DC fabric design & implementation

Paresh Khatri
CTO IP Networks APAC
22nd August 2025

NOKIA

btNOG

SANOG 43

Agenda

1. Data center architectures
2. EVPN basics
3. Live demo
4. Reference information

Agenda

1. Data center architectures
2. EVPN basics
3. Live demo
4. Reference information

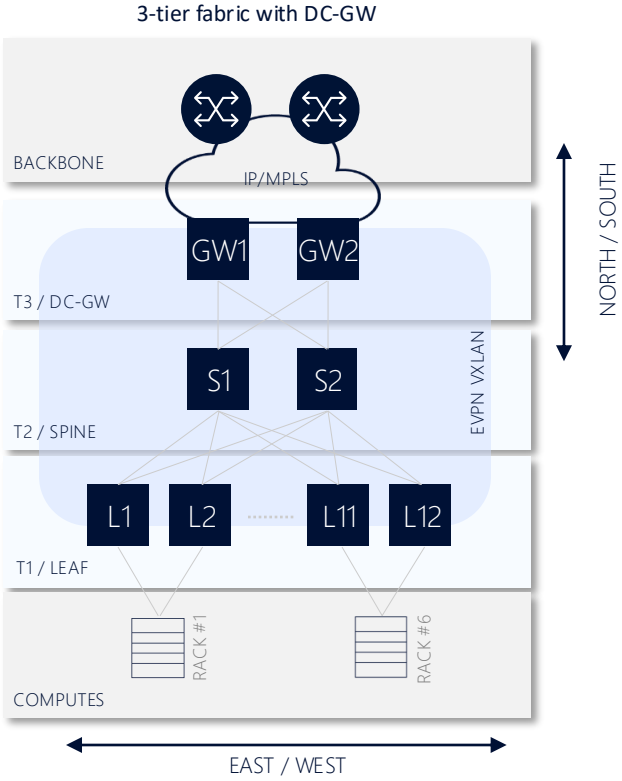
Agenda

1. Data center architectures
   a. In a nutshell
   b. Physical
   c. Logical
2. EVPN basics
3. Live demo
4. Reference information

Data center key foundations

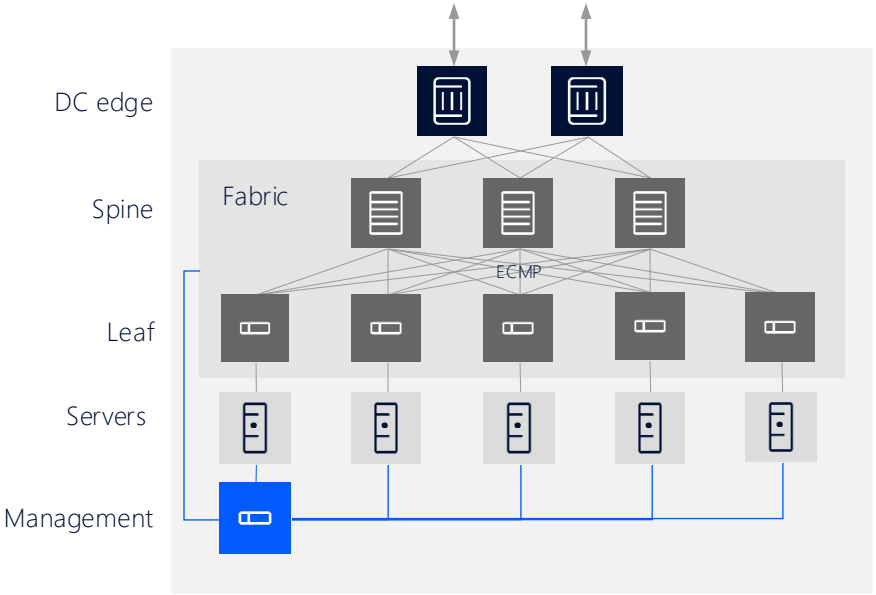
Goals and topology

- Purpose of a data center
  - Interconnect compute, storage and external networks at scale
  - Ensure low-latency and high-throughput across the fabric
  - Provide high availability through redundant design
  - Enable secure communication between workloads
- In practice, this is done through a Clos architecture.
- Key factors like oversubscription ratio, fault tolerance, redundancy and scale will determine physical characteristics of the data center.



Modern data center network architectures

The industry has converged



Non-blocking fabrics

- IP and EVPN fabrics
- DC gateway or border leaf derivatives
- Collapsed core for edge DC
- Scale via super spines / pods

ASICs tailored per use case

- Range of different ASICs on the market
- Key properties: latency, programmability, port speed & density, feature set

OOB management

- Merchant silicon
- 1G/10G port speeds

Modern data center network architectures

Key elements

Physical architecture

- (Folded) Clos leaf-spine topologies
- Multi-stage
- Multi-tier for scale

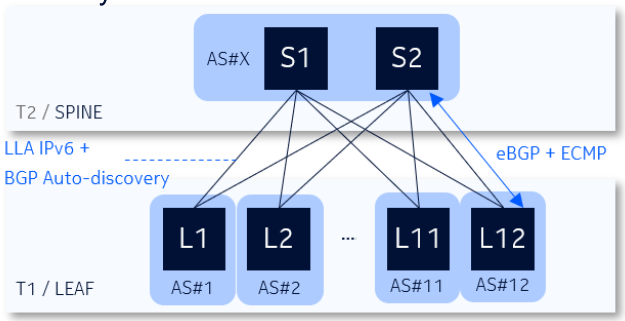
Underlay

- IP underlay
- Single BGP instance with no additional IGPs

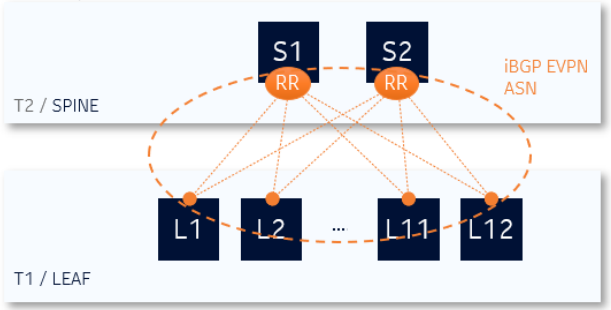
Overlay

- BGP-EVPN control plane
- VXLAN data plane
- Layer 2 and Layer 3 multi-tenant services

Underlay



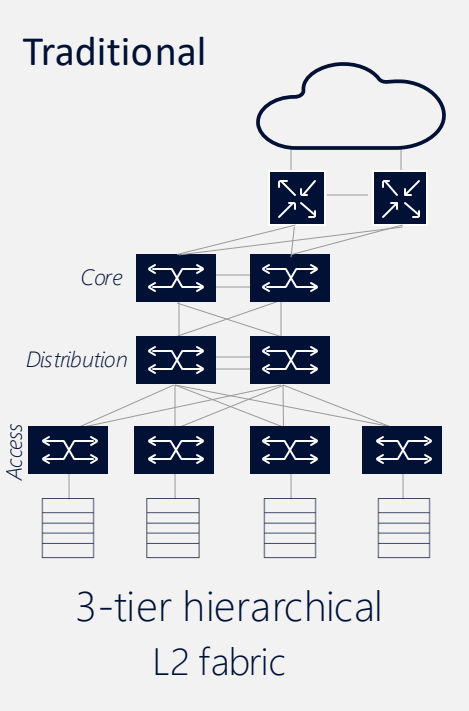
Overlay

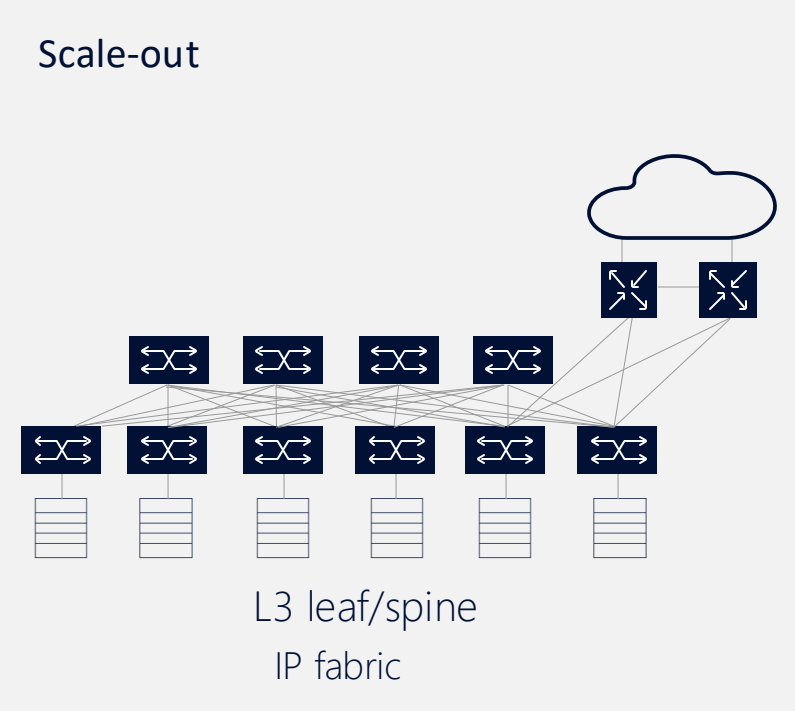


Agenda

1. Data center architectures
   a. In a nutshell
   b. Physical
   c. Logical
2. EVPN basics
3. Live demo
4. Reference information

Evolution of data center architecture





IP fabric architecture

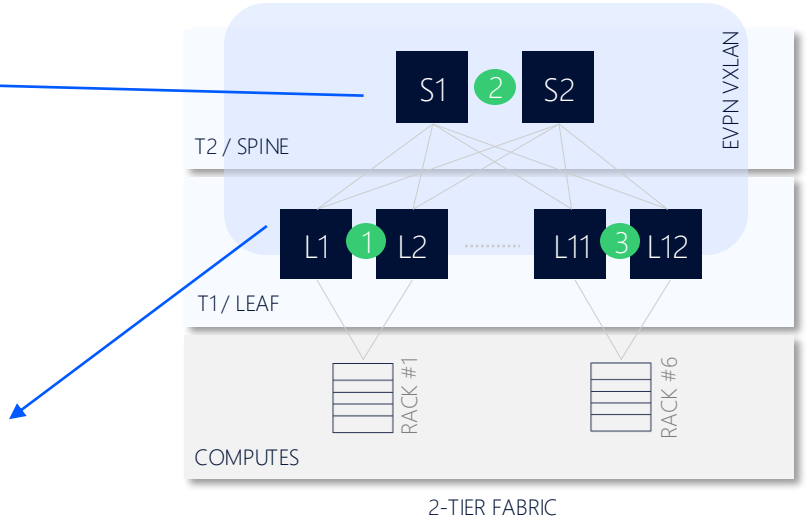
3-stage Clos

Spine:

- Provides connectivity between leaf switches. The major role of the spine is to participate in the control-plane and data plane operations for traffic forwarding between leafs
- Spines are not interconnected

Leaf:

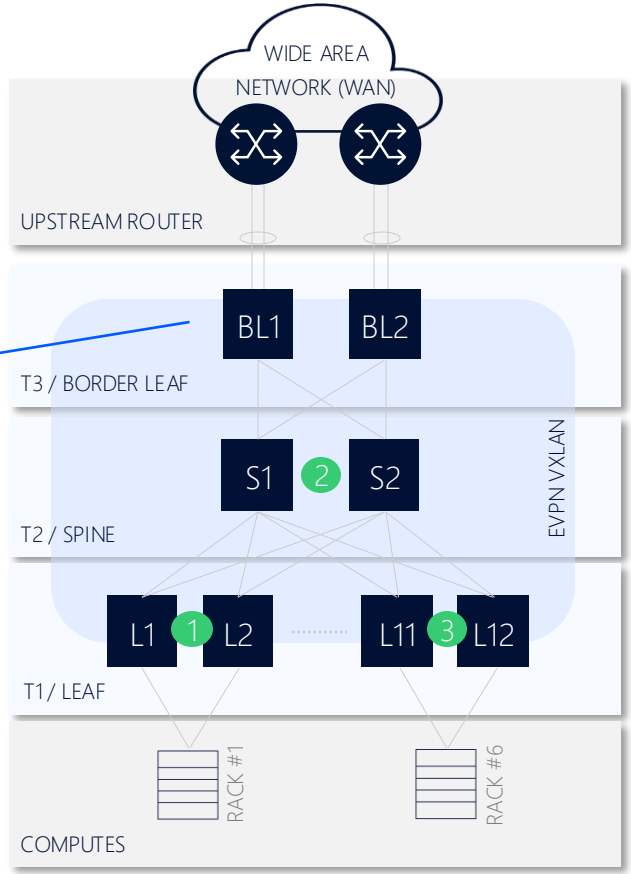
- Provides connectivity to the endpoints in the data center network which include compute servers and storage devices. The leaf provides VXLAN endpoint functionality and is also referred to as a Top of Rack (ToR) and can be deployed as a single switch or a dual switch to allow for server/storage redundant connections
- Each Leaf connects to each Spine



