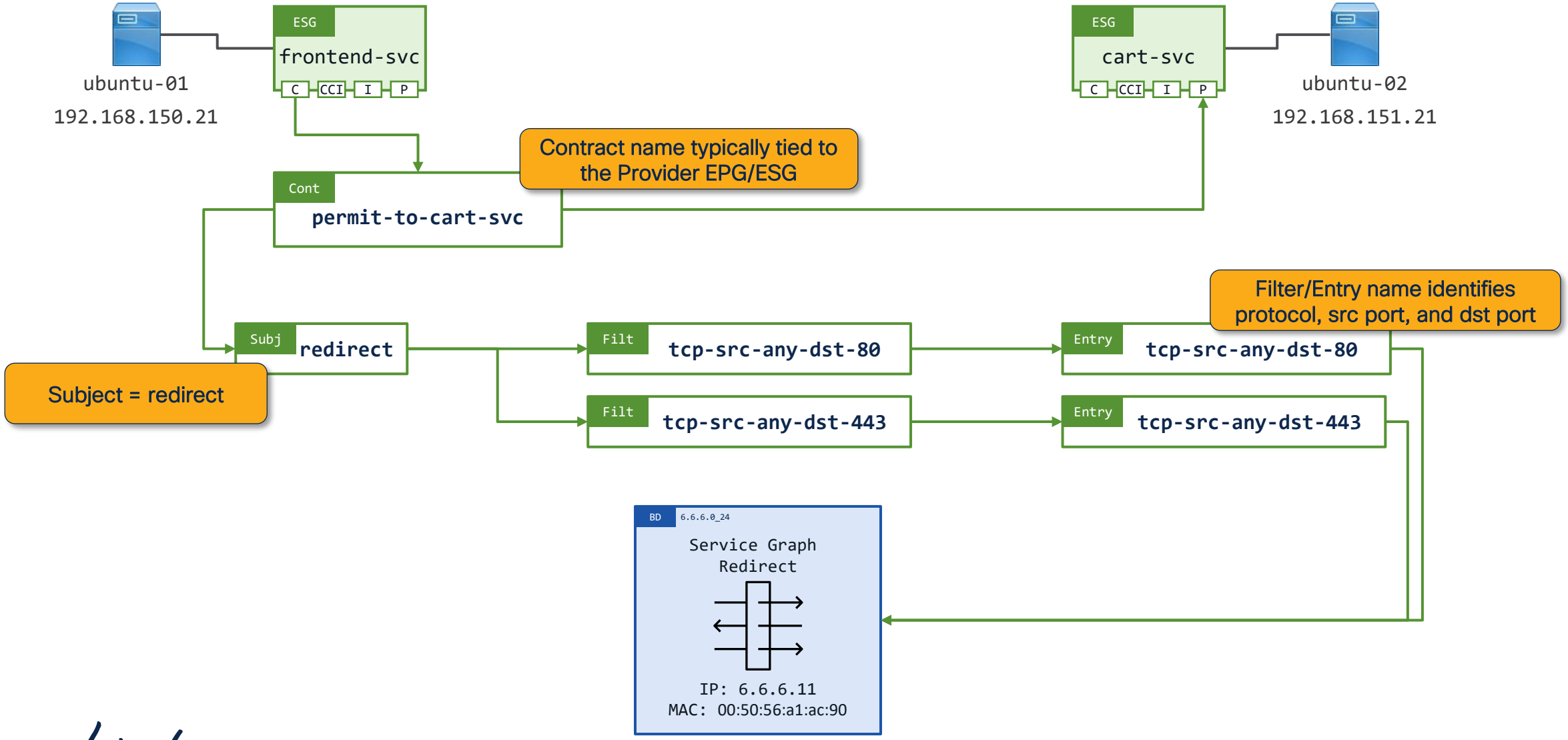
Redirect applied to all Filters under the Subject...



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Setting up PBR to a two arm attached firewall...

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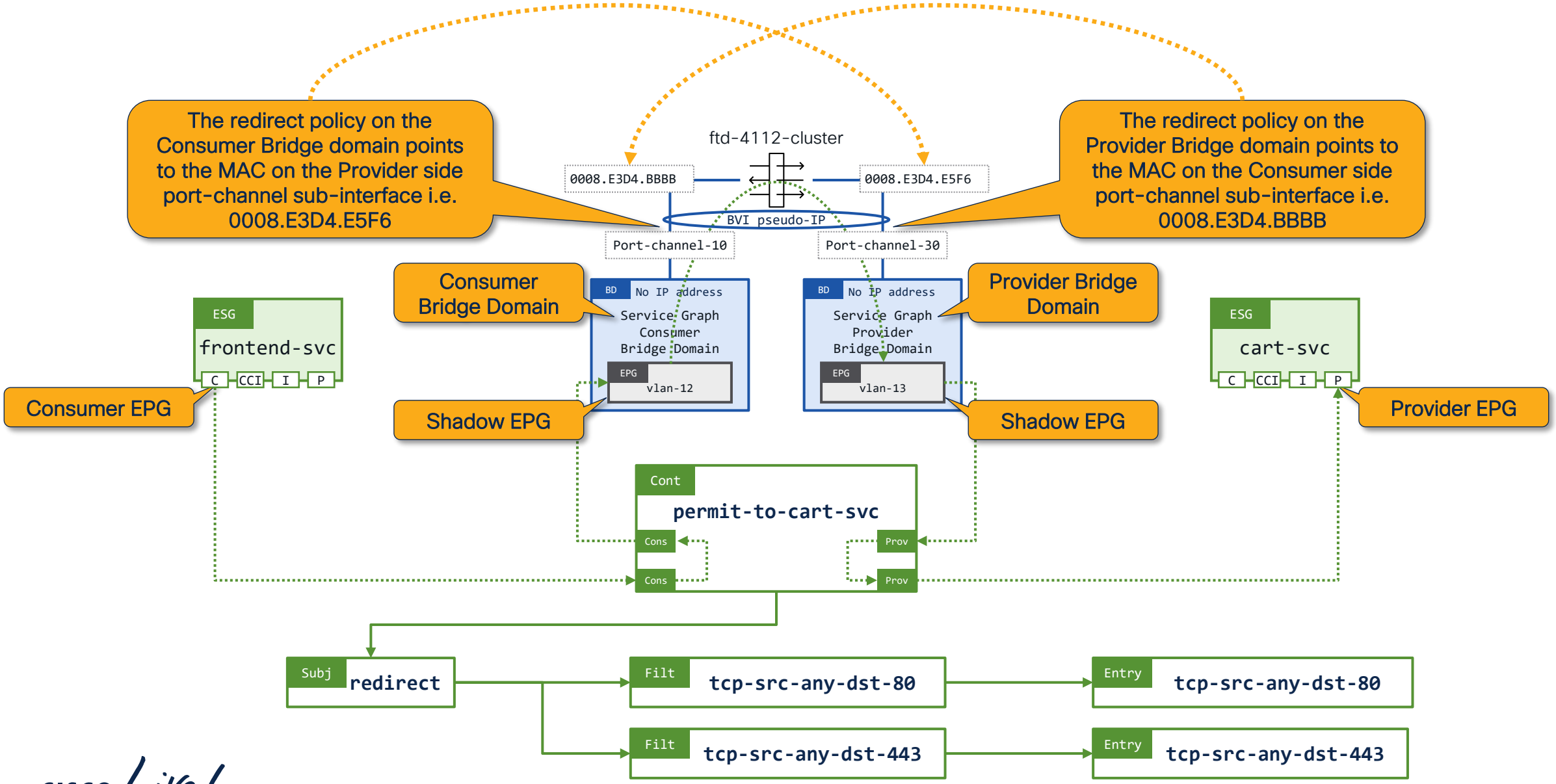
Two arm service graph – L2



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Do not use Two Arm with L3 redirect...

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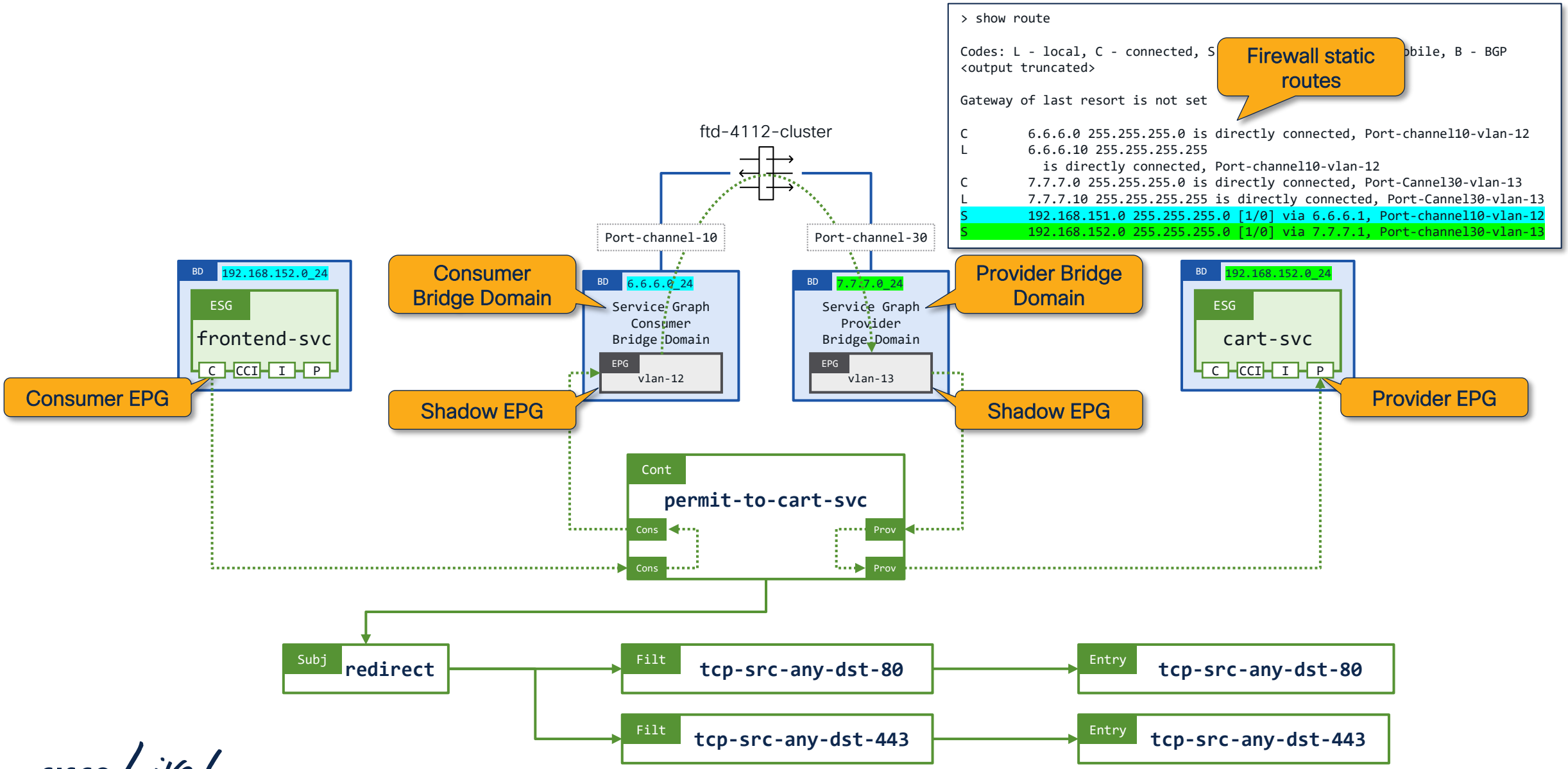
Two arm service graph – L3 Cons to Prov



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Two arm service graph – L3 Prov to Cons

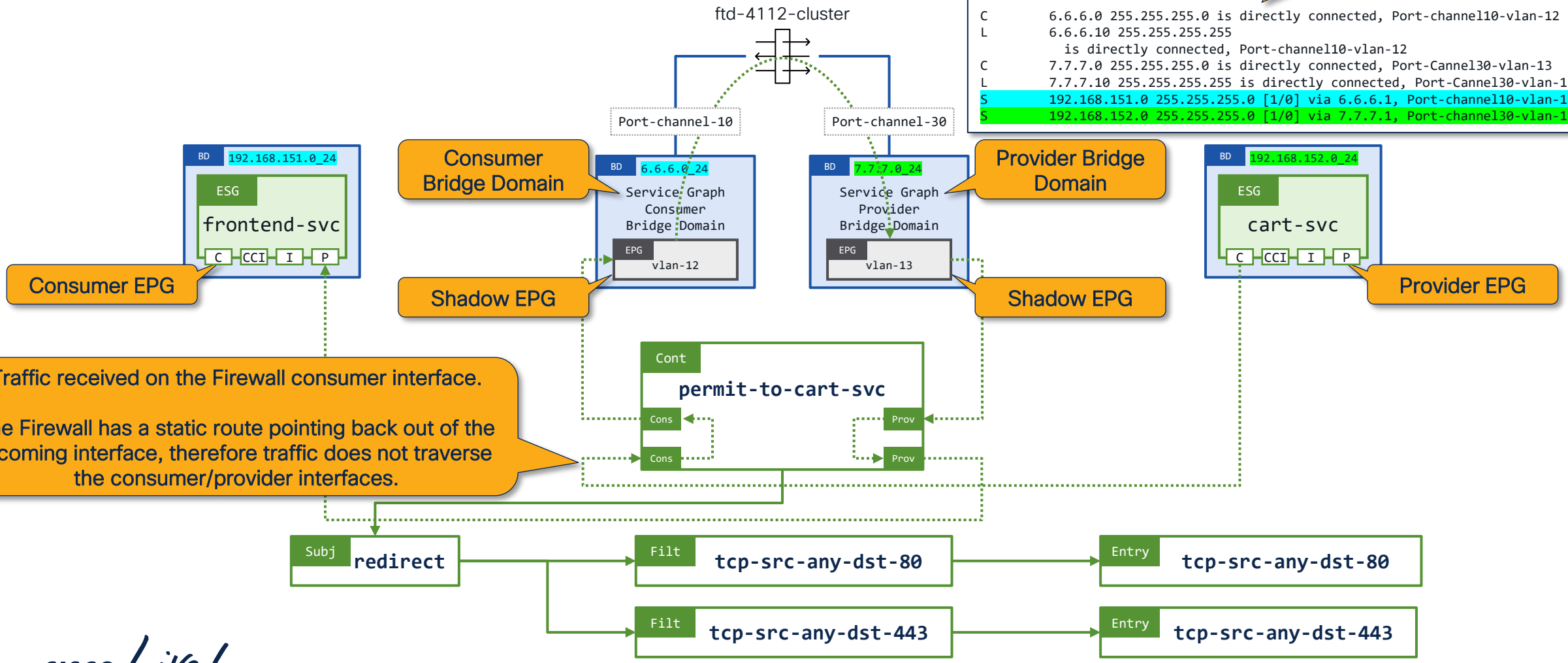
```
> show route

Codes: L - local, C - connected, S                    obile, B - BGP
<output truncated>

Gateway of last resort is not set

C        6.6.6.0 255.255.255.0 is directly connected, Port-channel10-vlan-12
L        6.6.6.10 255.255.255.255
           is directly connected, Port-channel10-vlan-12
C        7.7.7.0 255.255.255.0 is directly connected, Port-Cannel30-vlan-13
L        7.7.7.10 255.255.255.255 is directly connected, Port-Cannel30-vlan-13
S        192.168.151.0 255.255.255.0 [1/0] via 6.6.6.1, Port-channel10-vlan-12
S        192.168.152.0 255.255.255.0 [1/0] via 7.7.7.1, Port-channel30-vlan-13
```