IP fabric architecture

External connectivity

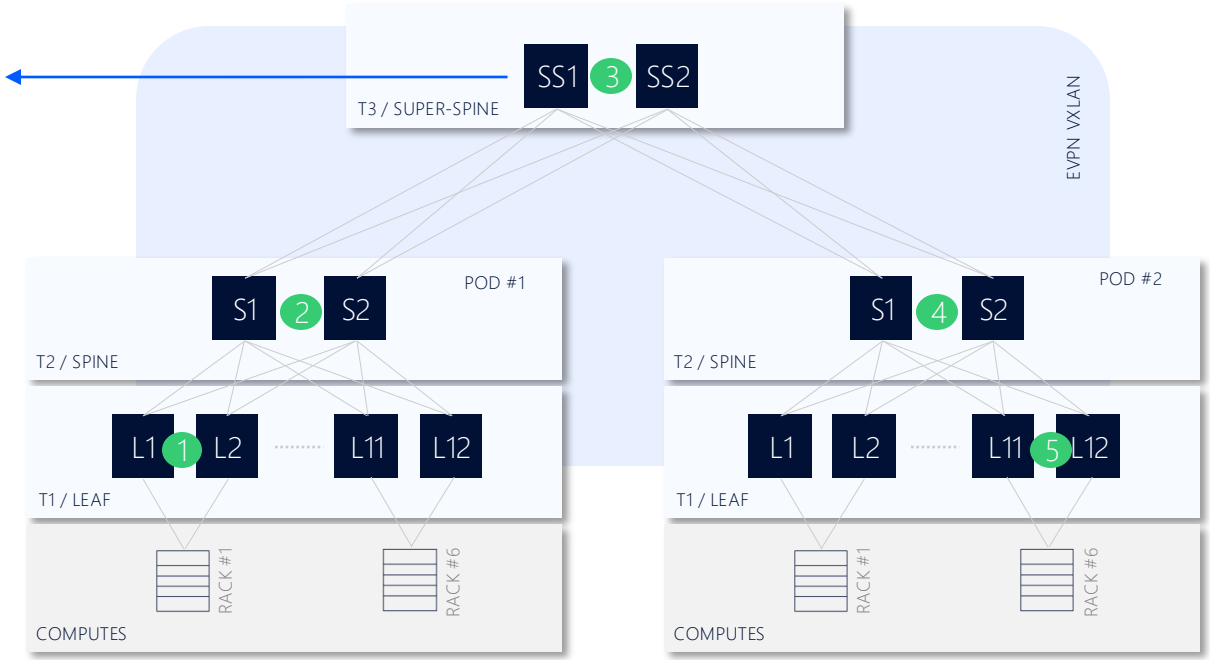
Border Leaf: Provides connectivity in and out of the IP Fabric to the WAN edge or other networks within the Data Center. Endpoints attached here normally include networking devices like routers, switches, load balancers, firewalls, and any other physical or virtual networking endpoints. The Border Leaf also provides VXLAN endpoint functionality



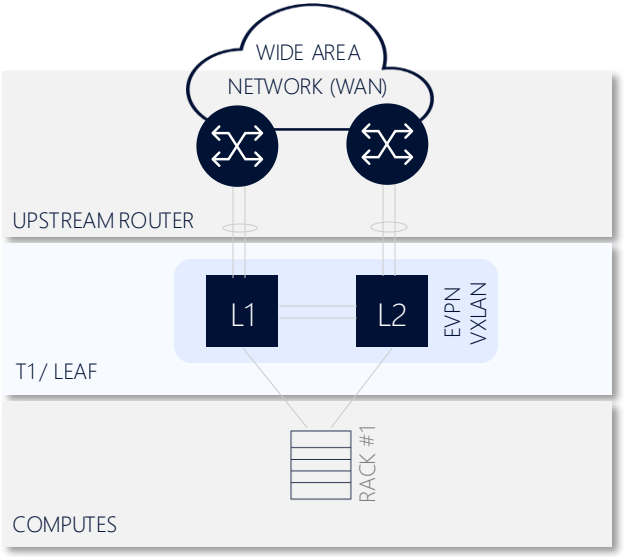
IP fabric architecture

5-stage Clos

Super Spine: Used in a 5-stage Clos providing connectivity between PoDs within the Data Center. Each PoD would consist of a 3-stage Clos IP Fabric. The major role of the spine is to participate in the control-plane and data plane operations for traffic forwarding between PoDs



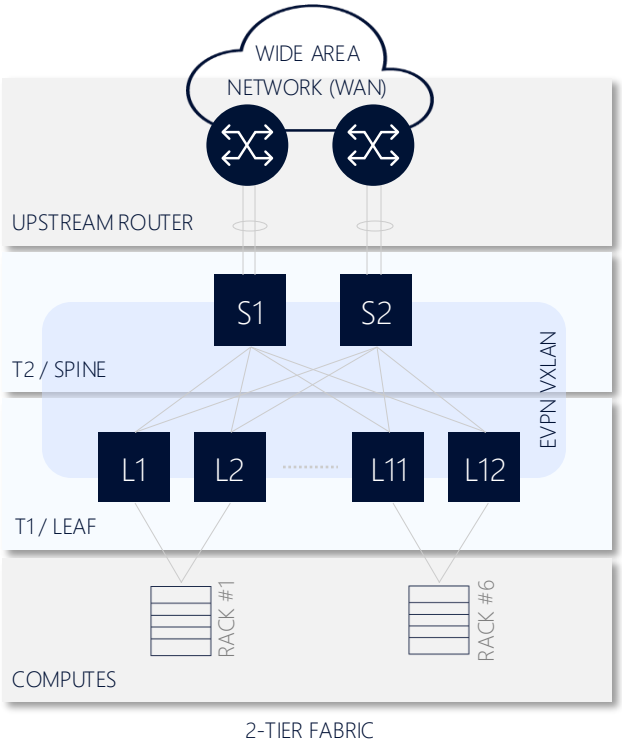
1-tier topology (single-rack)



1-TIER FABRIC

- Single-rack deployment with 2 leafs
- 2x back-to-back links are required (in this topology only)
- eBGP/iBGP between leafs (EVPN/VXLAN)
- The external bandwidth must not exceed the capacity of the back-to-back links.

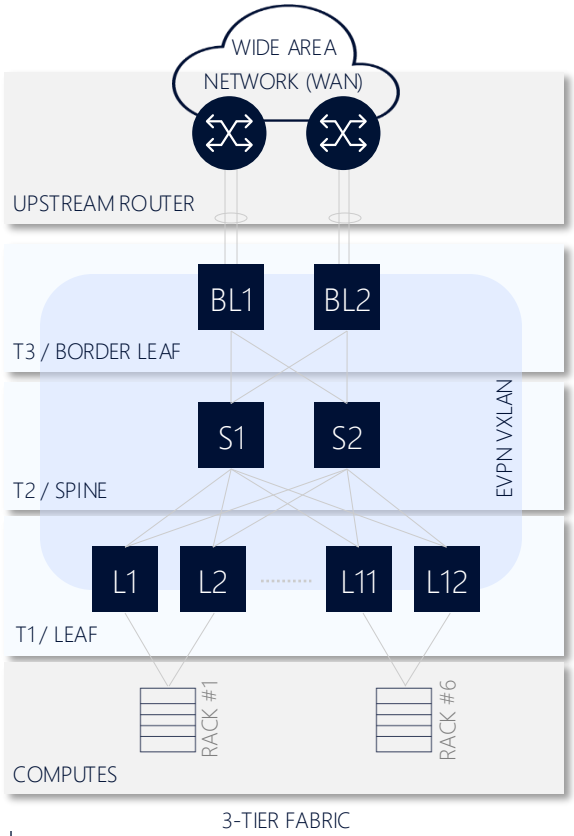
2-tier topology (leaf/spine)



2-TIER FABRIC

- 2 tiers:
  - Leaf
  - Spine
- VXLAN/VLAN handoff to upstream routers on spines.
- Well-suited for high external bandwidth (N/S)

3-tier topology (leaf/spine/border leaf)



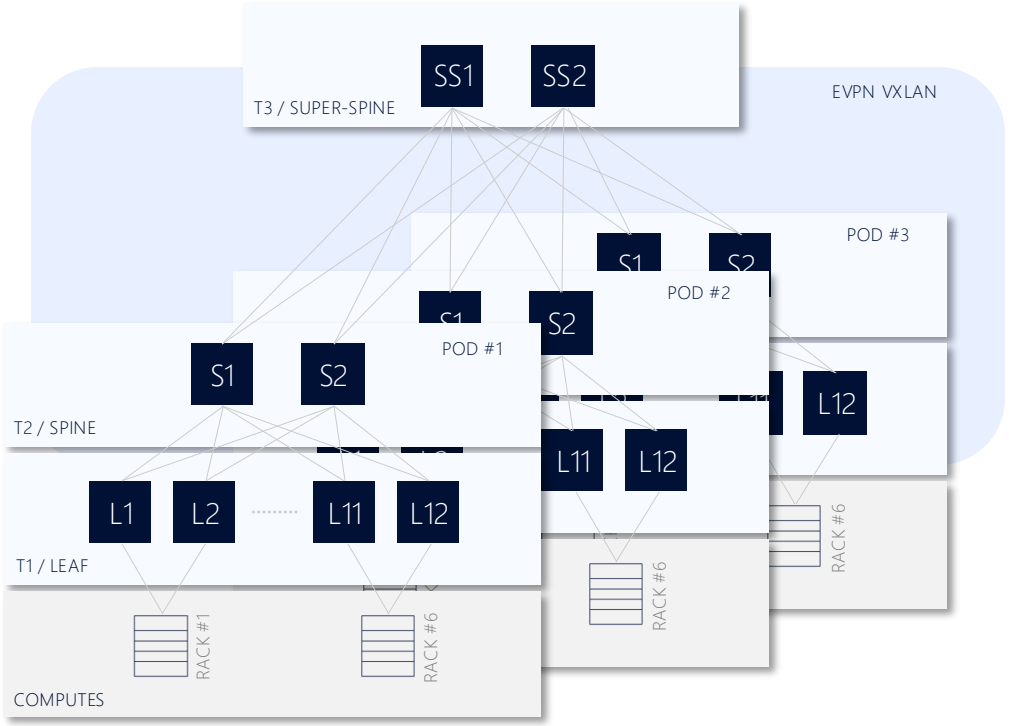
3-TIER FABRIC

- 3 tiers:
  - Leaf
  - Spine
  - Border leaf
- VXLAN/VLAN handoff to upstream routers on dedicated border leafs.
- Well-suited for high external bandwidth (N/S)

3-tier topology (multi-pod)

Design considerations (1/2)

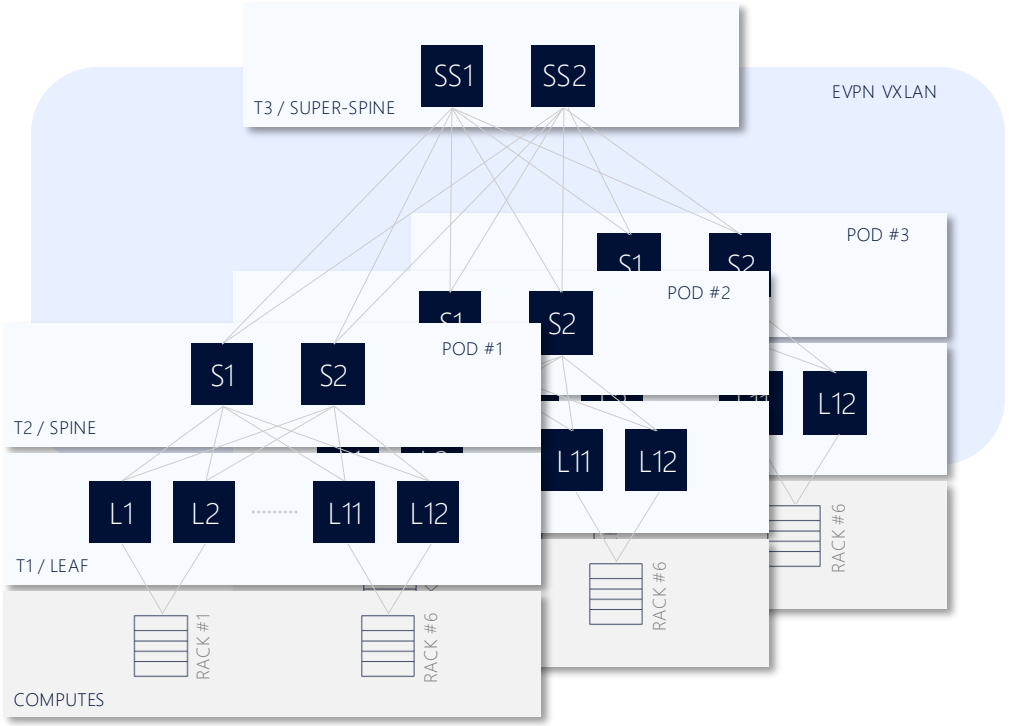
- A POD is composed of a pair of spines and its associated leafs.
- A multi-POD design is only possible with a 3-Tier topology.
- PODs are inter-connected at the super-spine layer.
- The EVPN VXLAN domain is extended accross the PODs.