Firewall static routes



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Layer 2 vs Layer 3 firewall insertion

Layer 2 – two arm attached

- Transparent IPS mode
- Slightly higher throughput
- No routing

- **Layer 3 – one arm attached**
- Simple “default” routing
- Easier installation method
- Used by more than 95% of customers

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Using Service Graphs for Security Enforcement and/or Application Dependency Mapping…

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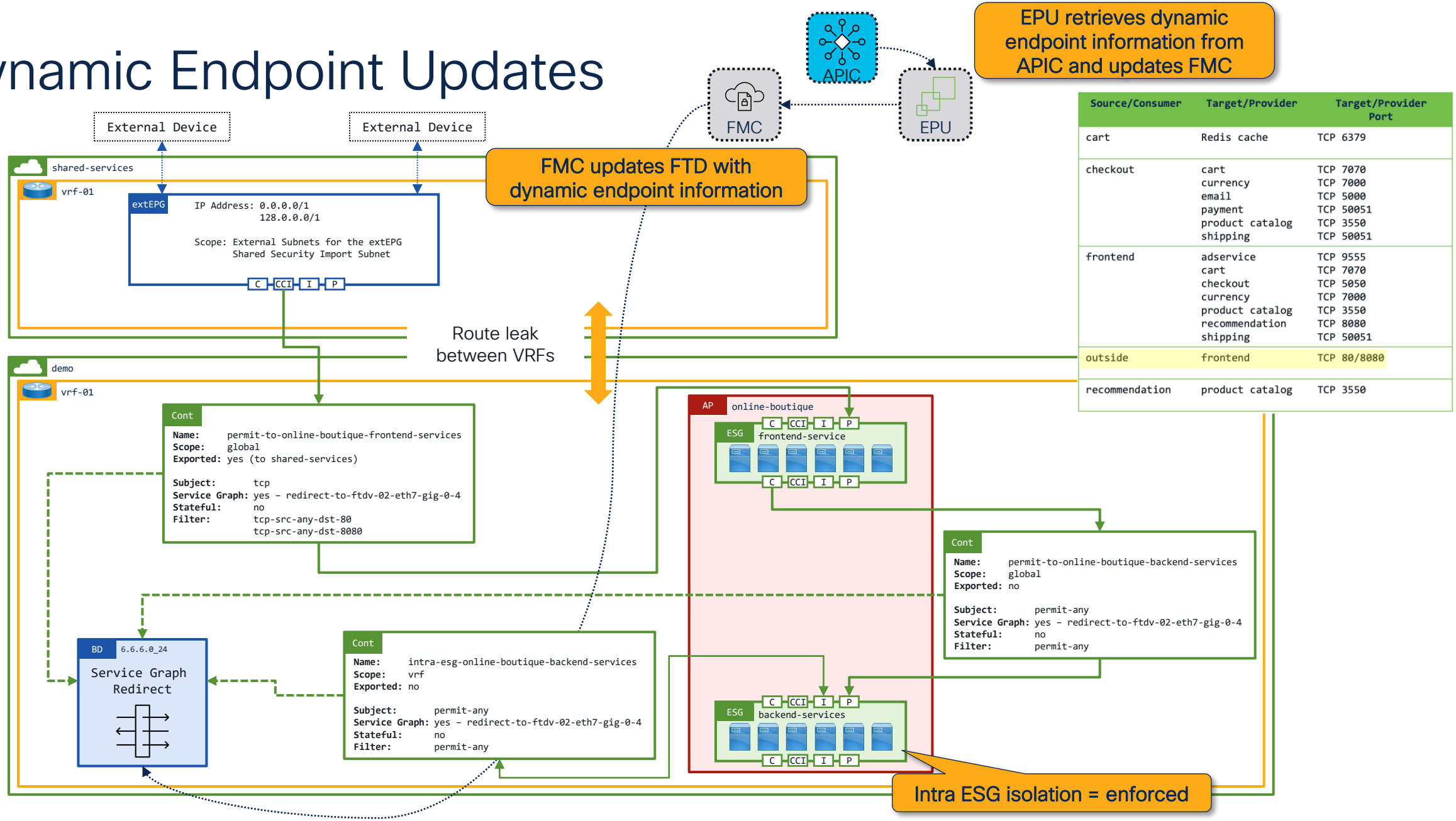
Dynamic Endpoint Updates



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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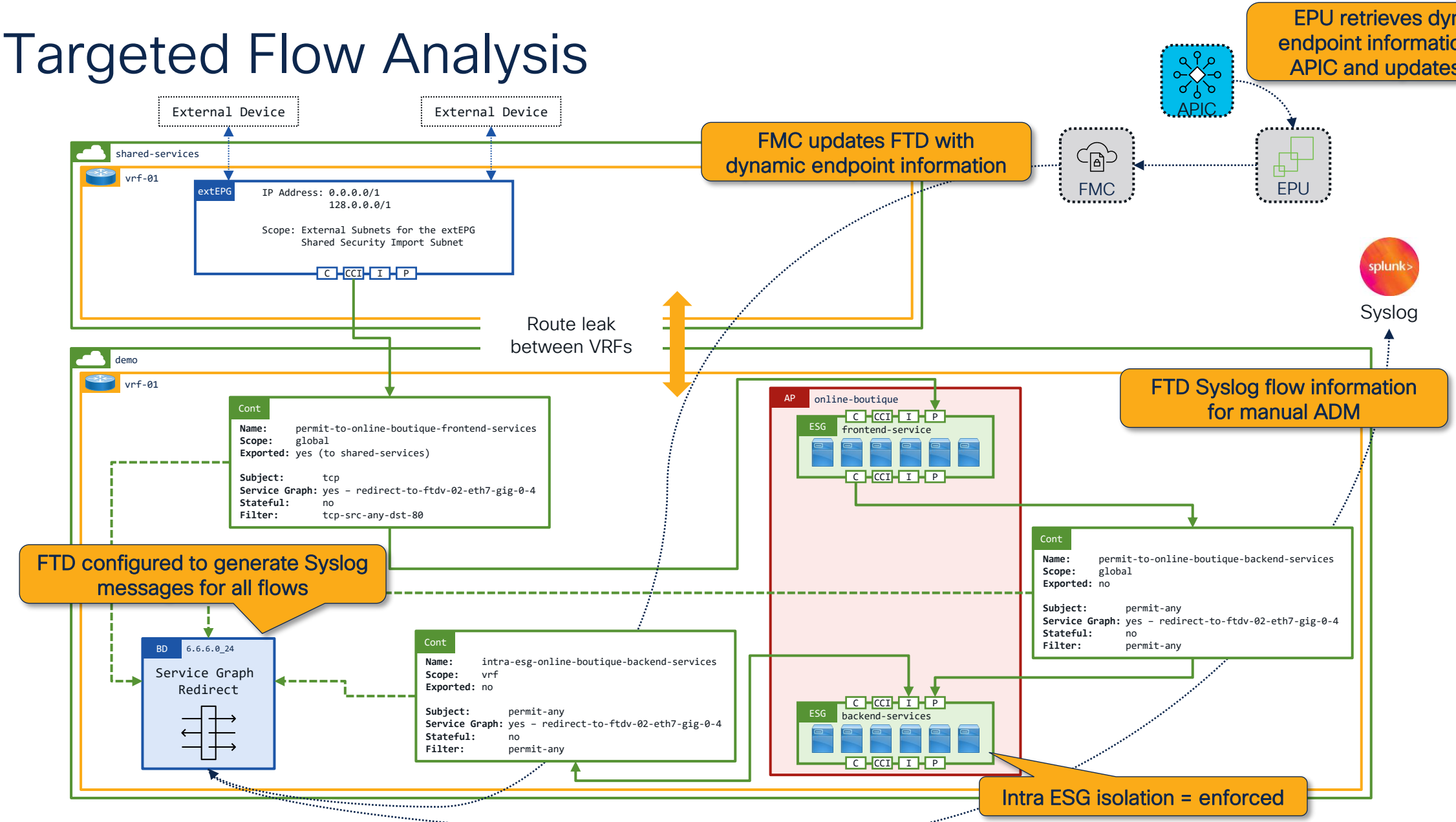
Targeted Flow Analysis



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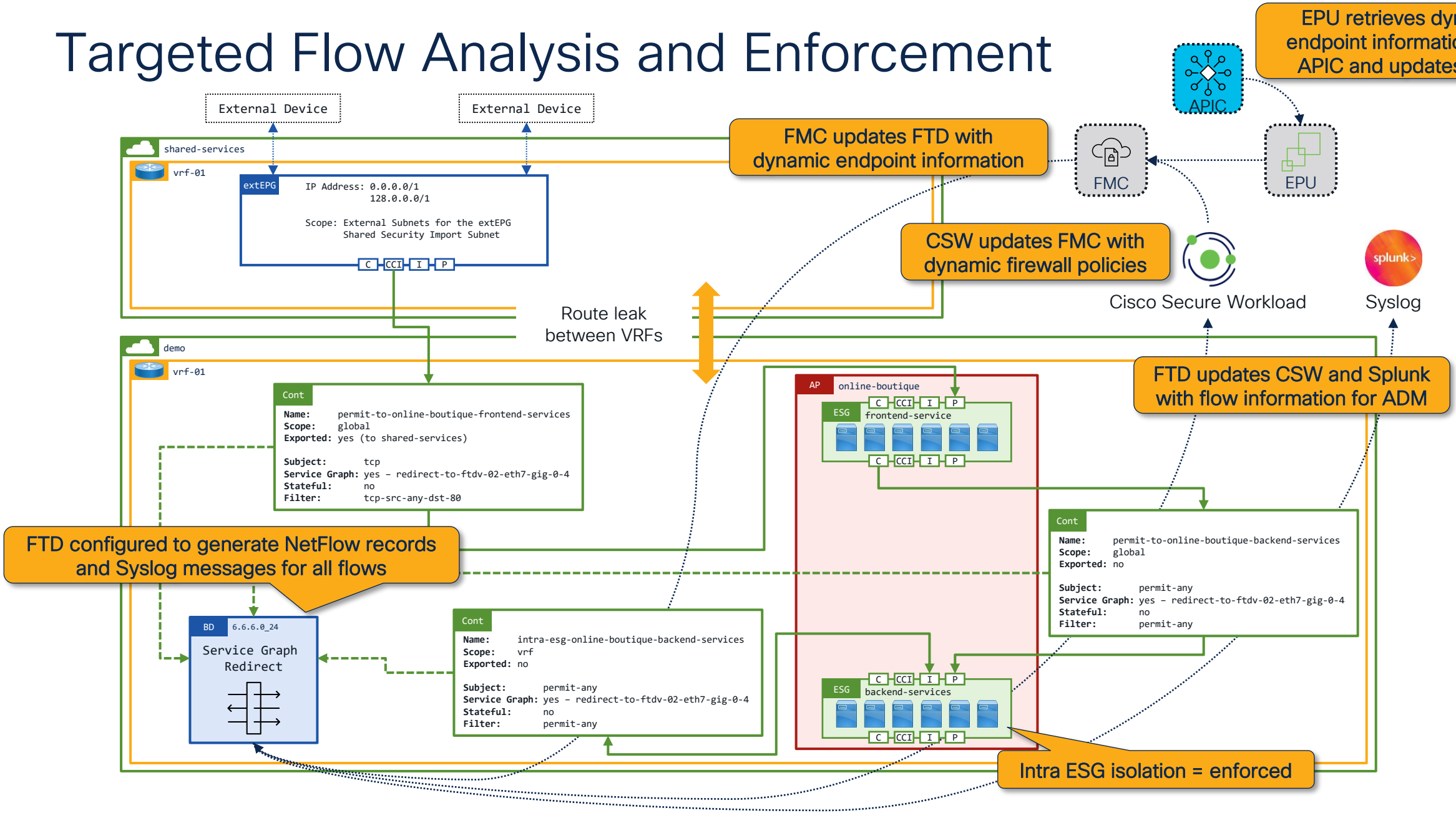
Targeted Flow Analysis and Enforcement



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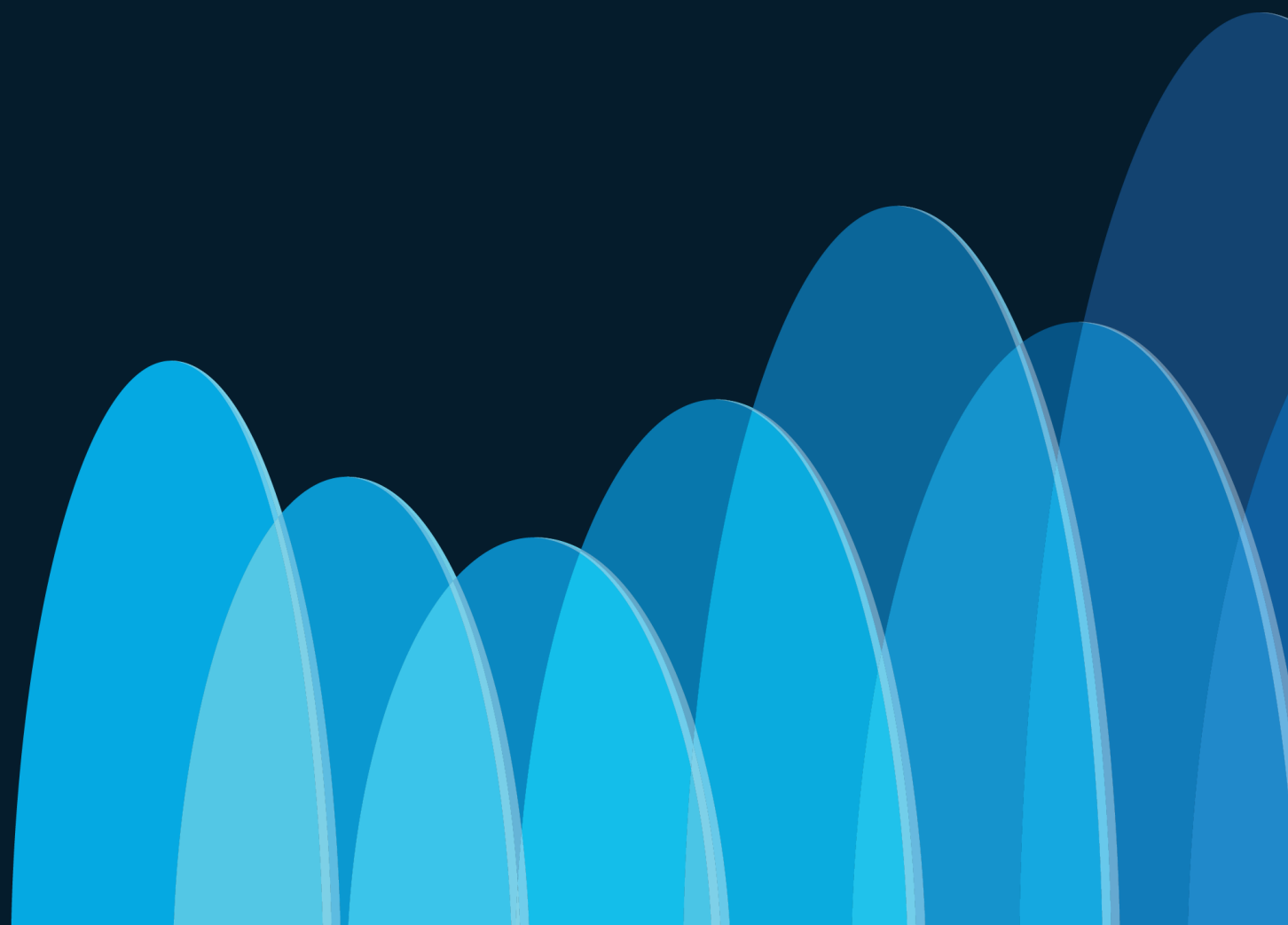
Tightening Security...



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Step 1: Assign Endpoints to the “correct” ESG…

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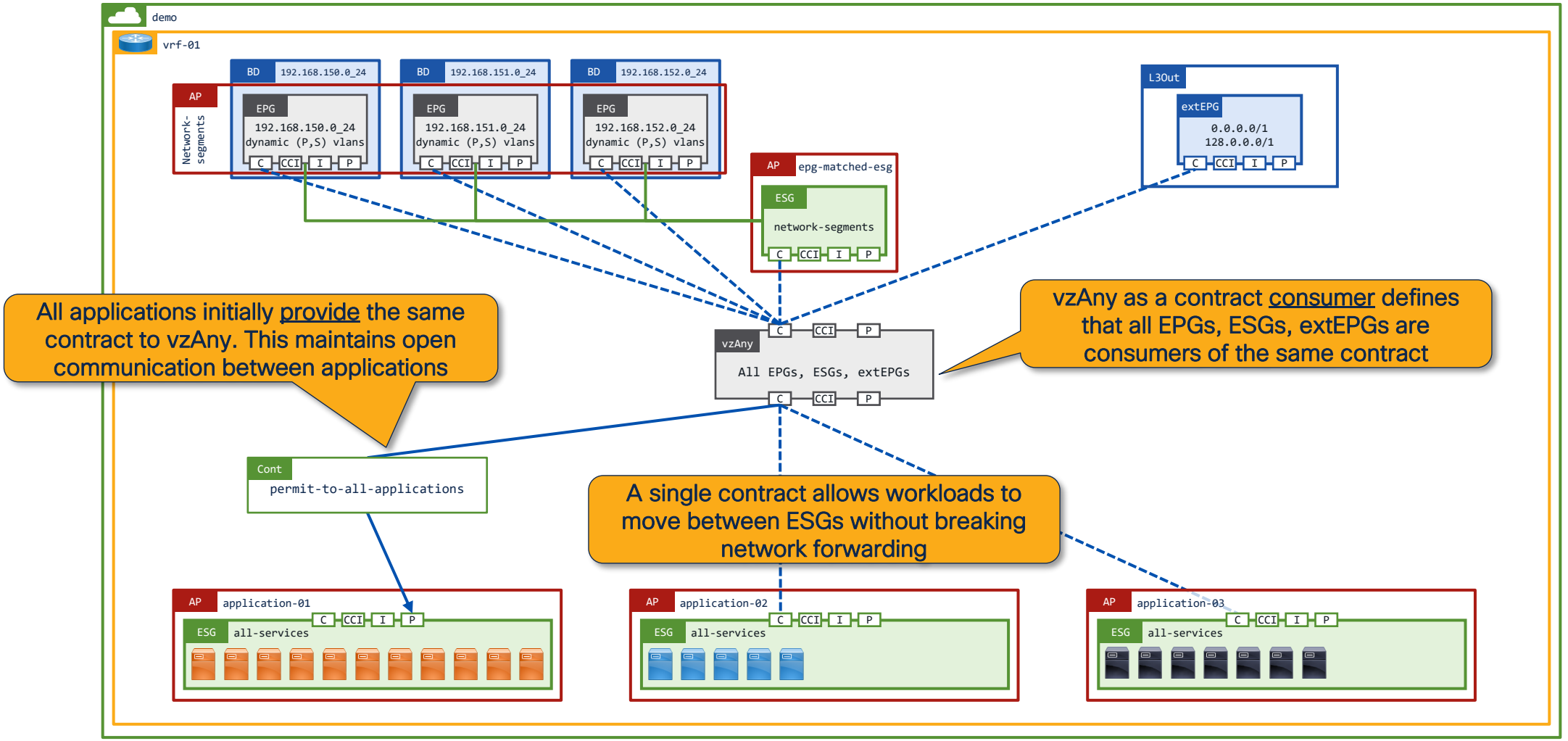
Assign endpoints by Tagging the endpoints to the correct group...



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Step 2: Decide how to tighten security…

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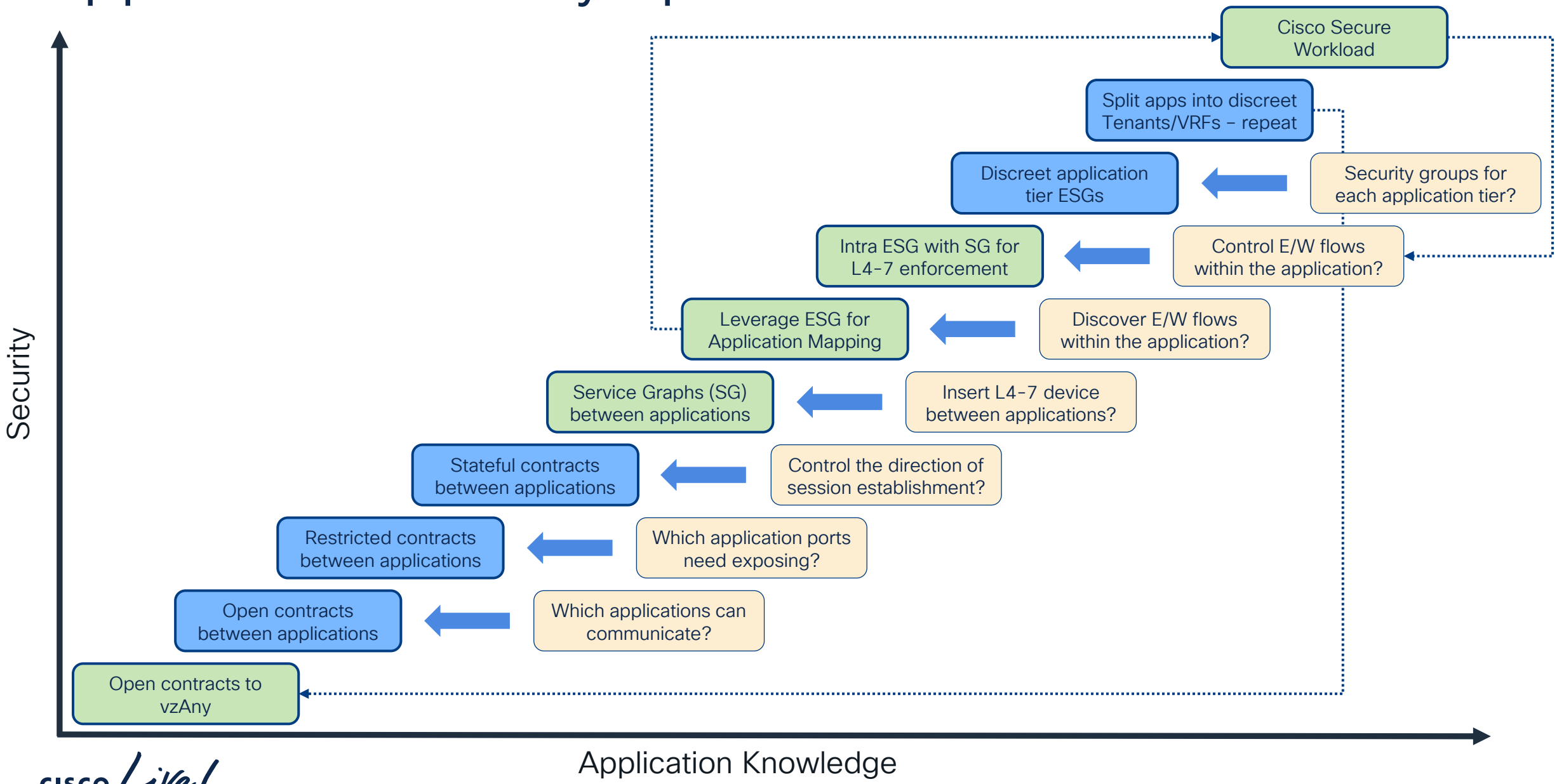
Application security options...



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Remember this from a little earlier...

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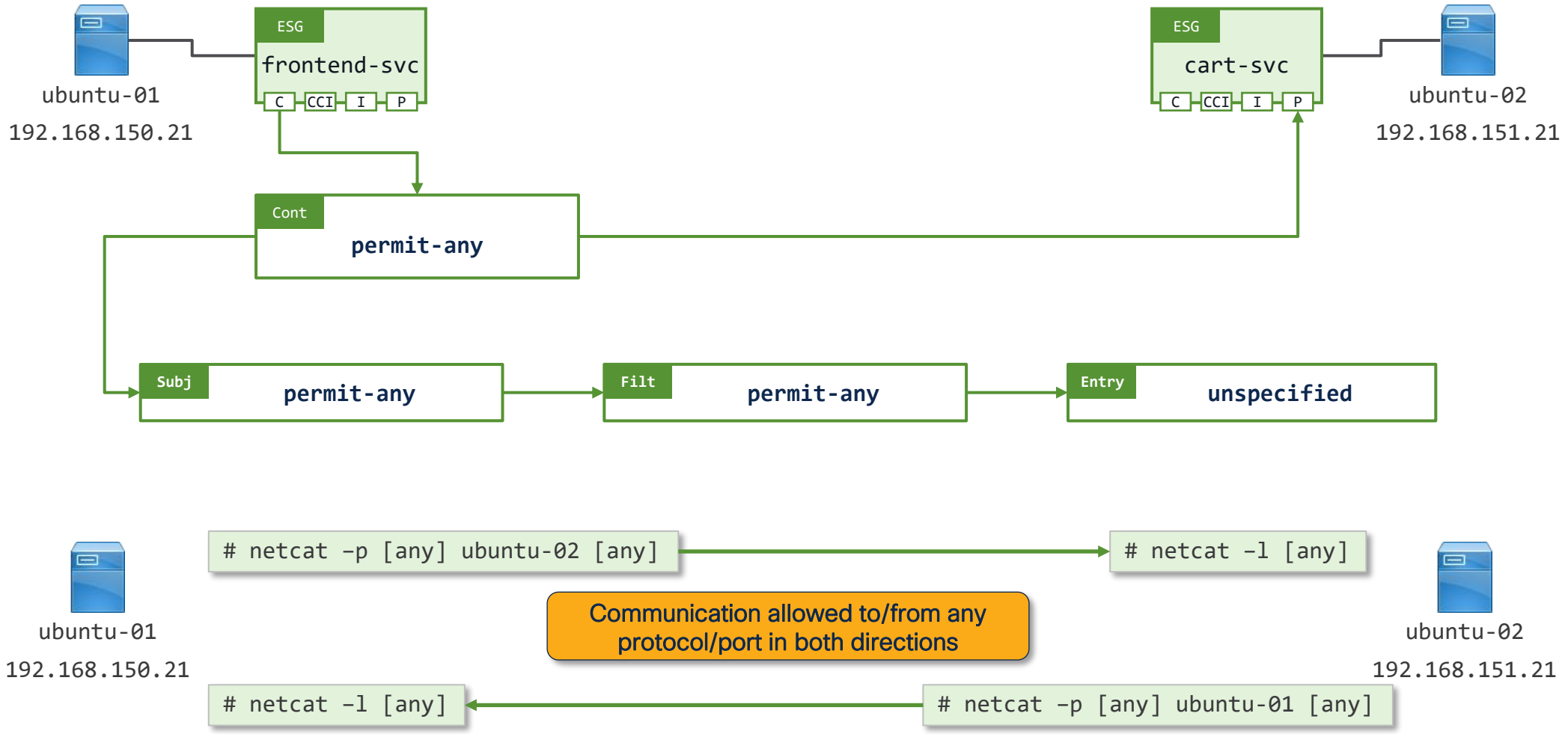
permit any/any



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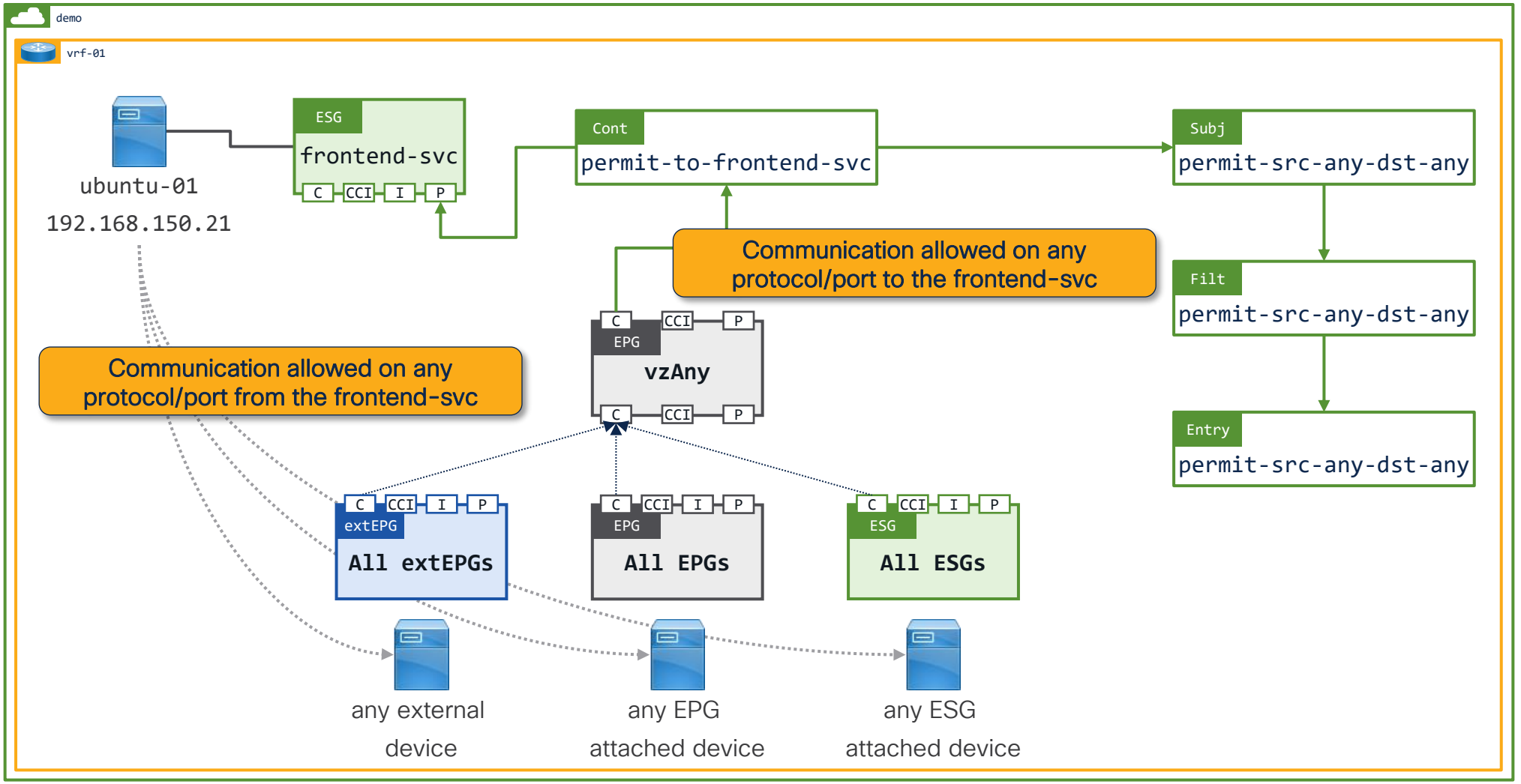
permit any/any with vzAny

Exercise caution when using vzAny...!