3-tier topology (multi-pod)

Design considerations (2/2)

- The multi-POD design allows an incremental build up of the fabric. The fabric can grow without impacting the existing nodes & cabling.
- East-west communications between PODs require additional hops when traversing the super-spine layer – this impacts latency.
- It is recommended to keep applications having strict latency requirements within a single POD.



Agenda

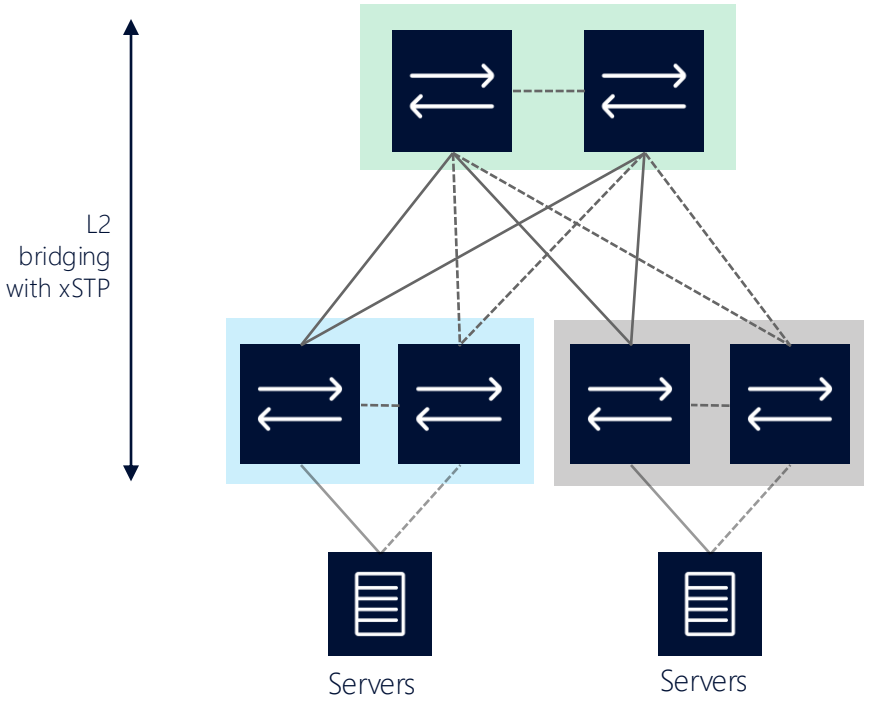
1. Data center architectures
   a. In a nutshell
   b. Physical
   c. Logical
2. EVPN basics
3. Live demo
4. Reference information

Agenda

1. Data center architectures
    a. In a nutshell
    b. Physical
    c. Logical
        a. Overview
        b. Underlay
        c. Overlay
2. EVPN basics
3. Live demo
4. Reference information

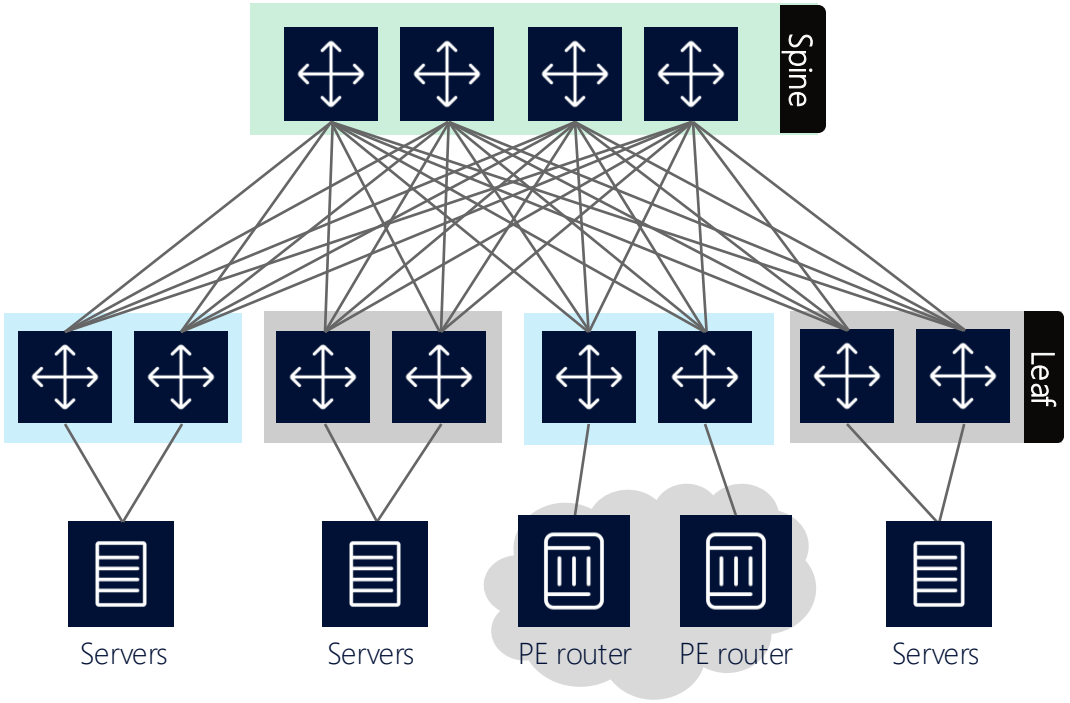
L2 fabric

Legacy design



- Scalability challenges
- Broadcast storms → STP and RSTP and MSTP
- Temporary L2 loops while converging
- Sub-optimal bandwidth usage
- Inefficient load distribution

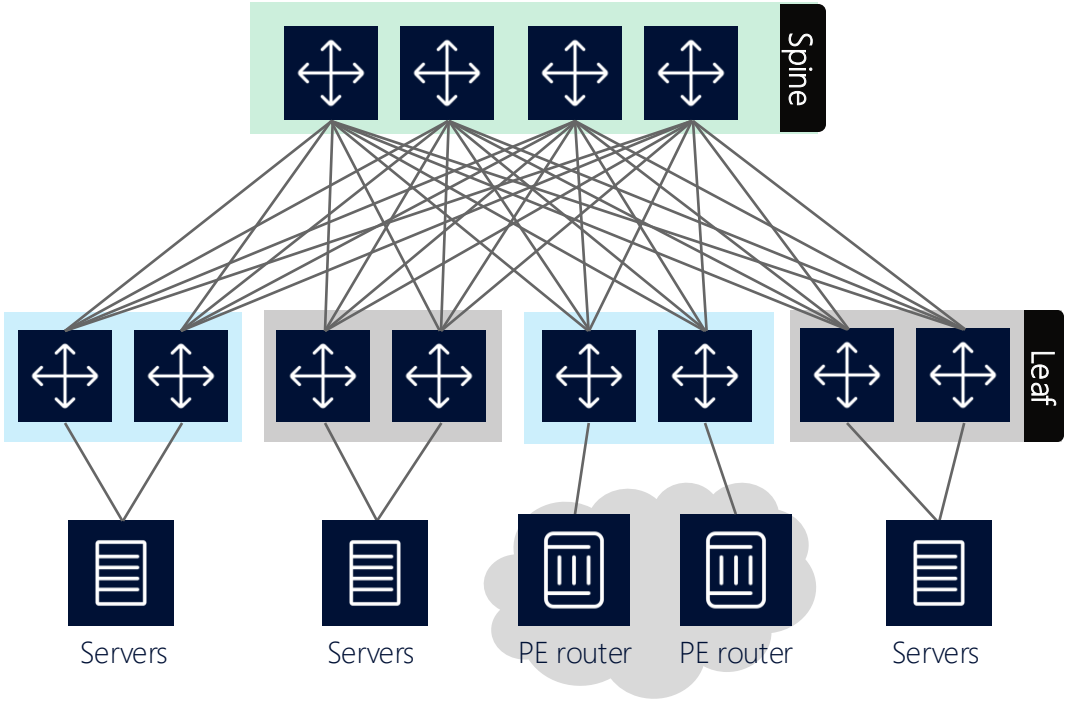
L3 Clos fabric



- Easy to scale up
- L2 loop-free
- Load balancing: ECMP and hash labels for extra entropy
- Design inputs
  - Workload BW – per rack BW
  - Traffic forecast and oversubscription ratio
  - Fault tolerance
  - Protocols: BGP, ISIS, OSPF

L3 fabric

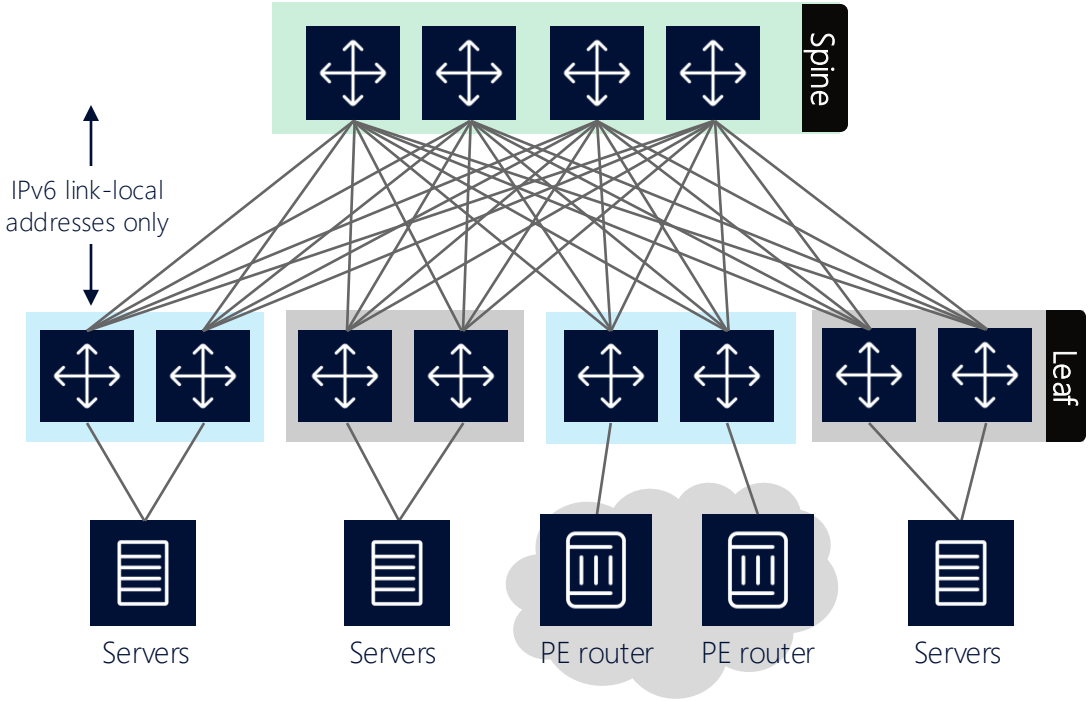
Underlay with eBGP/RFC 7938



- Simple design
- Scalable
- Lower HW resource consumption
- Flexible policy engine
- Smaller failure impact radius