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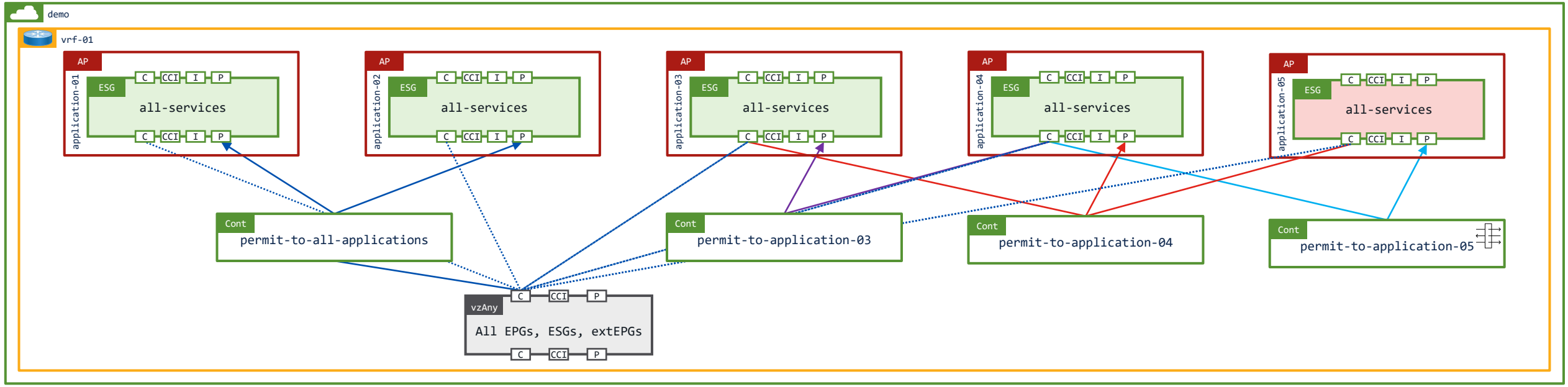

Consumer	Contract	Filter	Provider	Notes
vzAny (all EPGs/ESGs/extEPGs)	permit-to-all-applications	permit-src-any-dst-any	application-01	vzAny with permit-src-any-dst-any allows bi-directional communication on any port between **all** applications
vzAny (all EPGs/ESGs/extEPGs)	permit-to-all-applications	permit-src-any-dst-any	application-02	vzAny with permit-src-any-dst-any allows bi-directional communication on any port between **all** applications
application-04	permit-to-application-03	permit-src-any-dst-any	application-03	Bi-directional communication on any port between application-04 and application-03
application-03 application-05	permit-to-application-04	permit-tcp-src-any-dst-443	application-04	Communication from application-03 and application-05
application-04	permit-to-application-05 (Service graph to FTD for inter and intra application flows)	permit-src-any-dst-any	application-05	Bi-directional communication on any port via firewall between application-04 and application-05

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Let’s tighten the contract to our online-boutique application...

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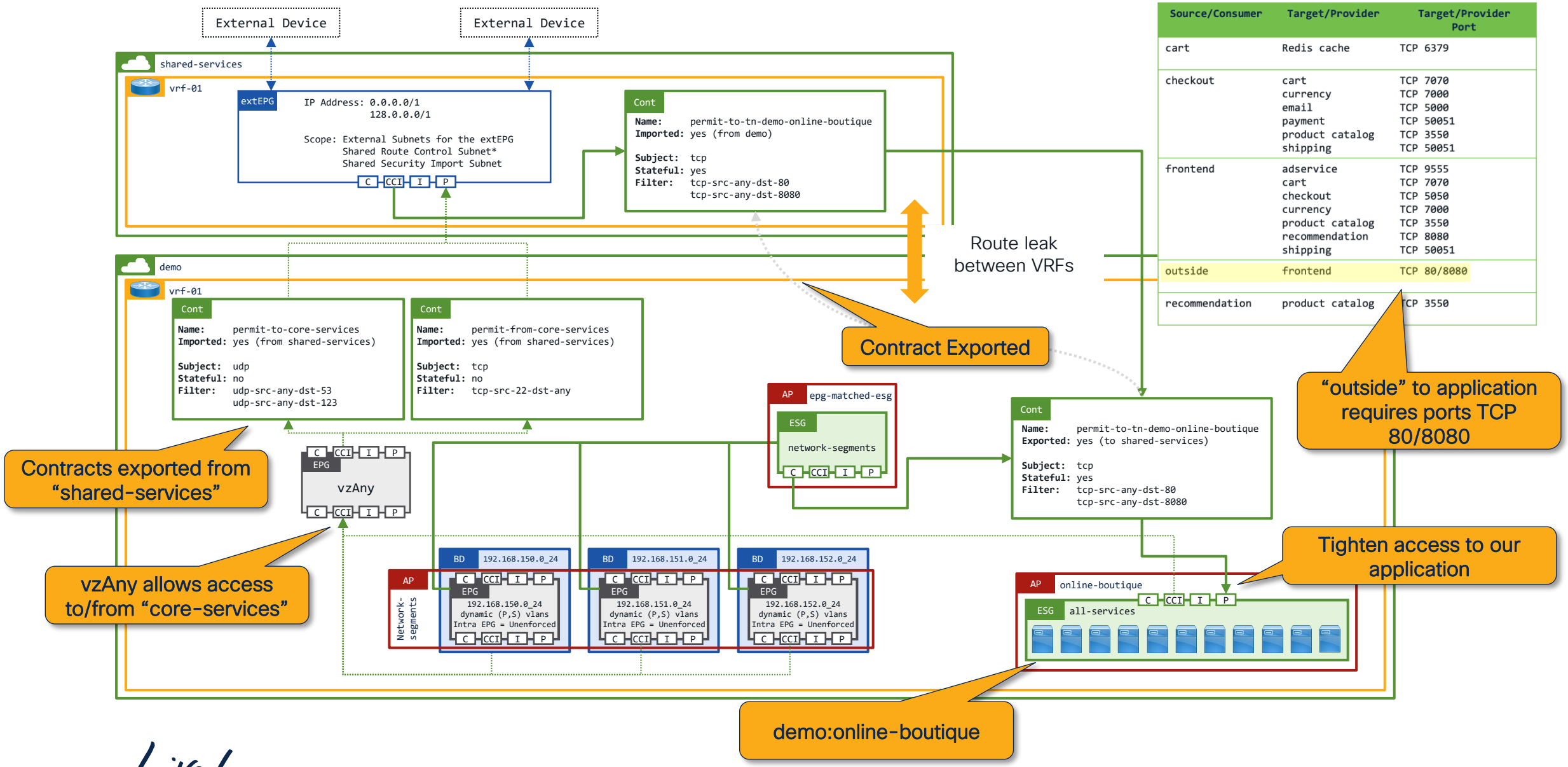
Tighten access to our online-boutique application...



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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Setting the scene...

Designing your Tenants...

Switching to Application Centric mode...

Working with ESGs...

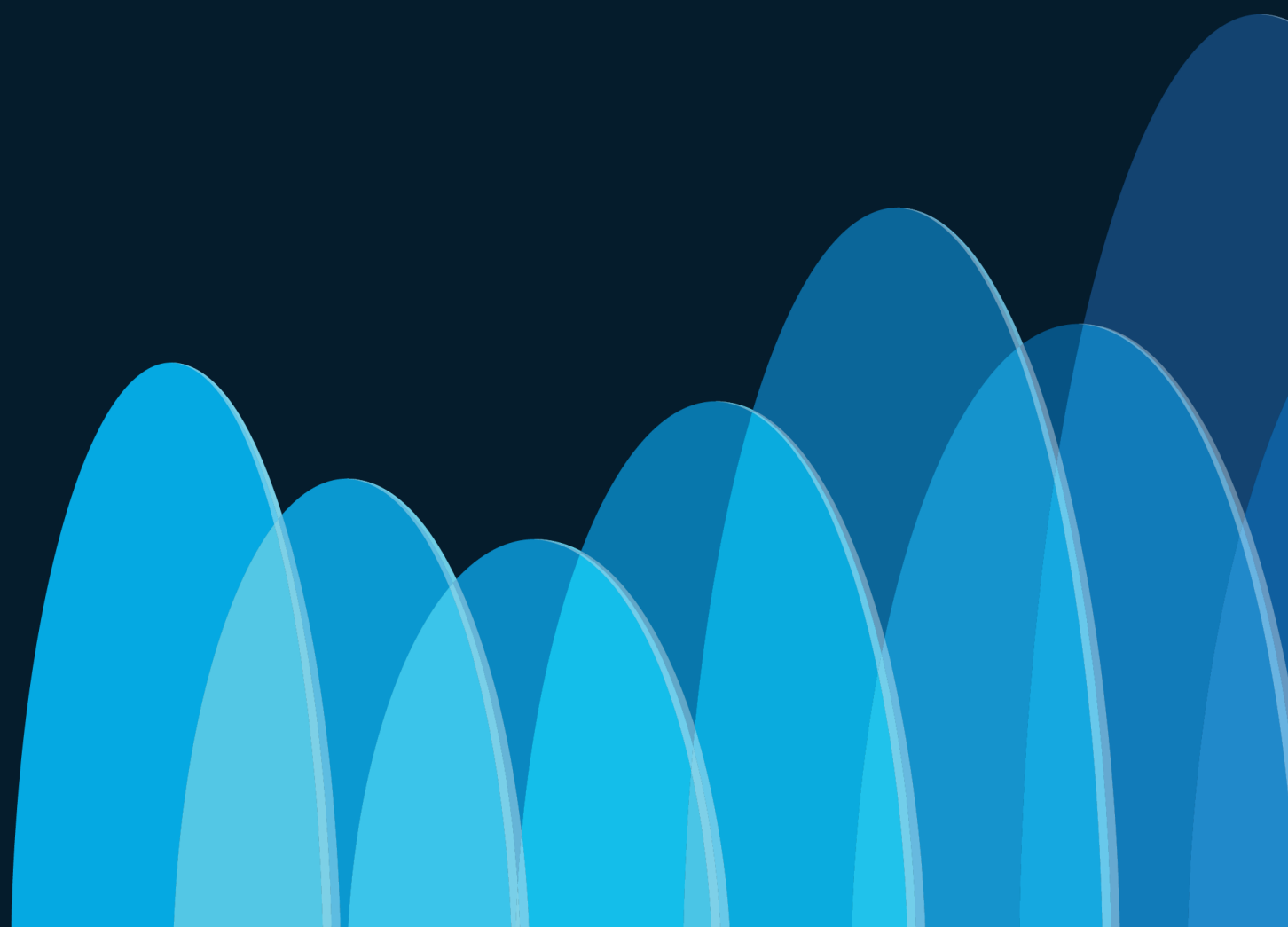
Understanding ACI security...

External Connectivity...

Increasing Security...

Automation Blueprints...

Wrapping up...



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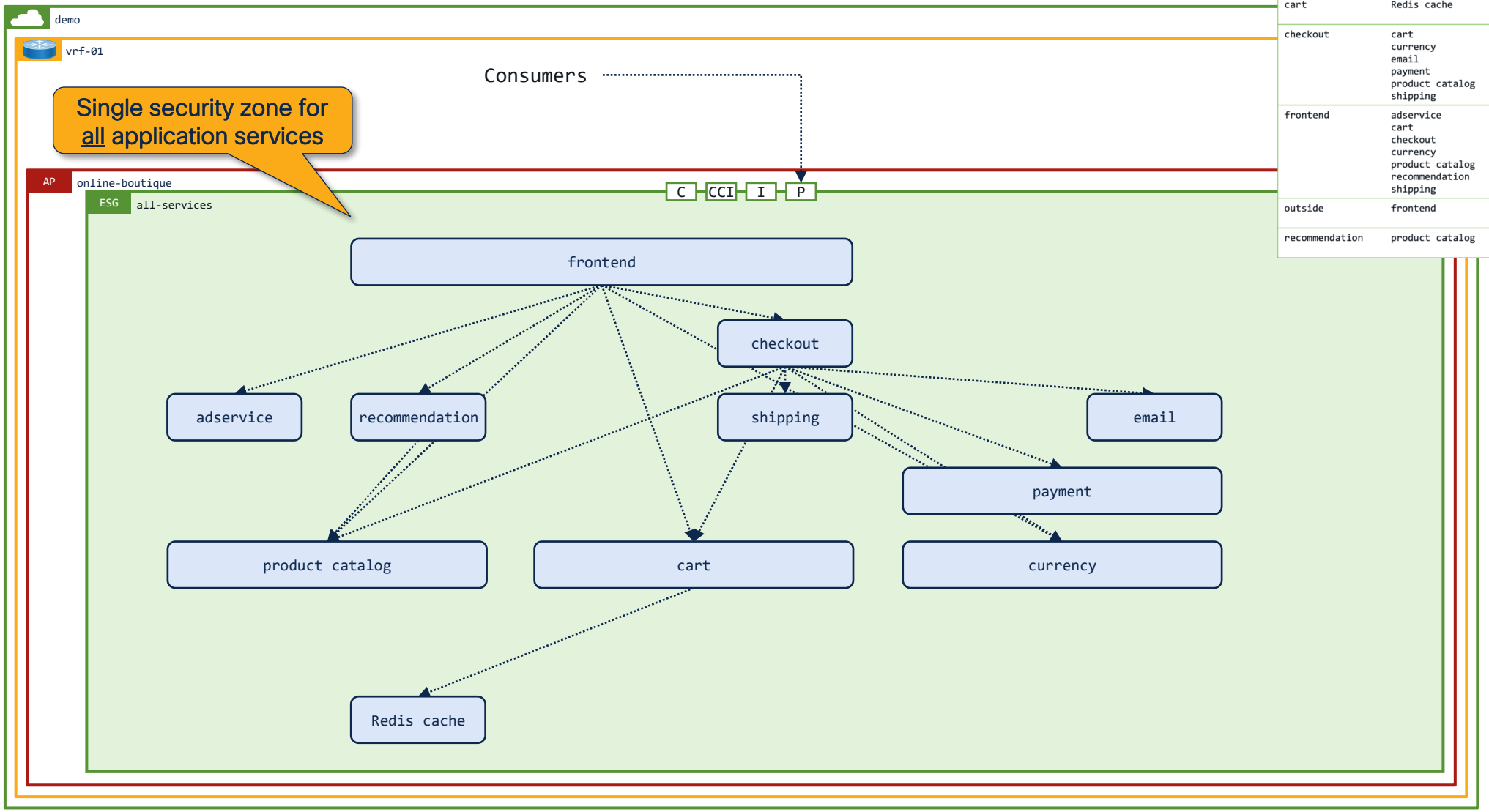
Application tiers across subnets

Application Centric Blueprint #1 – ESG “wrapper” for all services



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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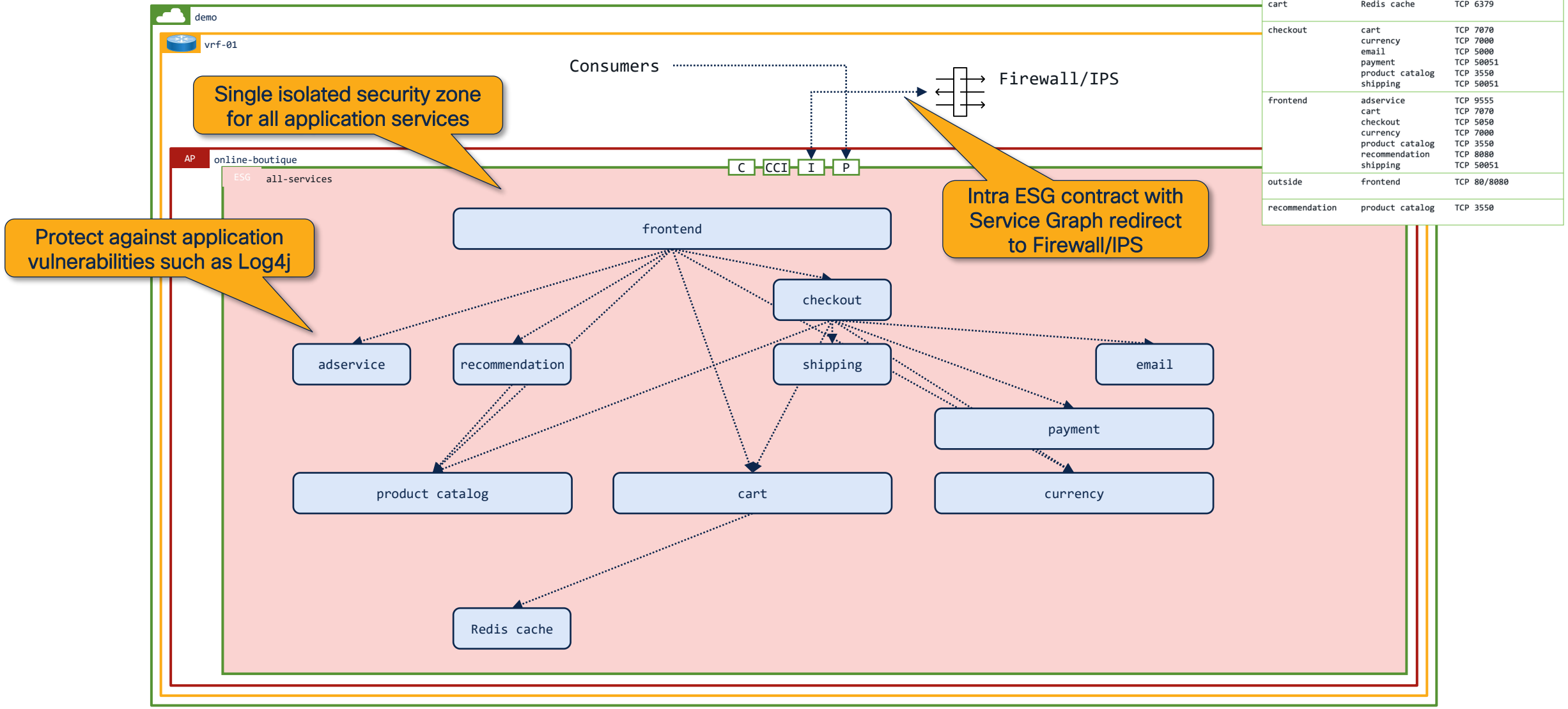
Application tiers across subnets

Application Centric Blueprint #2 – Intra ESG Isolation



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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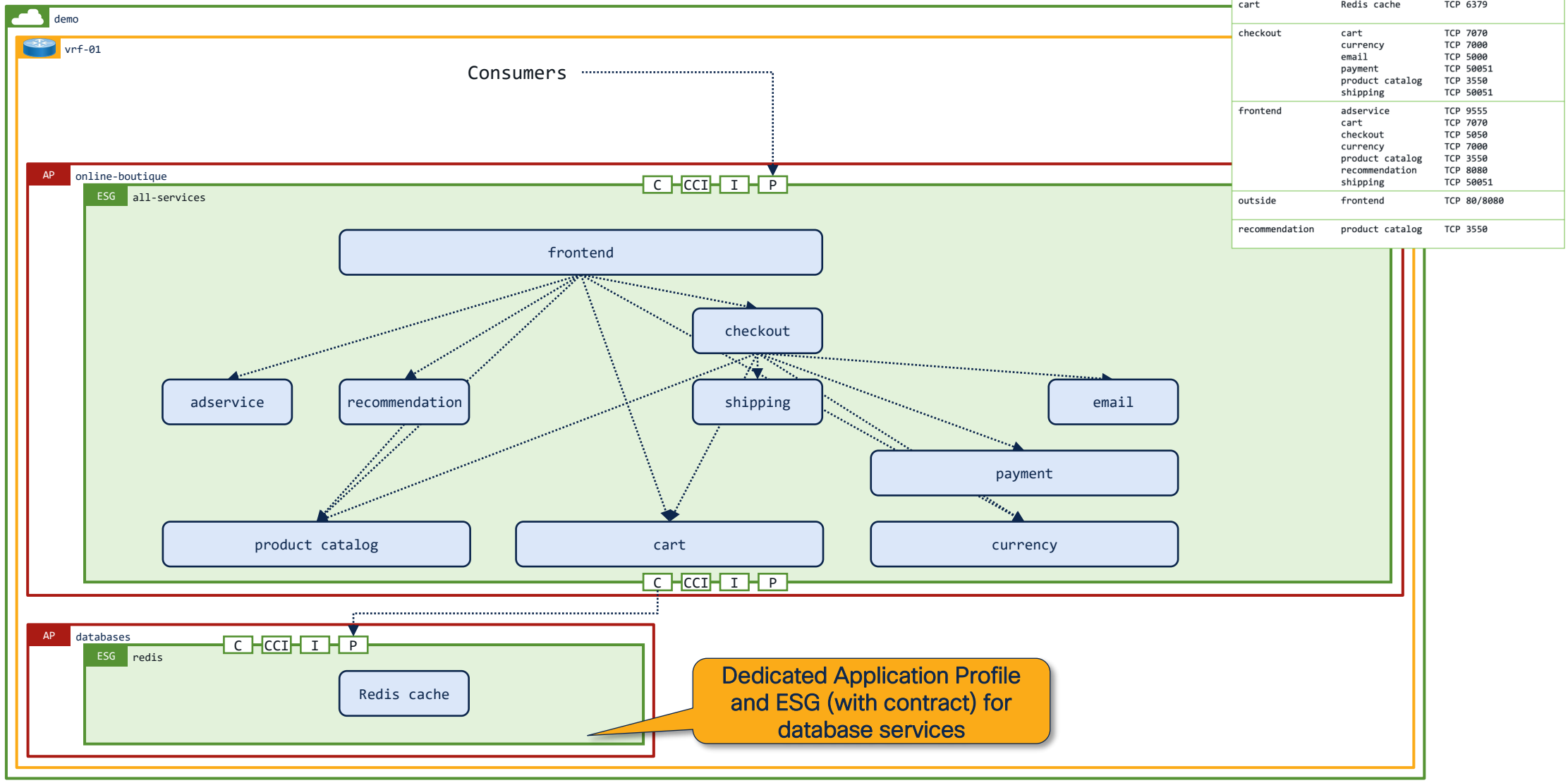
Application tiers across subnets

Application Centric Blueprint #3 – Dedicated AP/ESG for backend database



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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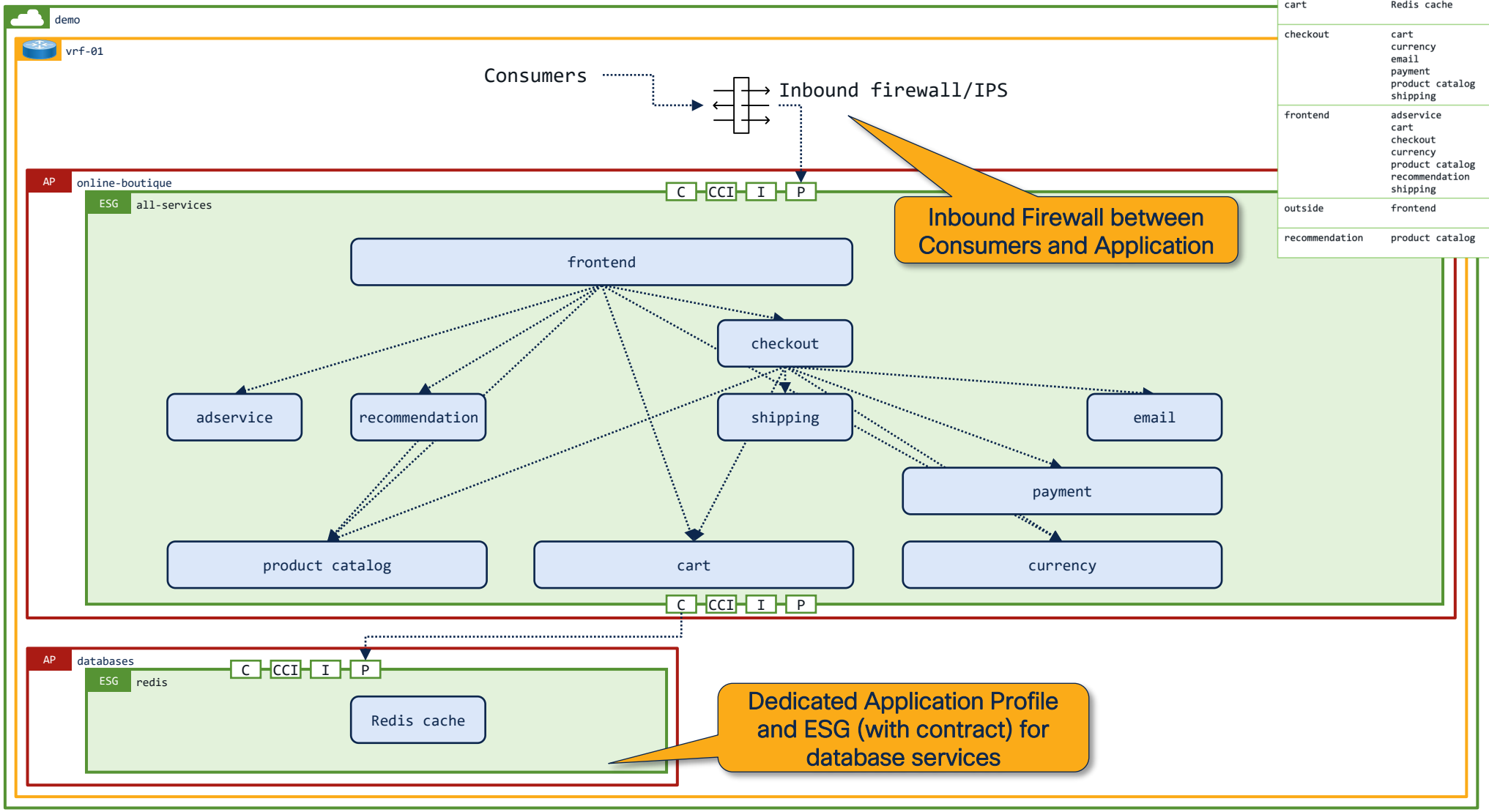
Application tiers across subnets