L3 fabric

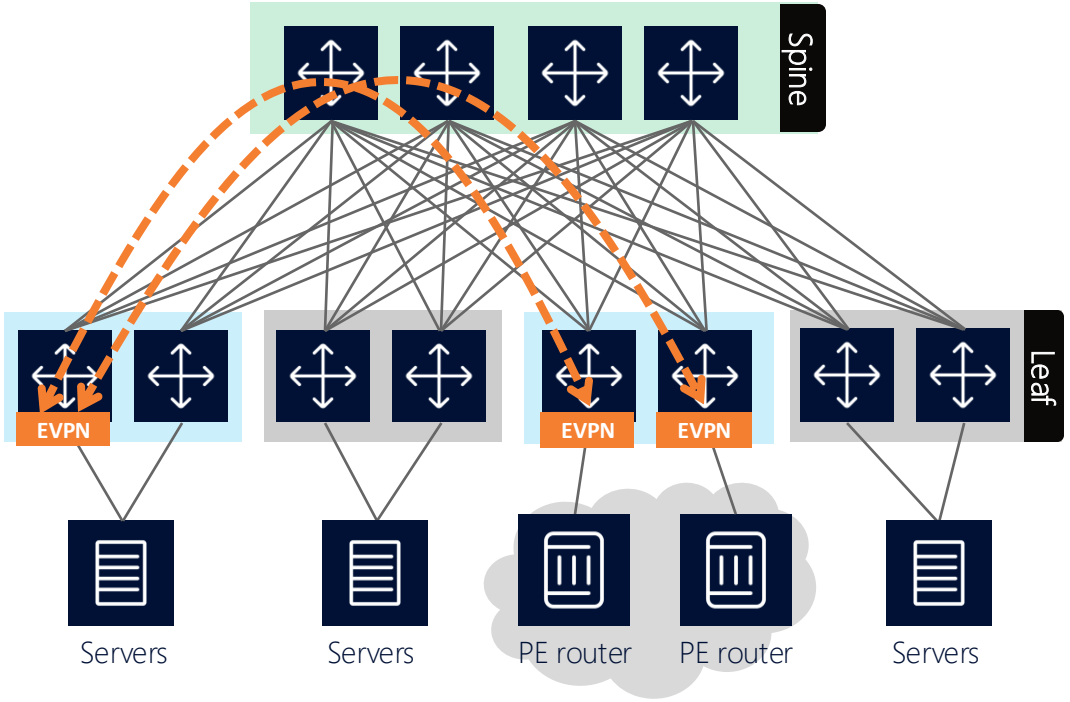
IPv6 unnumbered underlay



- Interfaces establish BGP sessions using IPv6 link-local addresses without needing a unique global IP address
- IPv6 ND Router Advertisements (RAs) are used to announce and learn peers' link-local addresses
- BGP unnumbered feature establishes the peerings based on the IPs exchanged

EVPN-VXLAN

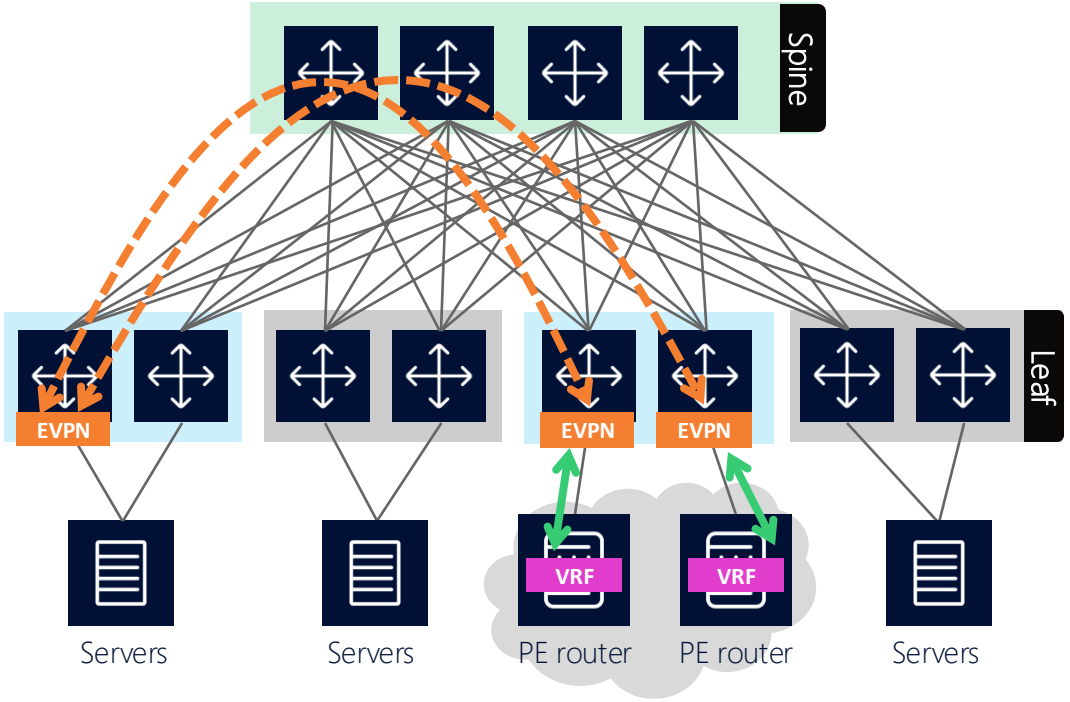
Overlay with EVPN



- Network segmentation
- Loop prevention
- L2 multi-homing
- Anycast gateway
- Host mobility
- ARP suppression

Connecting to WAN

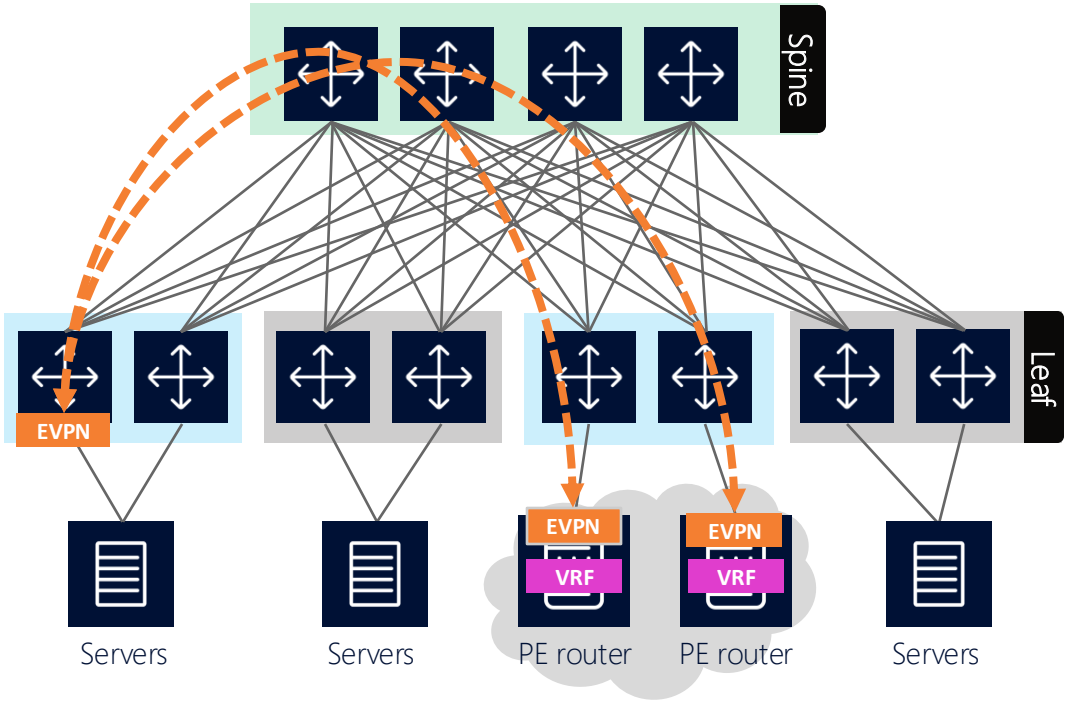
Vlan hand-off



- Clear demarcation between DC and WAN
- No need for high end PE
- For L2 networks, Ethernet Segments
- For L3 networks Inter-AS Option A

Connecting to WAN

Integrated model



- Faster convergence for L2
- Need for routing policies to segregate WAN and DC
- Need for a higher-end PE platform
- No need for Inter AS Option-A

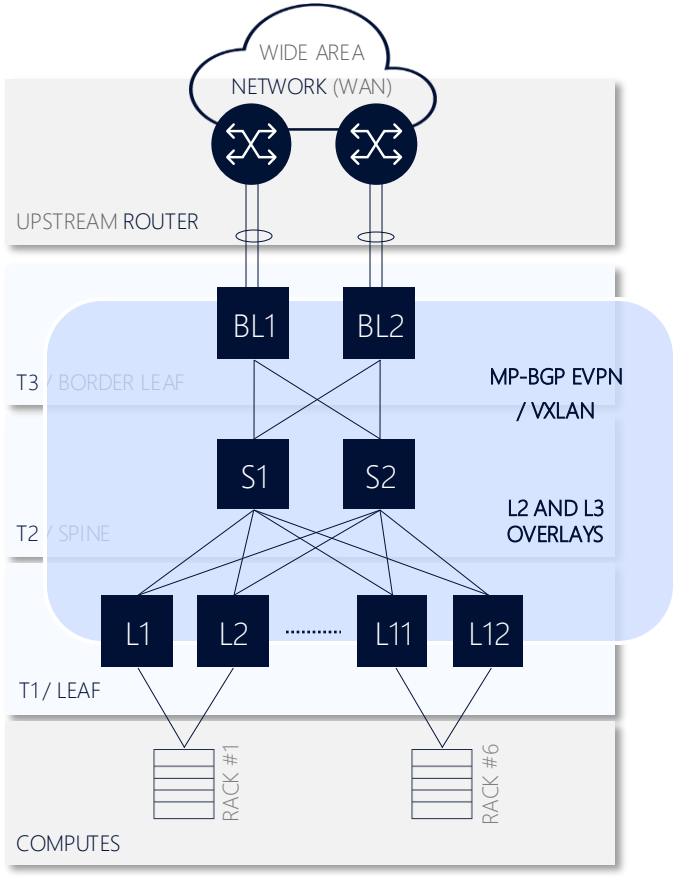
Agenda

1. Data center architectures
    a. In a nutshell
    b. Physical
    c. Logical
        a. Overview
        b. Underlay
        c. Overlay
2. EVPN basics
3. Live demo
4. Reference information

Fabric underlay

L3 Fabric with EVPN/VXLAN

- The Layer 3 spine and leaf architecture addresses limitations of the classic Layer 2 fabric such as spanning-tree protocol looping and multi-pathing uplink constraints by providing consistent and normalized any-to-any latency, throughput and performance for all racks while allowing simple scaling and a fully non-blocking architecture, if required.
- The L3 fabric routing is based on RFC7938 (Use of BGP for Routing in Large-Scale Data Centers) which describes a practical routing design that can be used in large-scale data centers.
- When building L3 Fabric, VXLAN and MP-BGP EVPN technologies are leveraged to provide control-plane and data-plane separation for both Layer 2 and Layer 3 forwarding in a VXLAN overlay network.

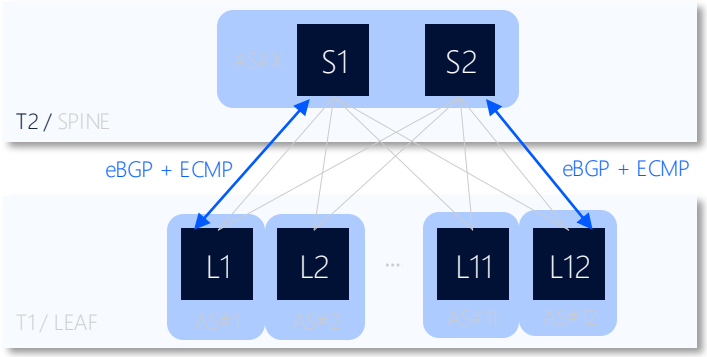


L3 FABRIC (MP-BGP EVPN/VXLAN)

Fabric underlay

BGP as underlay routing protocol (RFC7938)

- eBGP single-hop sessions are established over direct point-to-point links interconnecting the network nodes
- Private ASN (Autonomous System Number)
  - Each leaf with unique ASN
  - All spines/super-spines with same ASN per pod
- **IPv6 link-local addresses can be used on point-to-point links, along with BGP peer auto-discovery** to ease the planning & configuration process (implies that only a single IP address needs to be configured on each switch)
- No multi-hop or loopback sessions are used, even in the case of multiple links between the same pair of nodes.
- The point-to-point links are not advertised into BGP. Since the eBGP-based design changes the next-hop address at every device, distant networks will automatically be reachable via the advertising eBGP peer.
- There is no requirement for an IGP!
- **Only the system loopback interfaces (VTEP) are advertised across the fabric.**