Application Centric Blueprint #4 – Inbound firewall/IPS + backend contract



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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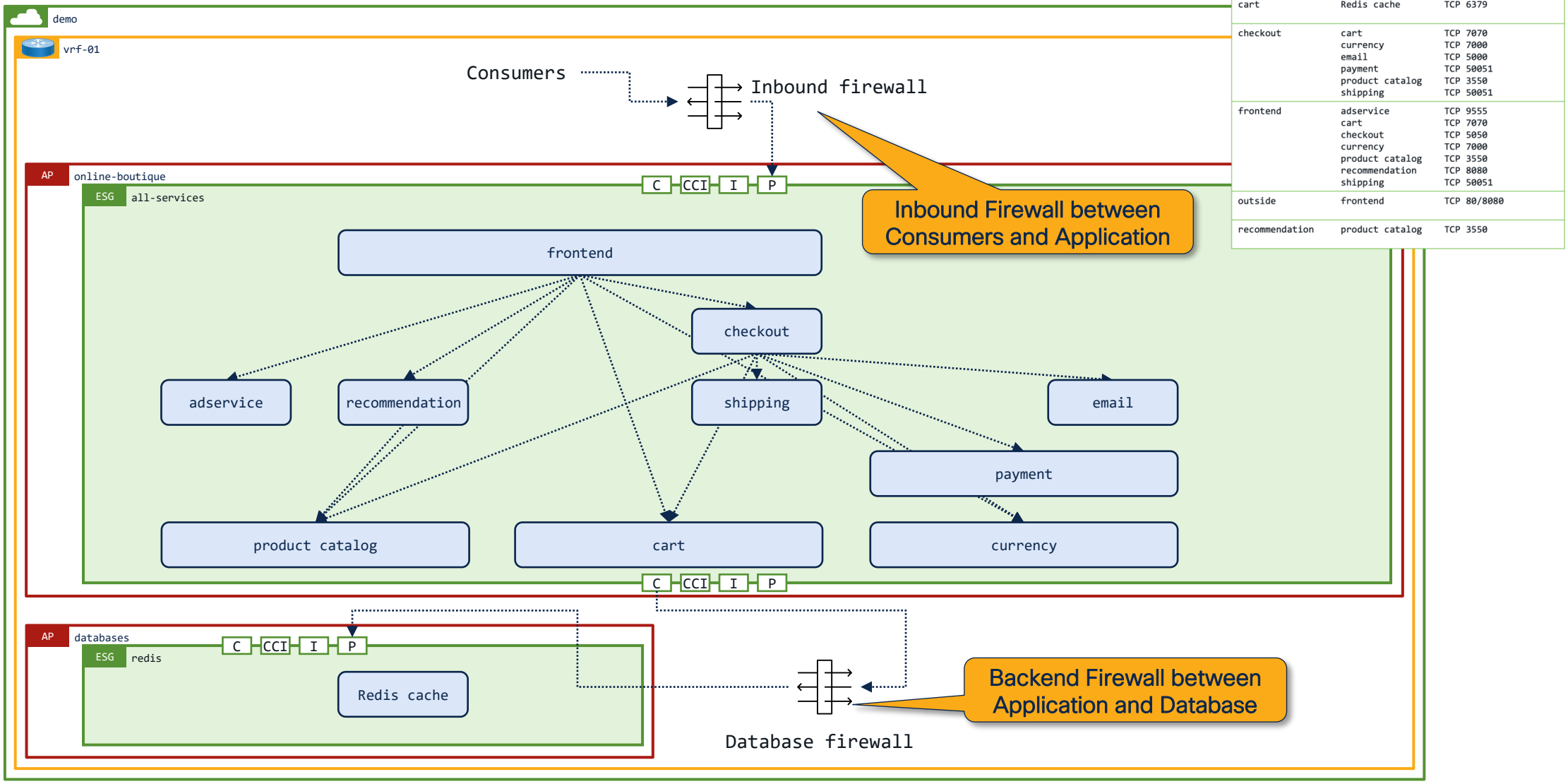
Application tiers across subnets

Application Centric Blueprint #5 – Inbound firewall/IPS + backend firewall/IPS



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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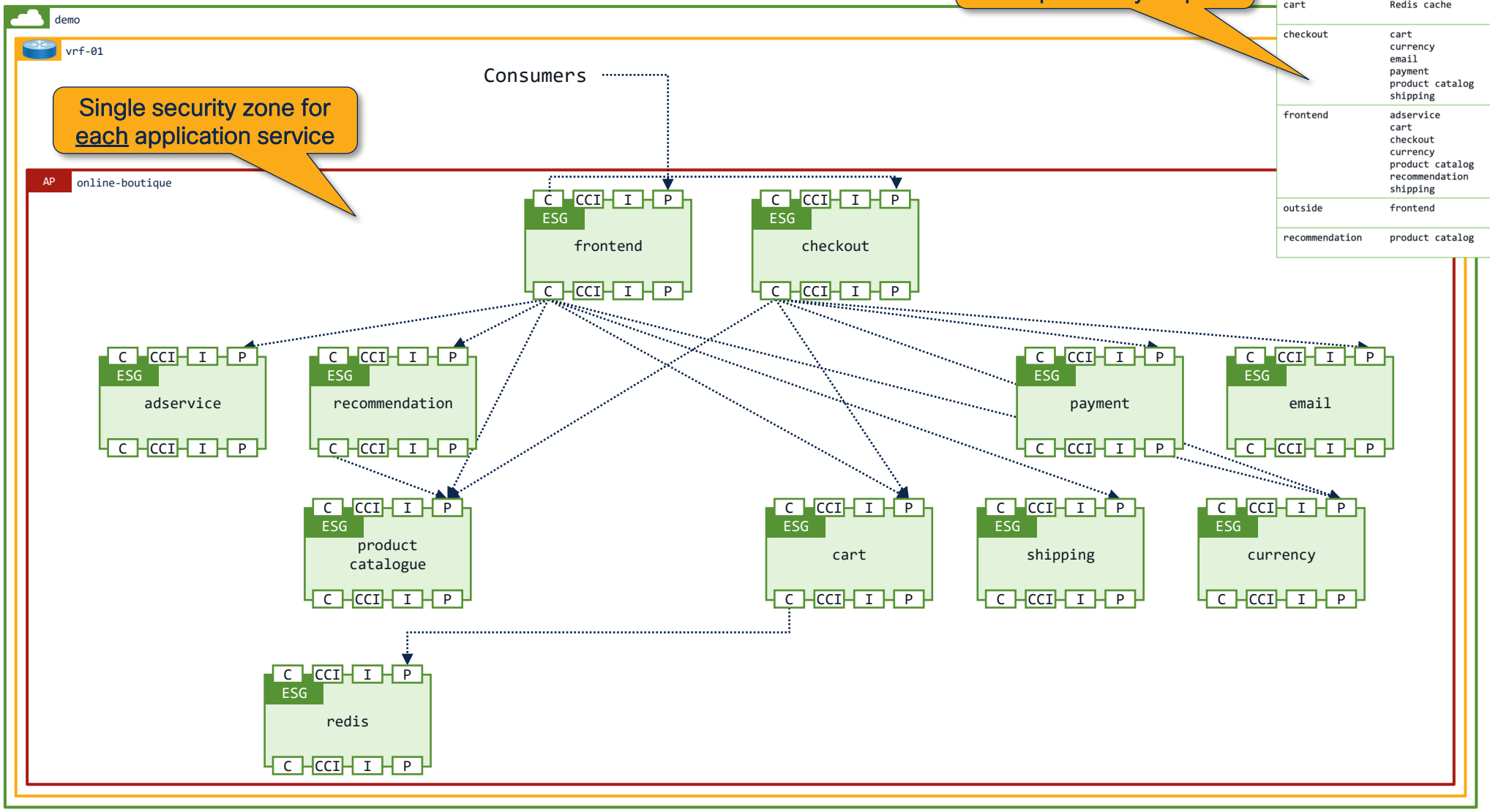
Application tiers across subnets

Application Centric Blueprint #6 – ESG per application tier



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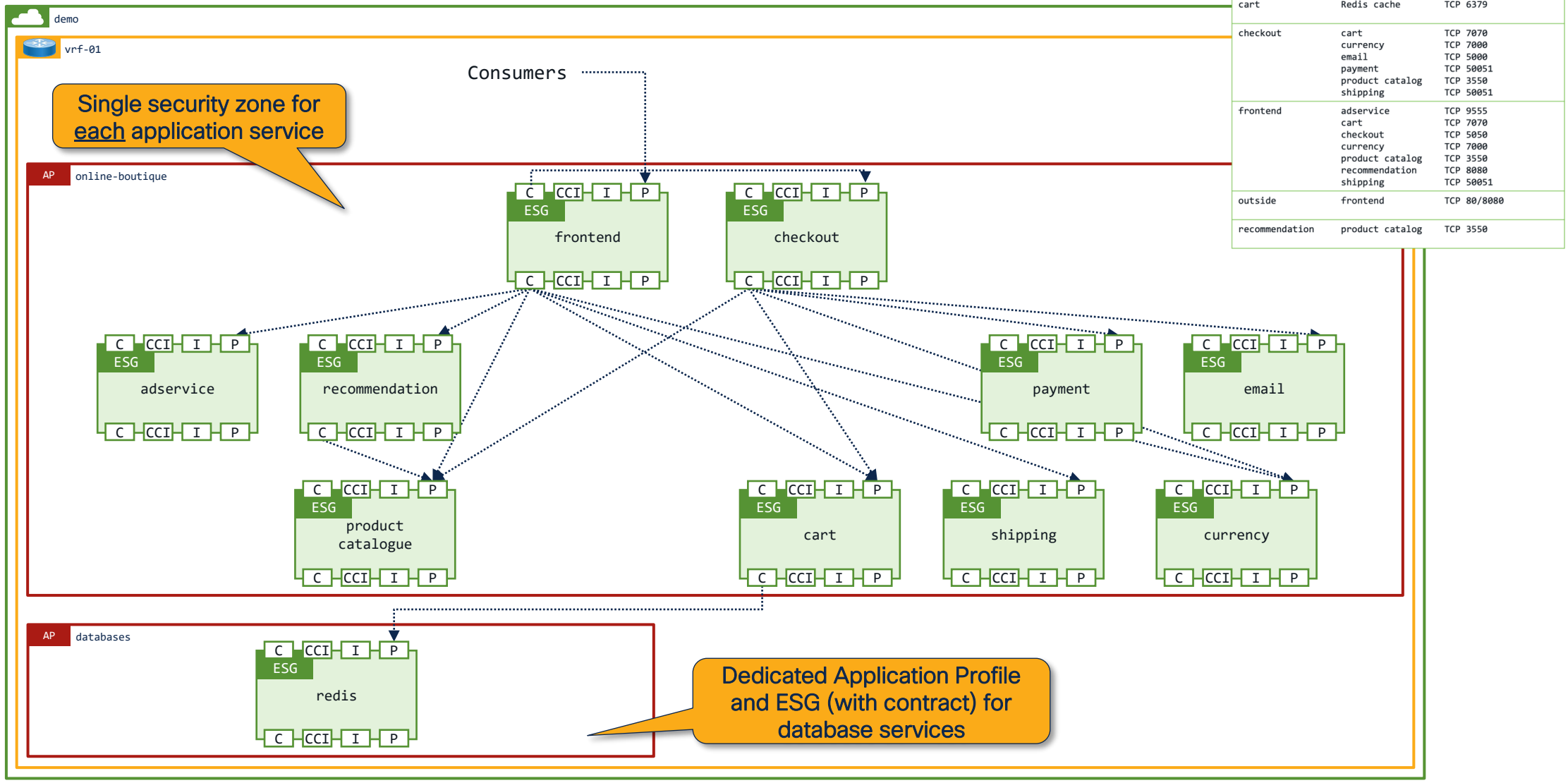
Application tiers across subnets

Application Centric Blueprint #7 – Dedicated AP/ESG for backend database



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
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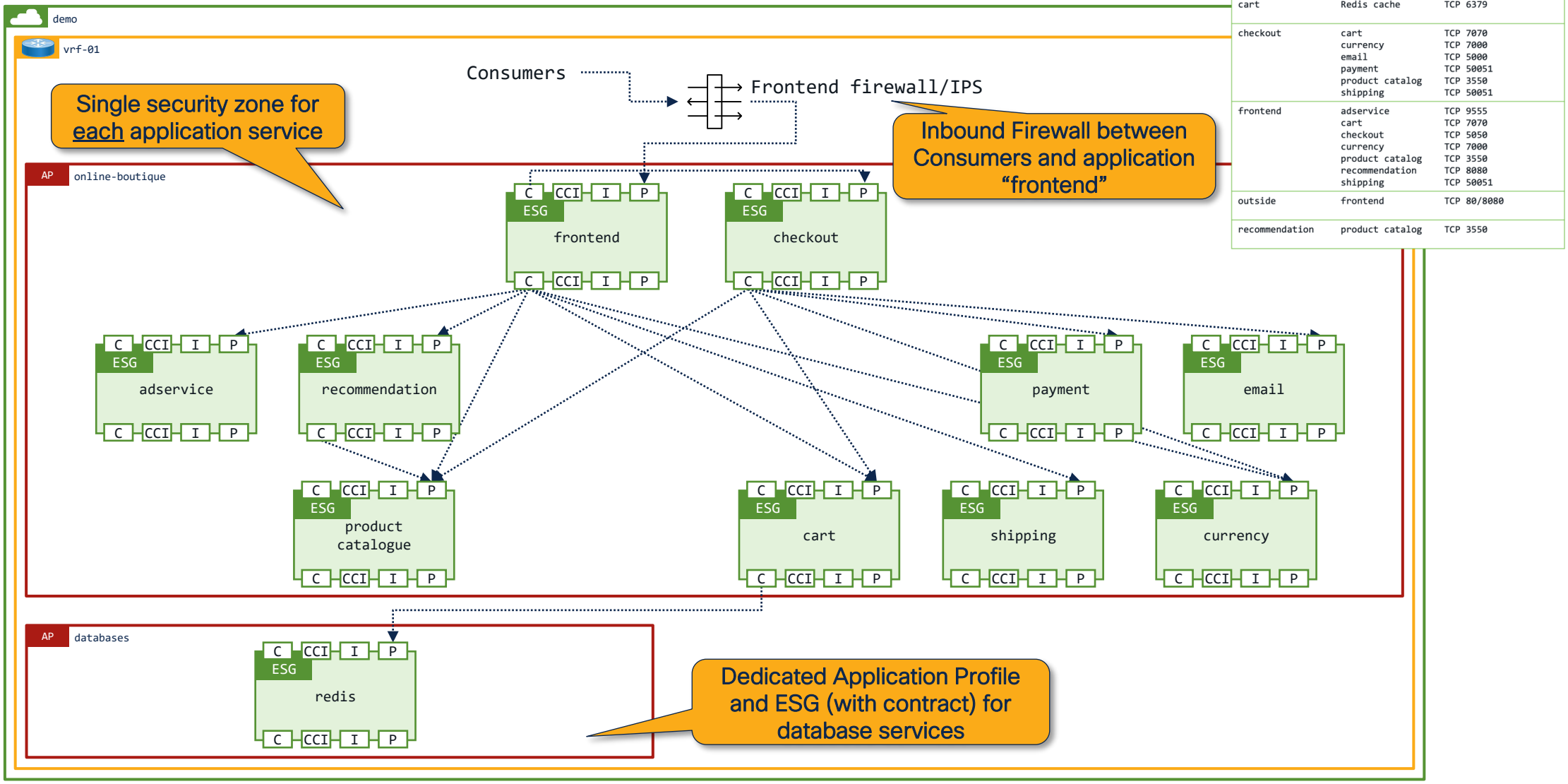
Application tiers across subnets

Application Centric Blueprint #8 – ESG per application tier + frontend firewall/IPS