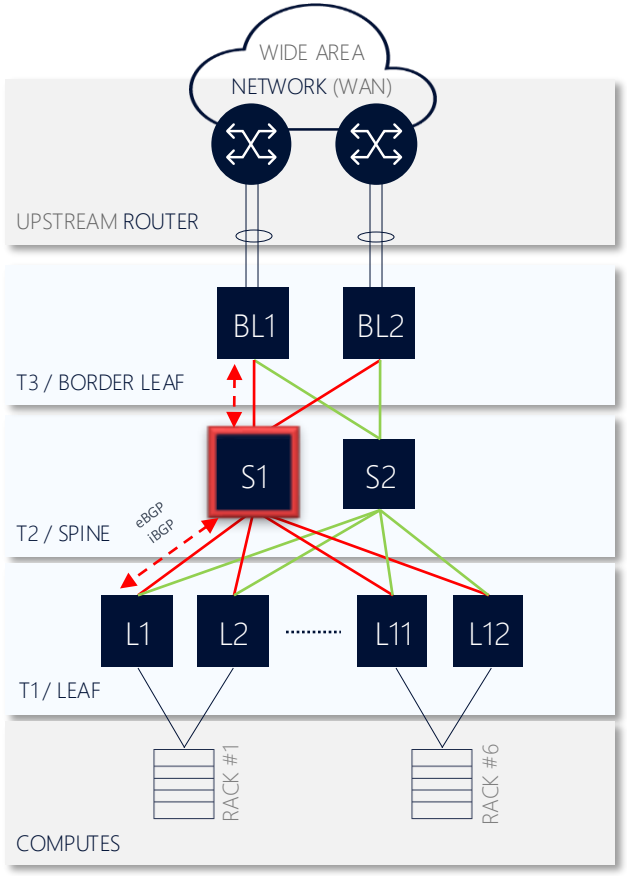
Recommendations for underlay

- Private ASNs (64512 – 65534), reused in different DCs
- IPv6 LLAs & BGP peer auto-discovery (*)

Fabric underlay

Resiliency

- Failure detection in the underlay relies on:
  - The **physical state of the links (L1)**. Any loss of signal (LOS) is immediately detected on both sides.
  - Or **Bidirectional Failure Detection (BFD)**, L3 protocol applied to BGP. A 100ms transmit interval with a multiplier of 3 is applied, offering a maximum failure detection time of 300ms.
- The BGP timers and route advertisements are optimized to speed up the convergence for both underlay and overlay EVPN (Rapid update / Rapid withdrawal)
- Once the fabric has converged, the flows are redirected to the other paths (BGP Multipath / ECMP)



3-TIER FABRIC

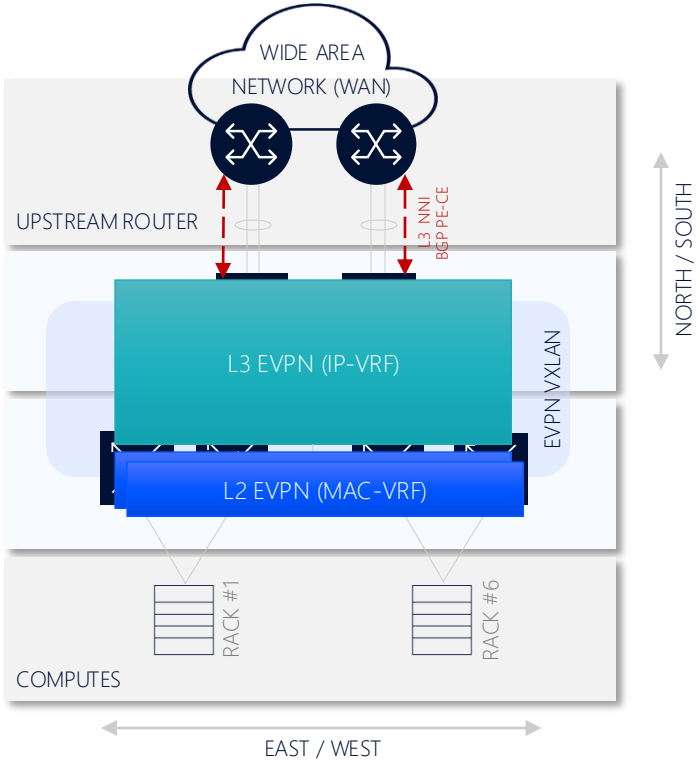
Agenda

1. Data center architectures
   a. In a nutshell
   b. Physical
   c. Underlay
   d. Overlay
2. EVPN basics
3. Live demo
4. Reference information

Overlay networks

EVPN/VXLAN Overlays

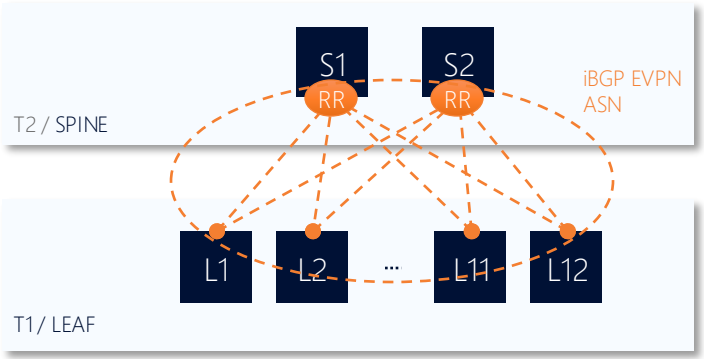
- Workloads (or tenants) networks are implemented as EVPN/VXLAN overlay networks.
- VXLAN and MP-BGP EVPN technologies are leveraged to provide control-plane and data-plane separation for both Layer 2 and Layer 3 forwarding.



Overlay networks

MP-BGP EVPN / VXLAN control plane

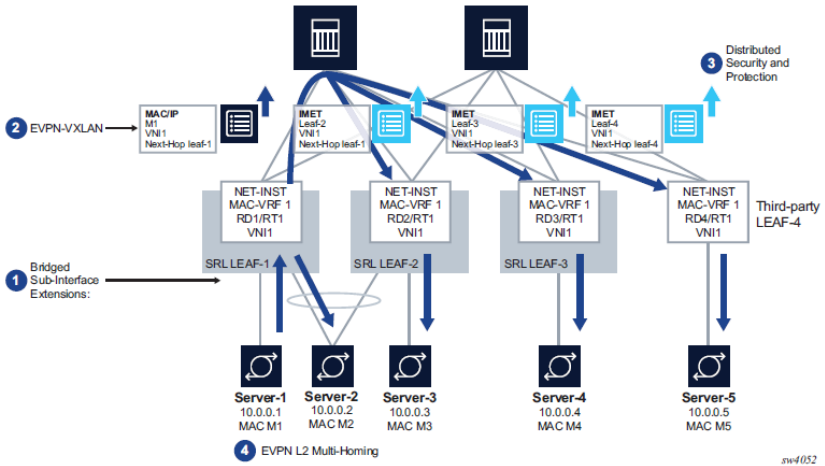
- The EVPN standard (RFC 7432) defines the functionality for delivering multi-tenant Layer 2/3 VPN services using VXLAN encapsulation across a common physical IP infrastructure.
- The EVPN control plane is supported by dedicated iBGP multi-hop sessions between VTEPs (leafs, border leafs) and route reflectors.
- The iBGP EVPN sessions are established between system loopbacks.
- In the 3-Tier & 2-Tier topologies the EVPN route reflector function is typically enabled on the spines. Each RR runs independently.



Overlay networks

L2 EVPN / MAC-VRF in SR-Linux (background for upcoming demo)

- The SR Linux EVPN-VXLAN solution supports using **Layer 2 Broadcast Domains (BDs)** in multi-tenant data centers. The primary usage for EVPN VXLAN tunnels (layer 2) is the extension of a BD in overlay multi-tenant DCs.
- The network-instance type mac-vrf functions as a broadcast domain. Each mac-vrf network-instance builds a bridge table composed of MAC addresses that can be learned via the data path on interfaces or via static configuration.
- **MAC duplication is the mechanism used by SR Linux for loop prevention.** MAC duplication monitors MAC addresses that move between sub-interfaces.
- Detection of duplicate MAC addresses is necessary when extending broadcast domains to multiple leaf nodes. Upon detecting a duplicate MAC, the MAC address will not be relearned anymore on this or any sub-interface ("stop-learning" action)



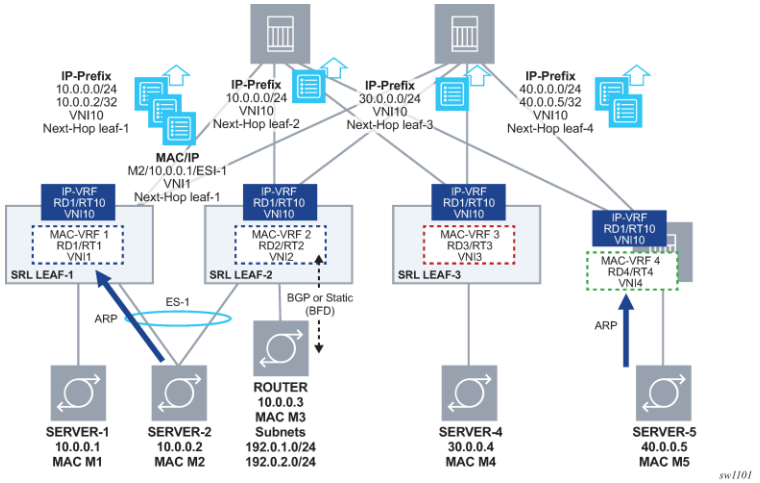
L2 EVPN (MAC-VRF)

Overlay networks

L3 EVPN / IP-VRF (background for upcoming demo)

- The SR Linux EVPN-VXLAN solution supports **L3 EVPN** routing, which provides **connectivity between subnets across multiple Broadcast Domains (BDs)** of the same tenant.
- The L3 EVPN solution implements the **EVPN Interface-less (IFL) model**, based on the advertisement and processing of IP prefixes using **EVPN type 5 routes (RT-5)**.
- All interfaces and local routes in an IP-VRF are automatically advertised in RT5s without the need for any export policy.

.



L3 EVPN (IP-VRF)

Overlay networks

L3 EVPN / PE-CE routing (background for upcoming demo)

- Routing mechanism is needed when server workloads need to advertise/receive non connected prefixes to/from the DC leaves or to/from a PE router connected. Two routing mechanisms exist in L3 IP-VRF to route to external workloads:
  - Static Routing: this requires both sides of the routing to know the prefixes behind the next hop - BFD is necessary to avoid blackholing traffic to far end that may not be operational.
  - eBGP (PE-CE): using dynamic routing to allows dynamic prefix exchange and control of advertisements - usually toward PE or cMG workloads.

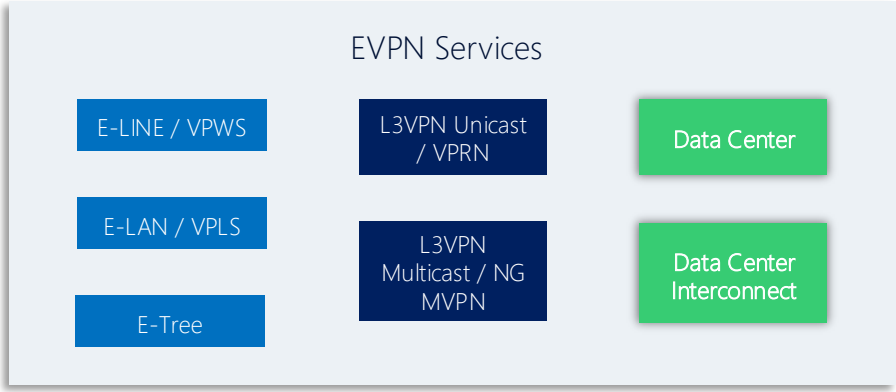
Agenda

1. Data center architectures
2. **EVPN basics**
3. Live demo
4. Reference information

What is Ethernet VPN ?

- **VPN services** were traditionally delivered using **a different technology per service type** : for instance, BGP/LDP to deliver VPLS and VPWS, MP-BGP/MPLS to deliver IP VPNs, and BGP/PIM to deliver multicast VPNs. Combined together, these technologies **add complexity and increase the operational costs** for service providers.

- Ethernet virtual private network (**EVPN**) introduces a **unified model** for VPNs and cloud-based services, by providing a **control plane framework** that can deliver **any type of VPN services**.



➢ Specifications for **overlays in data centers** are defined based on RFCs. Notably, they describe how to use EVPN across VXLAN or MPLS tunnels.