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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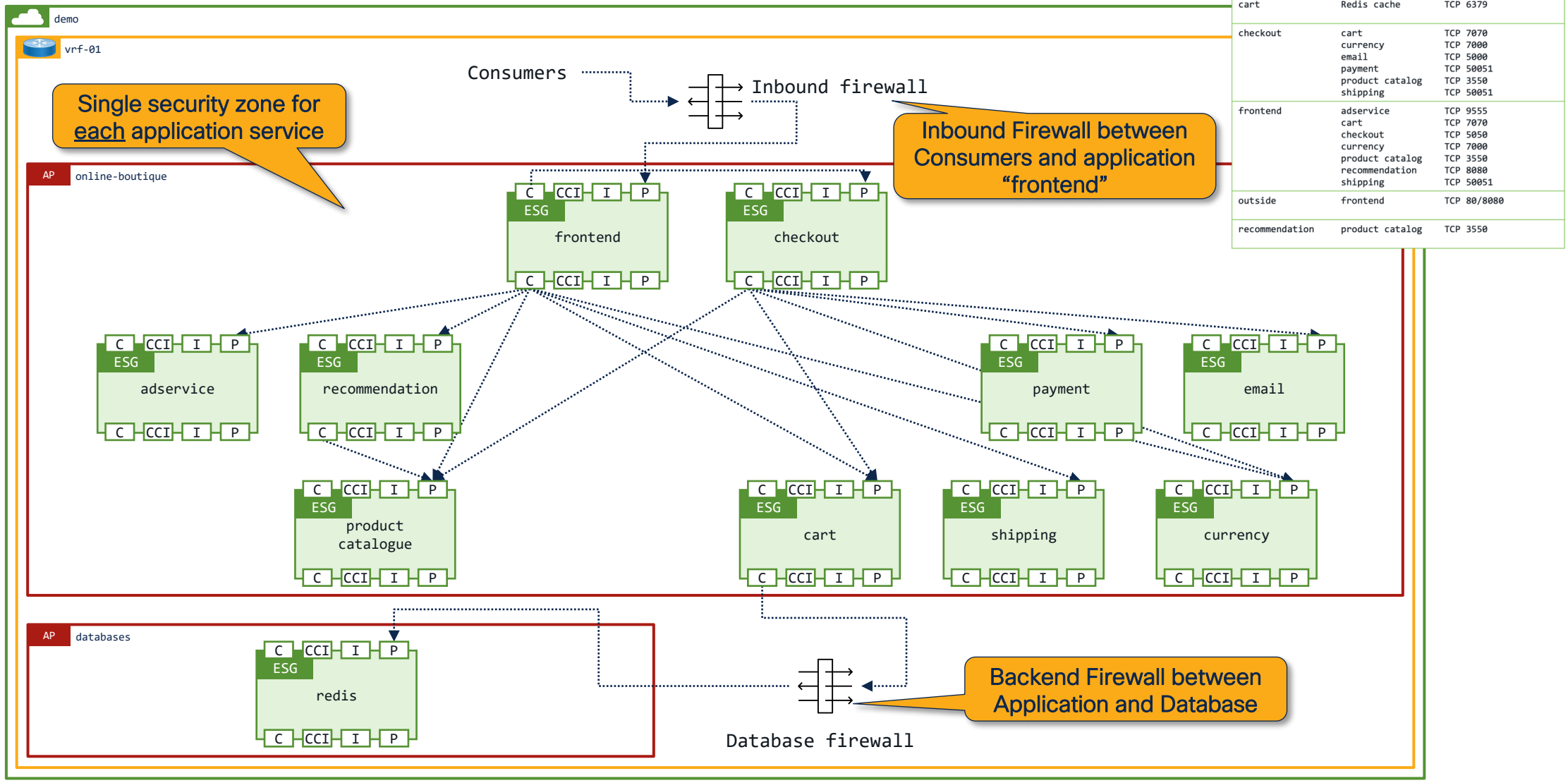
Application tiers across subnets

Application Centric Blueprint #9 – ESG per application tier + frontend firewall/IPS + backend firewall/IPS



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
	payment	TCP 50051
	product catalog	TCP 3550
	shipping	TCP 50051
frontend	adservice	TCP 9555
	cart	TCP 7070
	checkout	TCP 5050
	currency	TCP 7000
	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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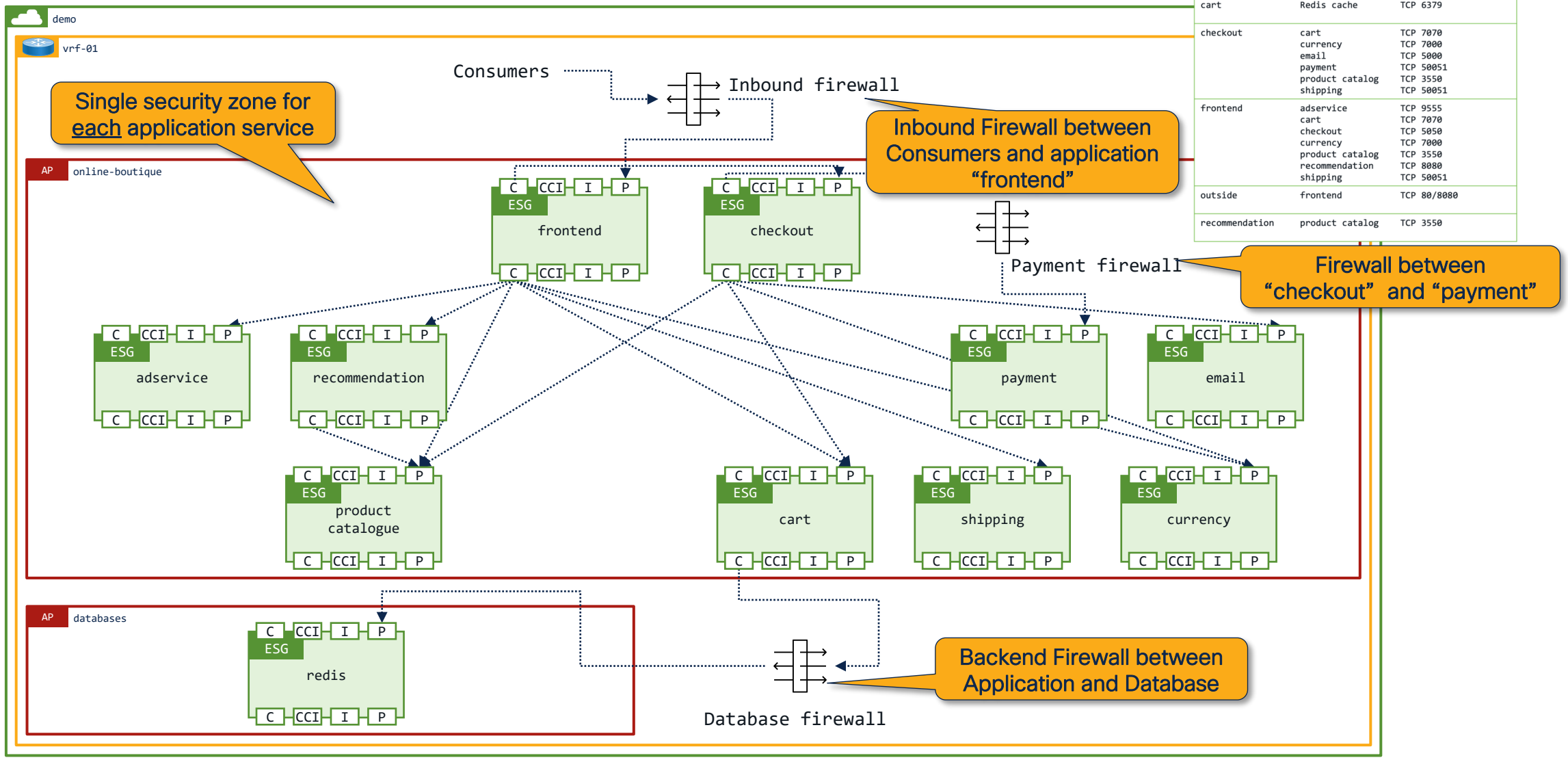
Application tiers across subnets

Application Centric Blueprint #10 – ESG per application tier + frontend, backend, and payment firewall/IPS



Source/Consumer	Target/Provider	Target/Provider Port
cart	Redis cache	TCP 6379
checkout	cart	TCP 7070
	currency	TCP 7000
	email	TCP 5000
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	product catalog	TCP 3550
	recommendation	TCP 8080
	shipping	TCP 50051
outside	frontend	TCP 80/8080
recommendation	product catalog	TCP 3550

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The ultimate aim is to provide a fully consumable fabric where resources are automated on demand...

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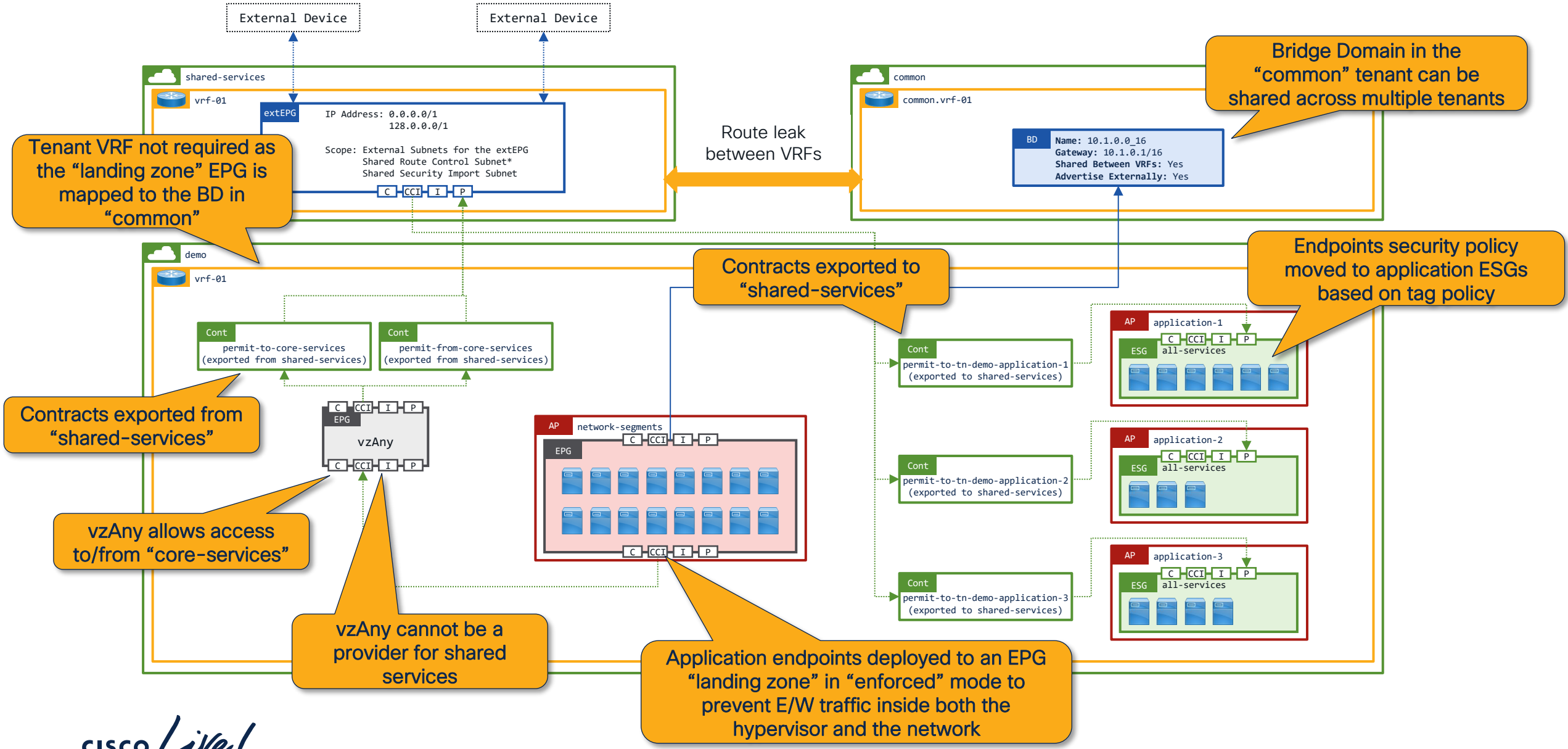
Example Internal Private Cloud Design – shared subnet(s)



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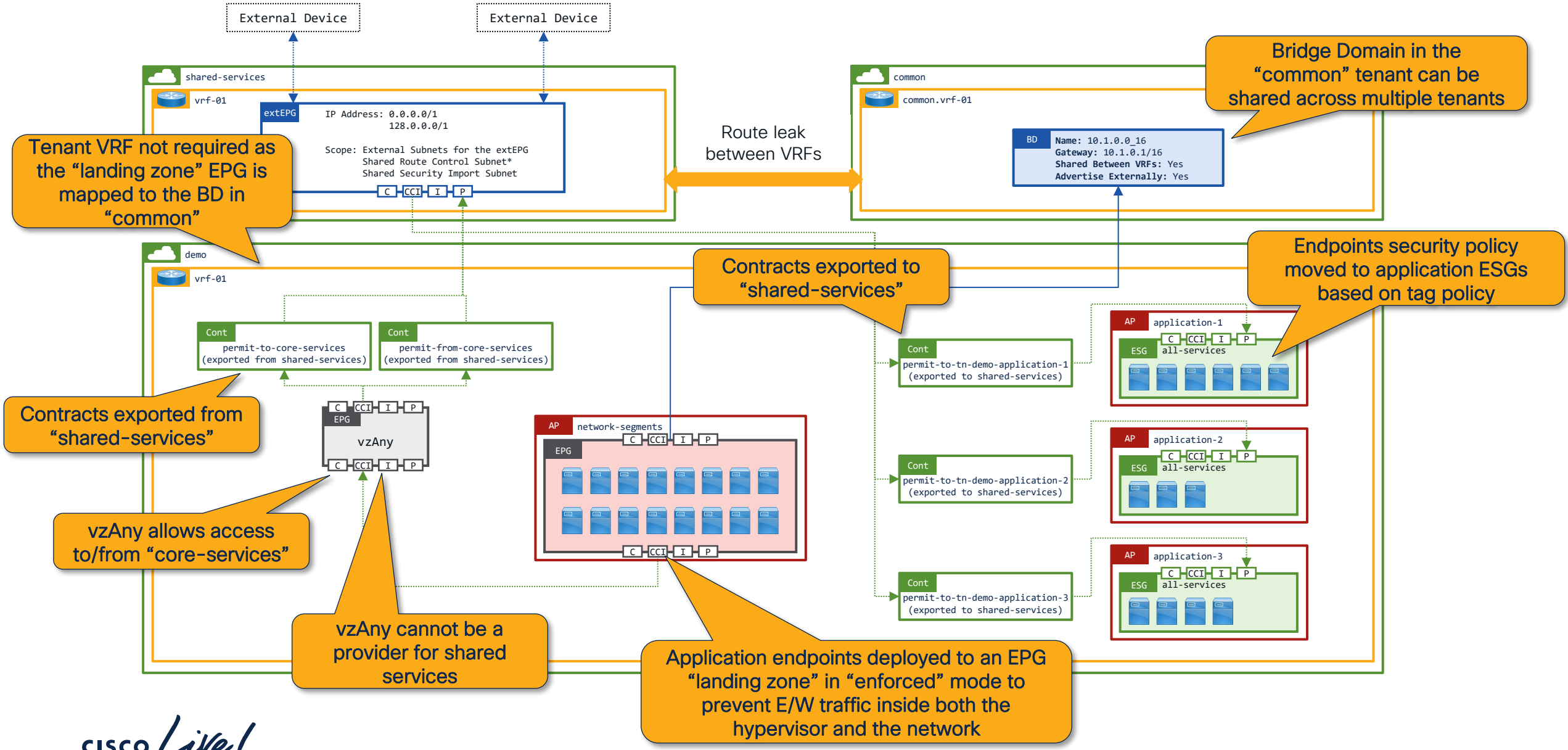
Example Internal Private Cloud Design – Auto Cleanup Isolation