For further reference,
RFC 7432 - BGP MPLS-Based Ethernet VPN (ietf.org)
RFC 8365 - A Network Virtualization Overlay Solution Using Ethernet VPN (EVPN) (ietf.org)
RFC 9014 - Interconnect Solution for Ethernet VPN (EVPN) Overlay Networks (ietf.org)

Ethernet Virtual Private Networks RFC7432

EVPN baseline spec as a VPLS replacement

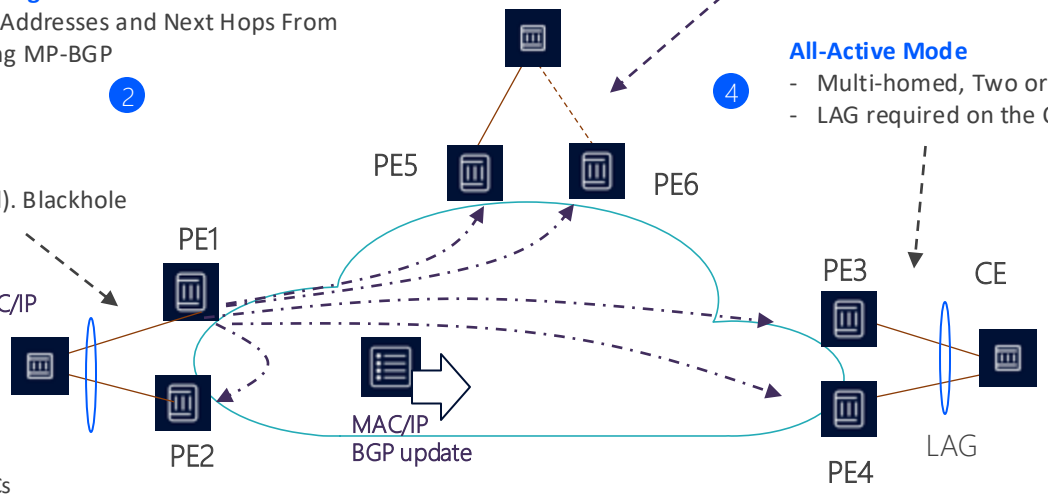
Control Plane Learning
PEs Advertise MAC Addresses and Next Hops From Connected CEs Using MP-BGP

2

Data Plane Learning
Dynamic or Static (Provisioned). Blackhole available.

1

Customer Edge (CE)
Host, VM, Router or Switch



MAC-VRF / BD (Broadcast Domain)
Virtual Routing Forwarding table for MACs
MAC-VRF==BD (if vlan-based/vlan-bundle)

EVPN Instance (EVI)
Group of MAC-VRFs (BDs) forming a VPN

3

Data Plane Encapsulation
Agnostic
MPLS, SR-MPLS, VXLAN, SRv6

4

Single-Active Mode
- Multi-homed
- One Active PE

All-Active Mode
- Multi-homed, Two or More Active PEs
- LAG required on the CE

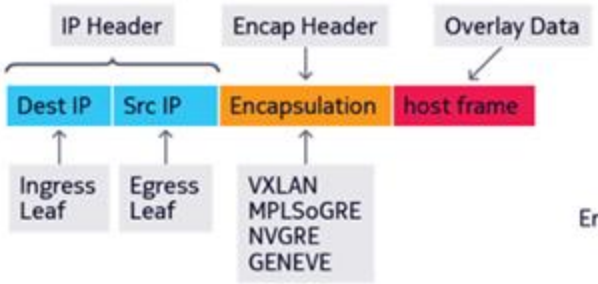
Ethernet Segment (ES) and virtual ES
- Link(s) that Connect the CE to PEs (ESIs are Unique Across the Network)
- An ES on a PE can contain LAG, port, MPLS tunnel, PW, vlan, QinQ tag combinations, VXLAN instance

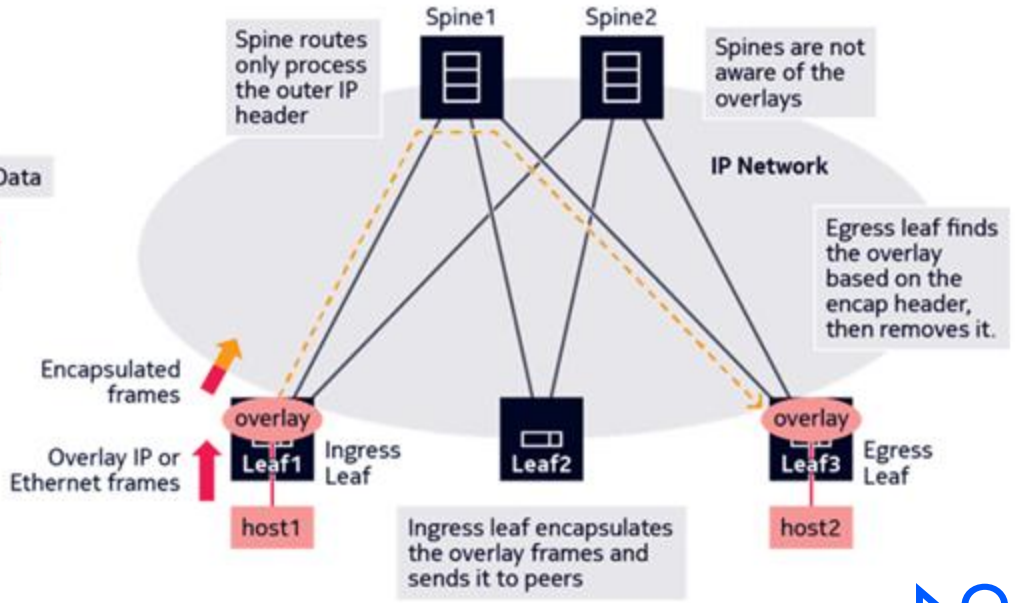
EVPN

Supported data planes

EVPN supports multiple data plane technologies for tunneling overlay networks

- Service Providers prefer MPLS (and PBB for very large-scale networks)
- IP-based encapsulation in the data center:
  - VXLAN is the most popular
  - Also MPLSoGRE, NVGRE, GENEVE





EVPN

VXLAN in data centers

VXLAN - Virtual eXtensible Local Area Network

- VXLAN is a Layer 2 overlay using an existing Layer 3 network infrastructure (underlay)
- VXLAN is defined in RFC7348
- Was in use well before EVPN

VXLAN became a de-facto standard in data center networking

- Allows the creation of L2 overlay networks that span the whole data center:
  - Scale up to 16M tenants (vs 4K with VLANs), isolating each overlay from each other
  - Seamless VM mobility within the data center
- Leverages the underlay IP networks:
  - To avoid loops (no more Spanning Tree Protocol)
  - To provide efficient multi-path load-balancing with ECMP
- However, RFC 7348 does not specify a control plane:
  - VXLAN uses Flood-and-Learn in the data plane
  - Requires static configuration to learn about other VXLAN endpoints

EVPN

VXLAN terminology

VXLAN tunnels:

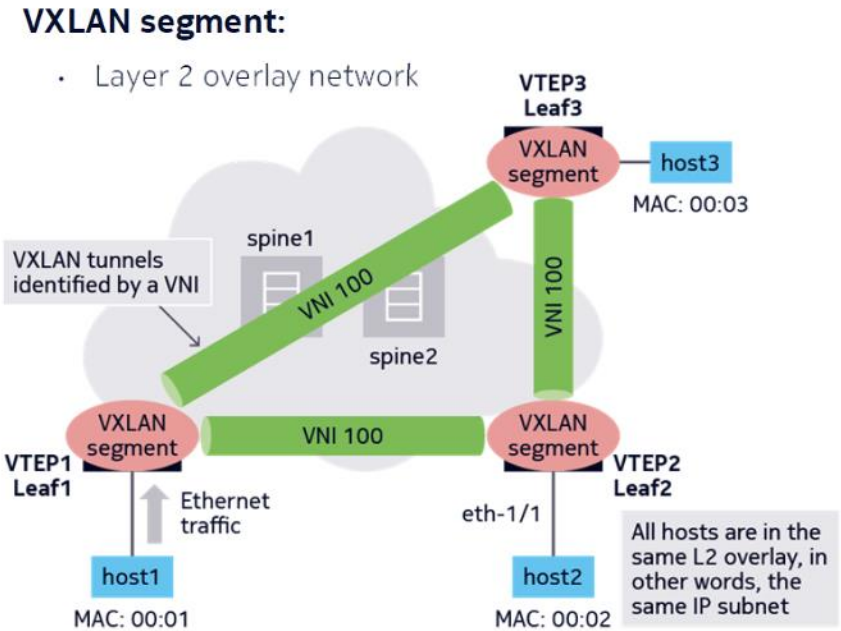
- To implement an overlay network, traffic is encapsulated with an extra header identifying the overlay. VXLAN is one of such encapsulation techniques.
- Encapsulated traffic flows between two end-points over the underlay network - hence the name 'tunnel'.

VXLAN Tunnel End Point (VTEP):

- Egress and Ingress point of the encapsulated traffic.
- Typically, the leaf routers
- The spine routers are not aware of the VLAN tunnels

VXLAN Network Identifier (VNI):

- 24-bit integer uniquely identifying a VLAN segment network-wide



EVPN

VXLAN-encapsulated frame

VLAN encapsulates Ethernet in IP:

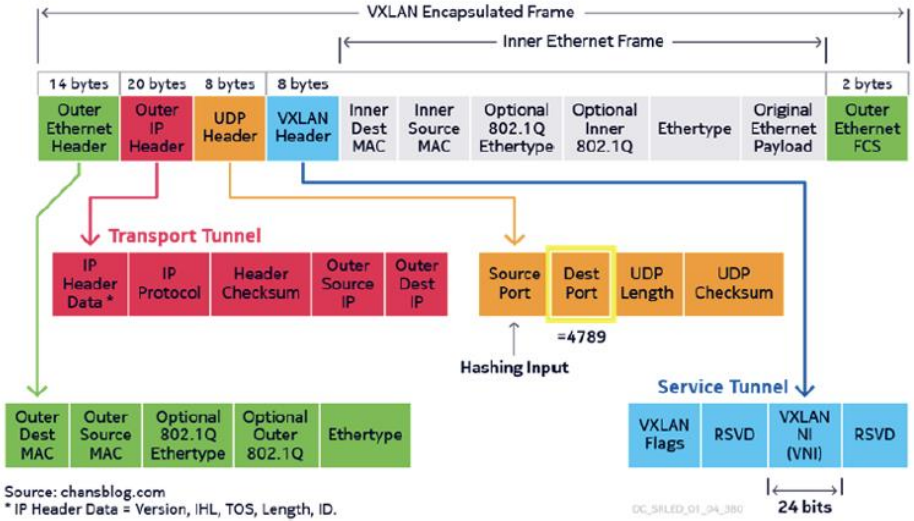
- UDP-based (port 4789)
- UDP source port is a hash of the original payload MAC, IPs, and ports to provide flow-based load balancing entropy

8-byte VXLAN header:

- VXLAN Network Identifier (VNI) 24-bits
- Allows for 16M overlays

Since VLAN is IP-based, it can be routed over any IP network:

- Enable ECMP for load-balancing
- Network must support the 50-byte encapsulation overhead



Why is EVPN used in modern DCs?

RFC8365

Modern DCs are based on:

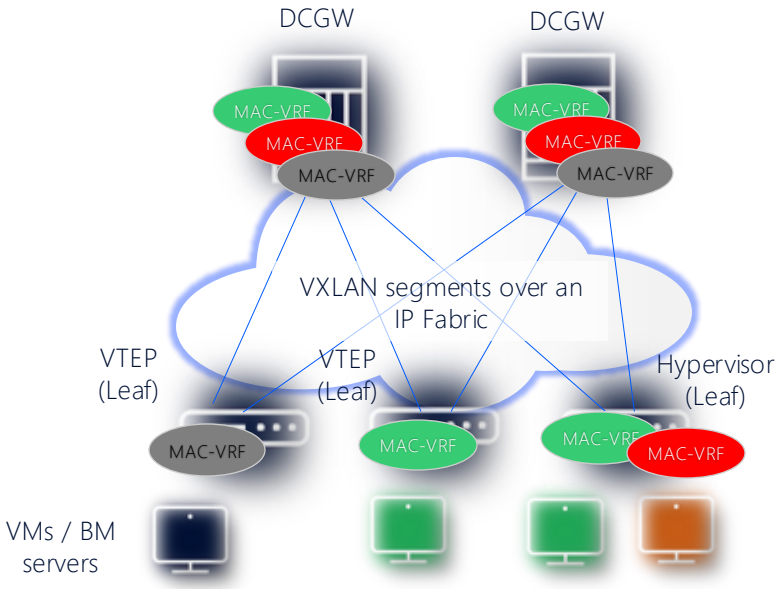
- CLOS architecture and IP Fabrics
  - No loops, no flooding, fast convergence
  - ECMP
- Multi-tenancy with intra (L2) and inter-subnet (L3) connectivity
- IP overlay tunnels are therefore needed (VXLAN is the most popular option)

Why do I need a control plane?

- Auto-discovery of the remote VTEPs
- Distribution of MAC/IP information in order to reduce/suppress flooding

What are my options?

- PIM, but…
  - Requires tenant states in the core (SG, *G)
  - Does not reduce/suppress broadcast/multicast
  - Does not do inter-subnet-forwarding
- EVPN
  - YES!