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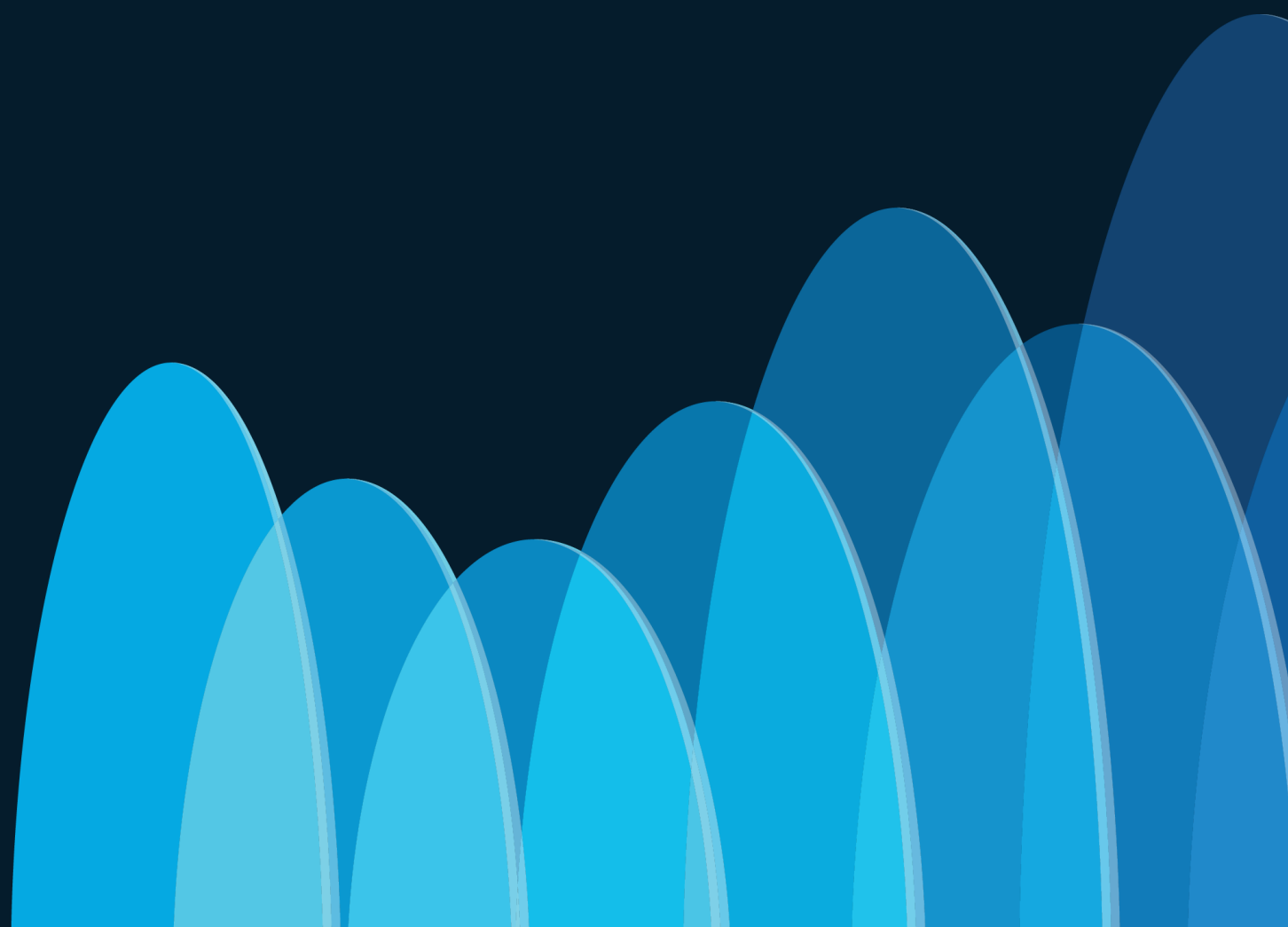

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Select one or more Design Patterns…

Carefully consider the use of:

- Tenant “common”
- Using a “shared services” tenant
- vzAny
- Dedicated border Leafs (recommended)
- Contract scopes
- External EPG with the classifier 0.0.0.0/0

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Benefits of Shared Service model...

- Looks and feels like a Public Cloud model of working
- Network team maintains control of North / South route peering
- Network team maintains control of Inter VRF route leaking
- Each Tenant can control their own CIDR range
- Each Tenant can control their own security rules
- Each Tenant can have private (non routable subnets)
- Security services can be easily inserted in the Tenants
- Do not use 0.0.0.0/0 as the extEPG classifier in a shared model

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Implement ESG “wrappers”…

Wrapping applications into ESGs provides the following benefits for both virtual and physical workloads:

- Improved application visibility
- Improved auditing capabilities
- Improved troubleshooting
- Intelligent service insertion
- Security tied applications rather than network segments
- Reduce the reliance on monolithic physical security devices

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Automation Considerations...

- A simple consumption model is everything
- Single API for all networking functions
- Application security requirements should be declared to the infrastructure
- Add virtual application firewalls to deployments if required
- Large physical monolithic firewalls are useful at network boundaries, however they should only provide broad security rules
- Remove unnecessary overlay networks that add layers of complexity

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Getting started resources

- Visual Studio Code with extensions
  - Yaml
  - Indent Rainbow
  - Hashi Terraform
- https://netascode.cisco.com/solutions/aci/terraform/overview
- https://developer.cisco.com/docs/nexus-as-code/introduction/
- https://github.com/netascode/terraform-aci-nac-aci/tree/main
- https://github.com/netascode/nac-aci-simple-example
- https://github.com/netascode/nac-aci-comprehensive-example
- https://github.com/spsharman/CiscoLive2024
- https://github.com/spsharman/aci-prod
- https://github.com/spsharman/aci-dev-01
- https://tl10k.dev/categories/terraform/nexus-as-code-architecture/

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ESG Design Guide

https://www.cisco.com/c/en/us/td/docs/dcn/whitepapers/cisco-aci-esg-design-guide.html?cachemode=refresh

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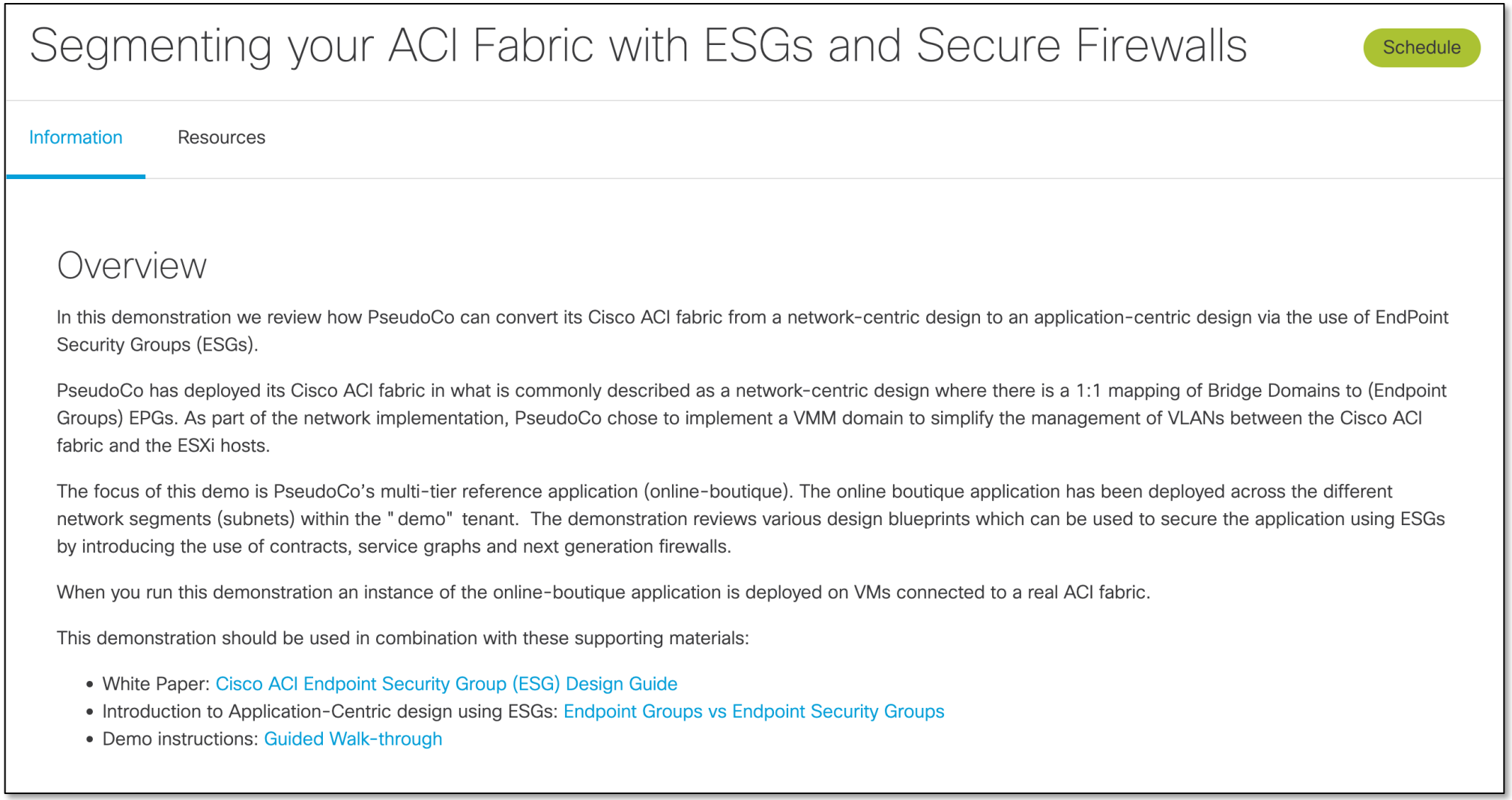
Now available on dCloud

https://dcloud2-sjc.cisco.com/content/demo/333928?returnPathTitleKey=content-view



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BRKDCN-2634 – Deploying EVPN G/W...
BRKDCN-2673 – Nexus-as-Code...
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BRKDCN-2949 – ACI Multi-Pod...
BRKDCN-2980 – ACI Multi-Site...
BRKDCN-3900 – ACI Forwarding...
BRKDCN-3982 – ACI PBR Deep Dive...

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- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at www.CiscoLive.com/on-demand

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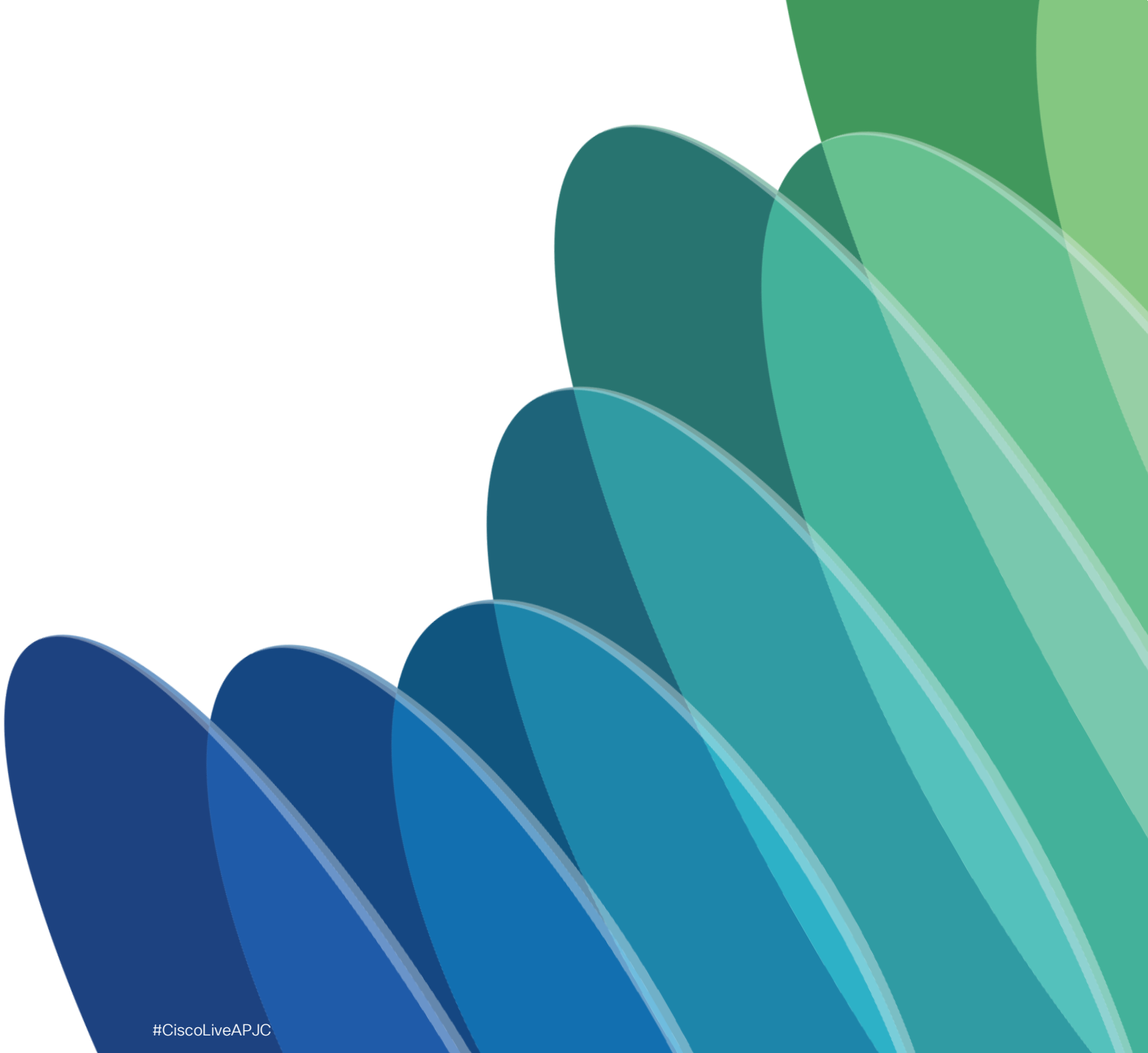

Thank you

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