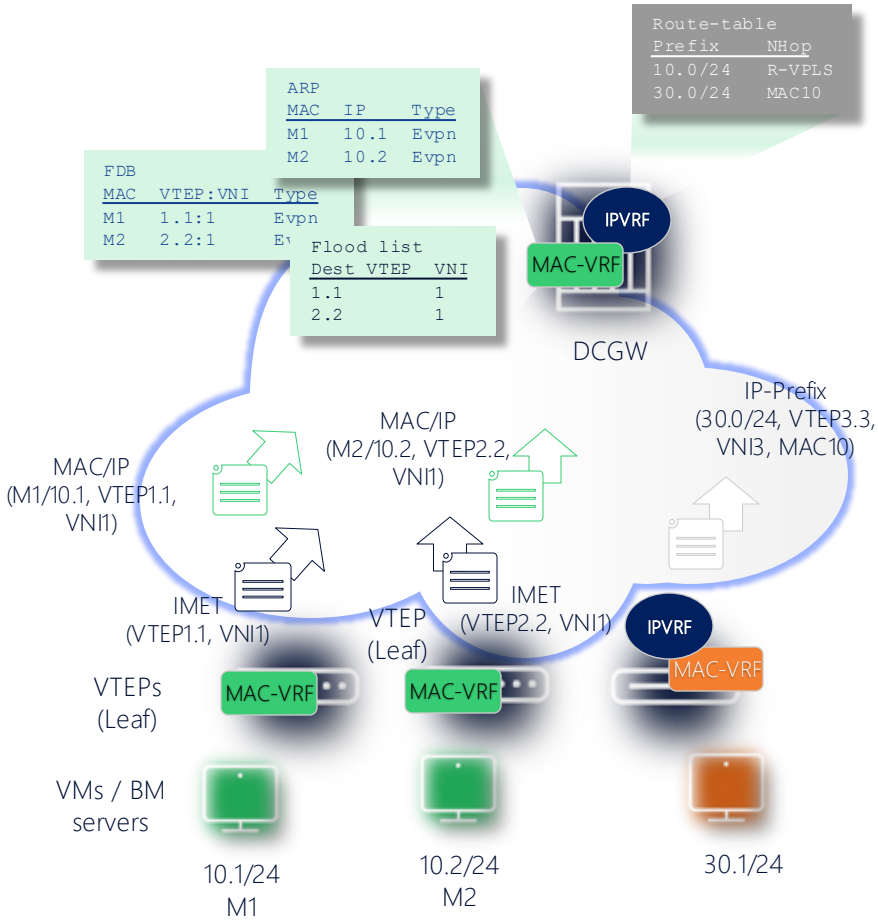
EVPN for VXLAN tunnels

EVPN provides the basic Control Plane needs…

- Auto-discovery of remote VTEPs through Inclusive Multicast Routes (IMET)
- Distribution of MAC/IP information in order to reduce/suppress flooding through MAC/IP routes

But also advanced options

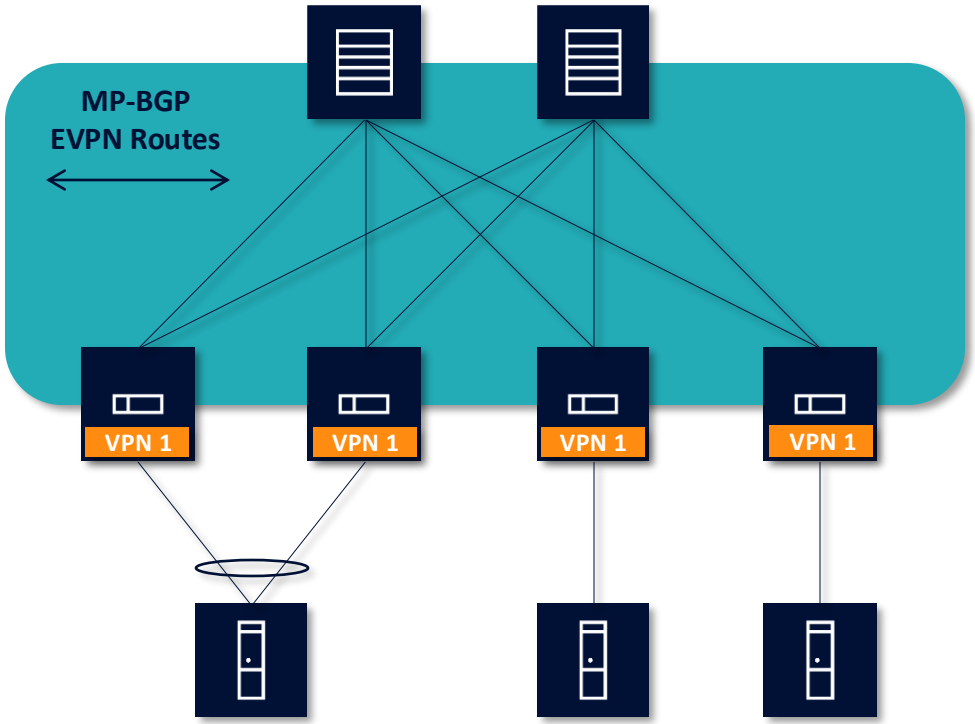
- Distribution of IP-Prefixes so that not all the subnets must be defined in all the NVEs (through IP-Prefix type 5 routes)
- MAC/IP mobility
- MAC protection, duplication detection, loop protection
- Proxy-ARP/ND
- Assisted-Replication
- Service-chaining



Control plane

EVPN in data centers

- EVPN relies on **MP-BGP** in the service provider network, i.e. the data center fabric.
- Several EVPN route types are defined:
  - EVPN routes are **exchanged between leafs**, via a route reflector or not.
  - Route types advertised are based on the **use case** and the **type of service** being delivered.



Control plane – EVPN route types

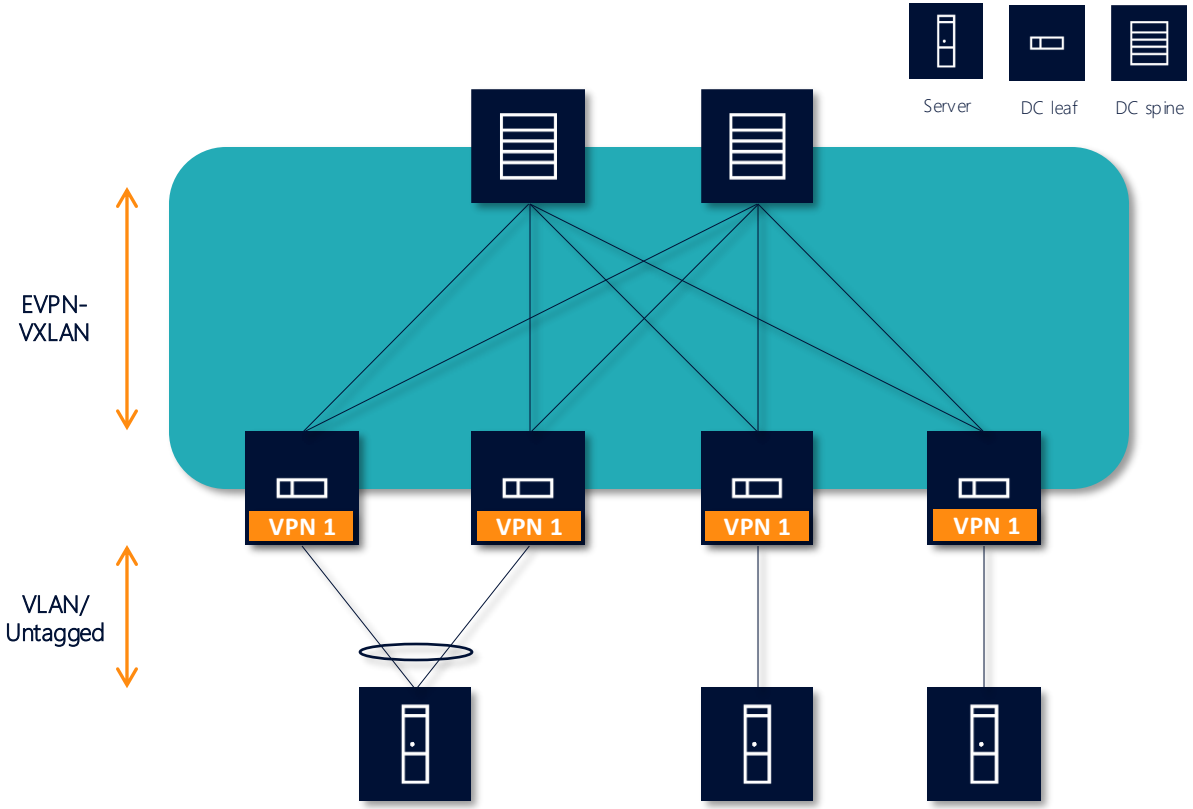
EVPN in data centers

Route type	Route name	Purpose
1	Ethernet Auto-Discover (A-D)	Used in multi-homing scenarios to support aliasing and fast convergence
2	MAC/IP Advertisement	Used to advertise host MAC address or host MAC/IP addresses
3	Inclusive Multicast Ethernet Tag (IMET)	Used to discover member PEs and to setup the flooding tree for BUM traffic
4	Ethernet Segment (ES)	Used in multi-homing scenarios to suppport Ethernet segment discovery and DF election
5	IP-Prefix	Used to advertise IP prefixes for inter-subnet connectivity in L3VPN services

Data plane

EVPN in data centers

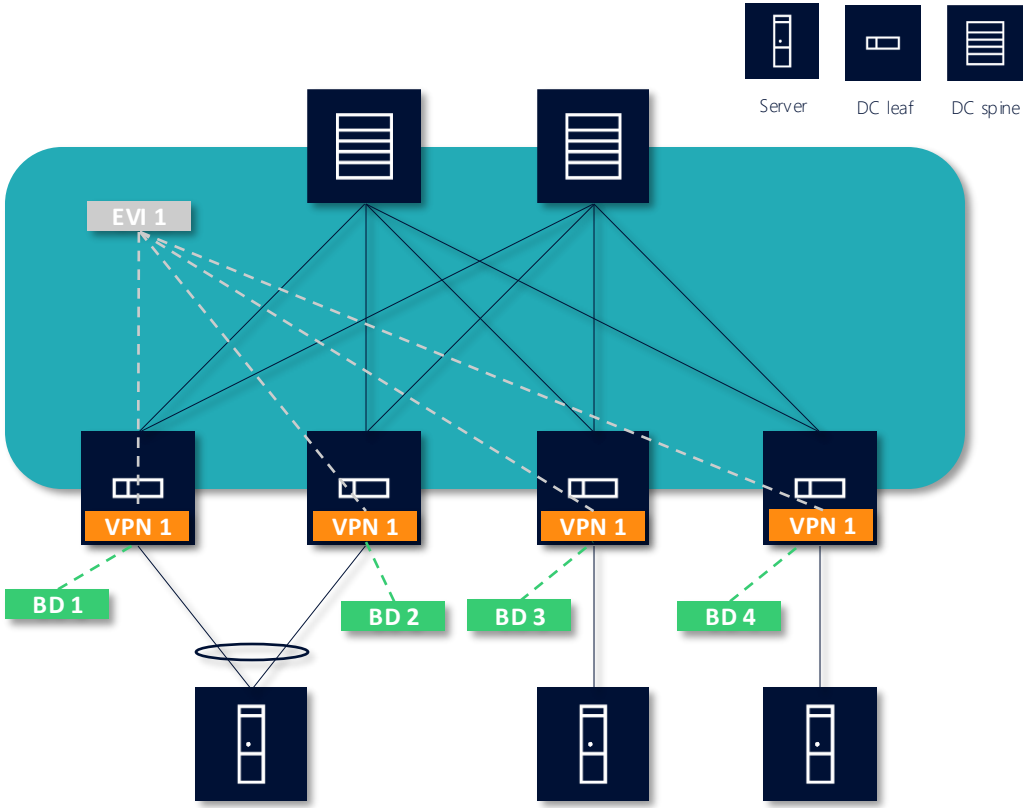
- EVPN allows the delivery of multiple services over a single core network
- Leafs encapsulates customer data with a **label that uniquely identifies each service**
- Encapsulated data is **tunnelled between leafs** (or border leafs, or DCGWs).
- **VXLAN** tunnels are used within the fabric.
- **MPLS** tunnels are used within IP/MPLS networks.



Layer-2 services - terminology

EVPN in data centers

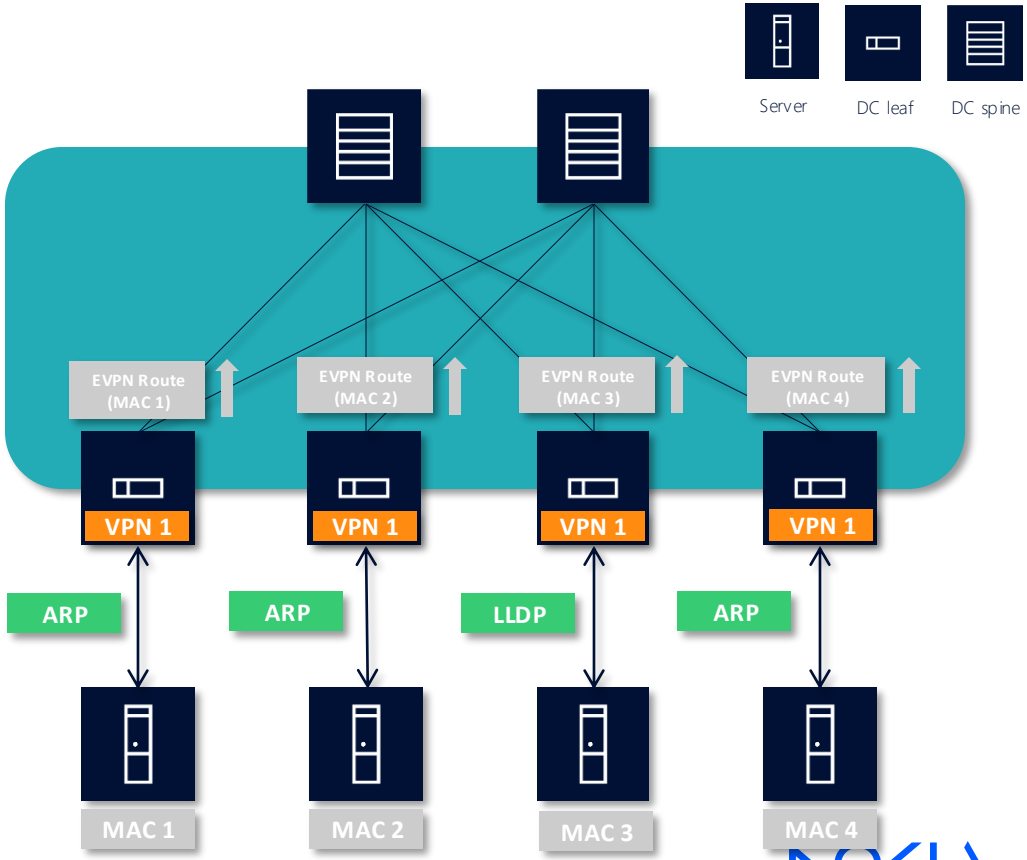
- Broadcast domain (BD)
  - An instantiation of an EVPN service on a given leaf
- MAC-VRF
  - The virtual routing and forwarding (VRF) table that contains the MAC addresses for an EVPN service
- EVPN instance (EVI)
  - The group of BDs that are part of the same EVPN service



Layer-2 services – EVPN operation

EVPN in data centers

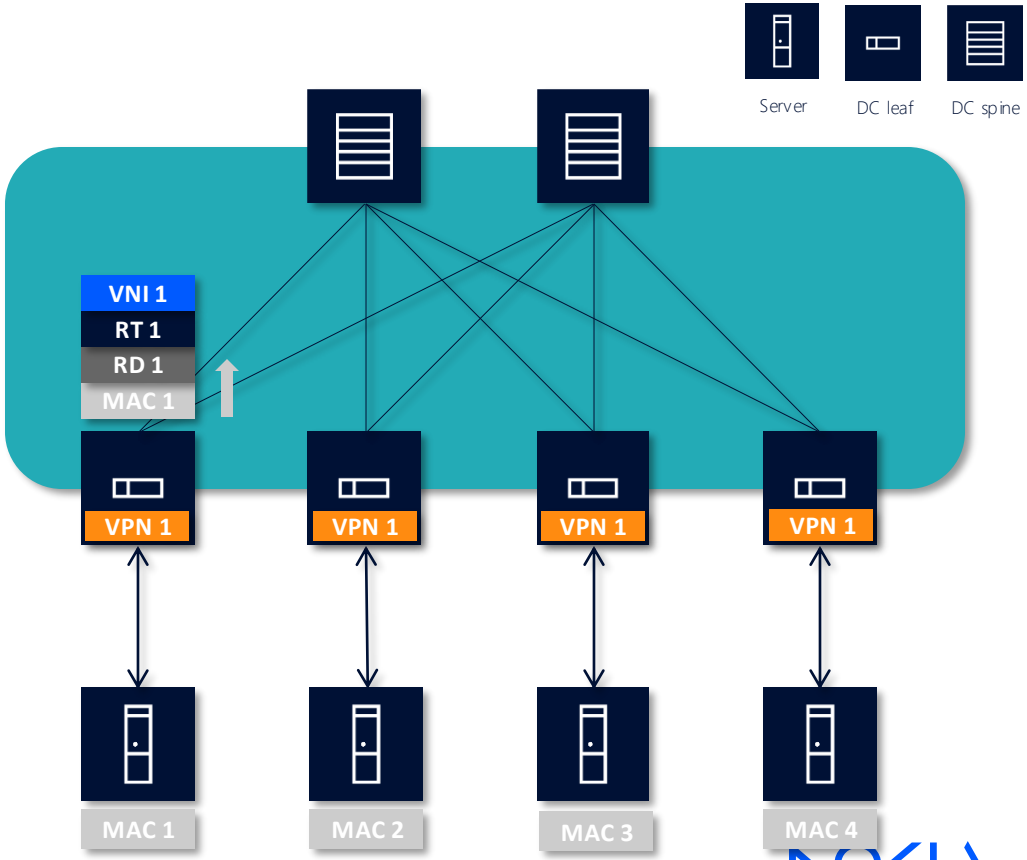
- EVPN enables control-plane MAC learning in the core
- Leafs exchange EVPN routes over MP-BGP to advertise local MAC addresses across the fabric
- Attached clients can be physical or virtual
- Leafs learn MAC addresses of locally-connected clients using data-plane learning, static provisioning or control-plane protocols.



Layer-2 services – leaf-to-leaf MAC address advertisement

EVPN in data centers

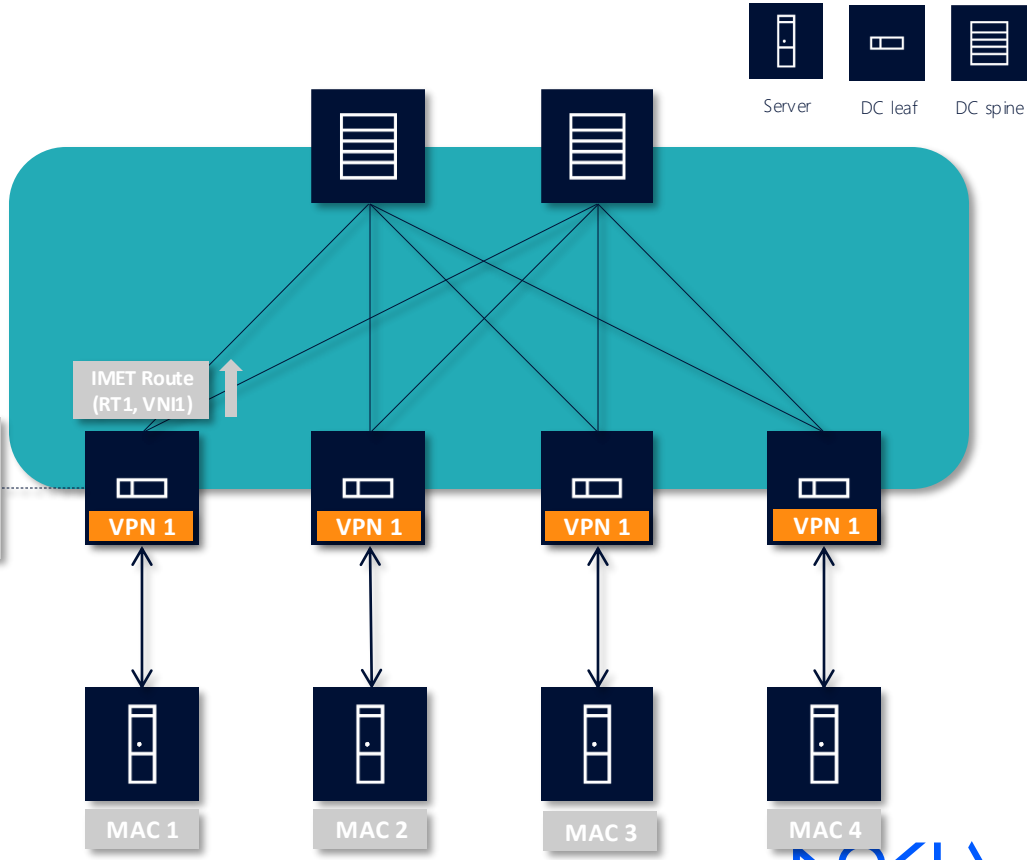
- Leafs advertise **locally-learned MAC addresses** using **MAC/IP routes** (EVPN route type 2)
- A single MP-BGP instance handles the exchange of routes for all EVIs on the leaf
- **Route distinguisher** is used to distinguish routes between EVIs in case of overlaps. **Route targets** identify which EVPN routes are to be installed in the local MAC-VRF
- Provided label (i.e. **VxLAN network identifier**) is used by remote leafs when encapsulating frames destined to the advertised MAC address



Layer-2 services – flooding lists & BUM traffic handling

EVPN in data centers

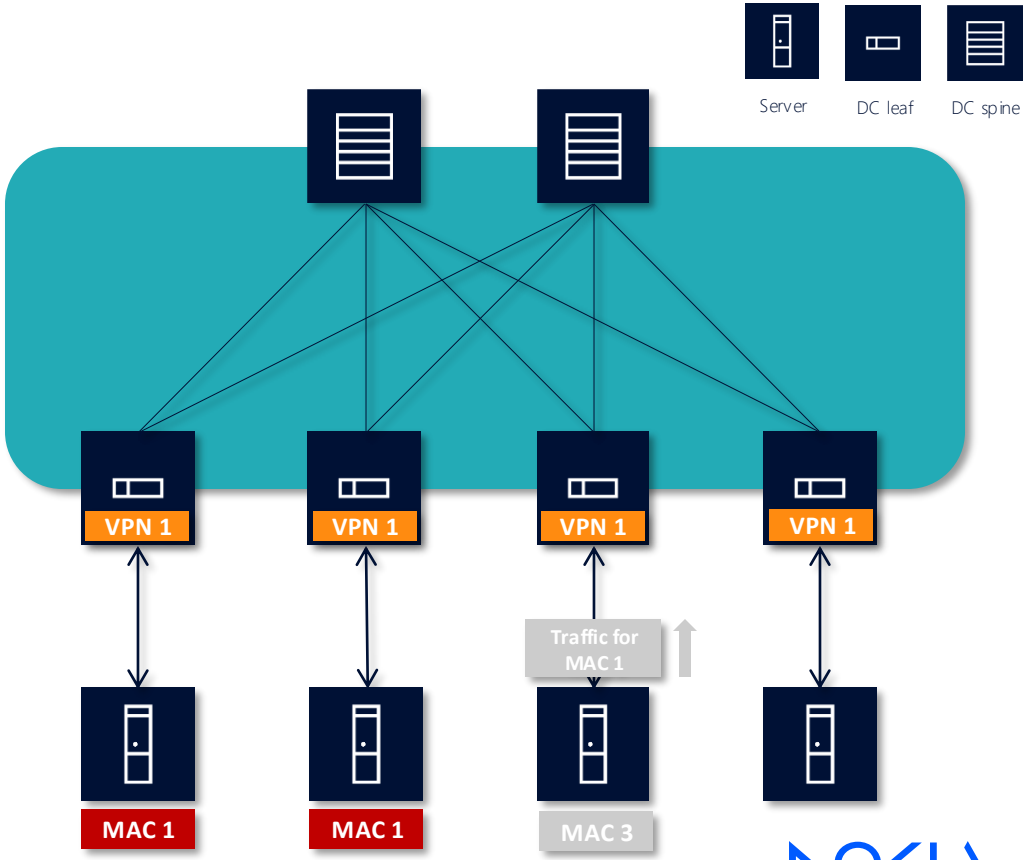
- When an EVPN service is enabled, leafs participating in this service exchange **inclusive multicast Ethernet tag routes** (**IMET** or type 3)
  - Discover all leafs attached to the same EVI
  - Build a flooding list in each leaf
- A leaf receiving a **BUM frame** from a client, **consults the flooding list** of the EVPN service to determine the leafs to which it needs to flood the frame
- A leaf receives this encapsulated BUM frame from the fabric, **decapsulates** the packet and then **floods it to its local interfaces**
  - Due to **split-horizon**, the BUM frames are never flooded back to the fabric



Layer-2 services – dealing with layer 2 loops

EVPN in data centers

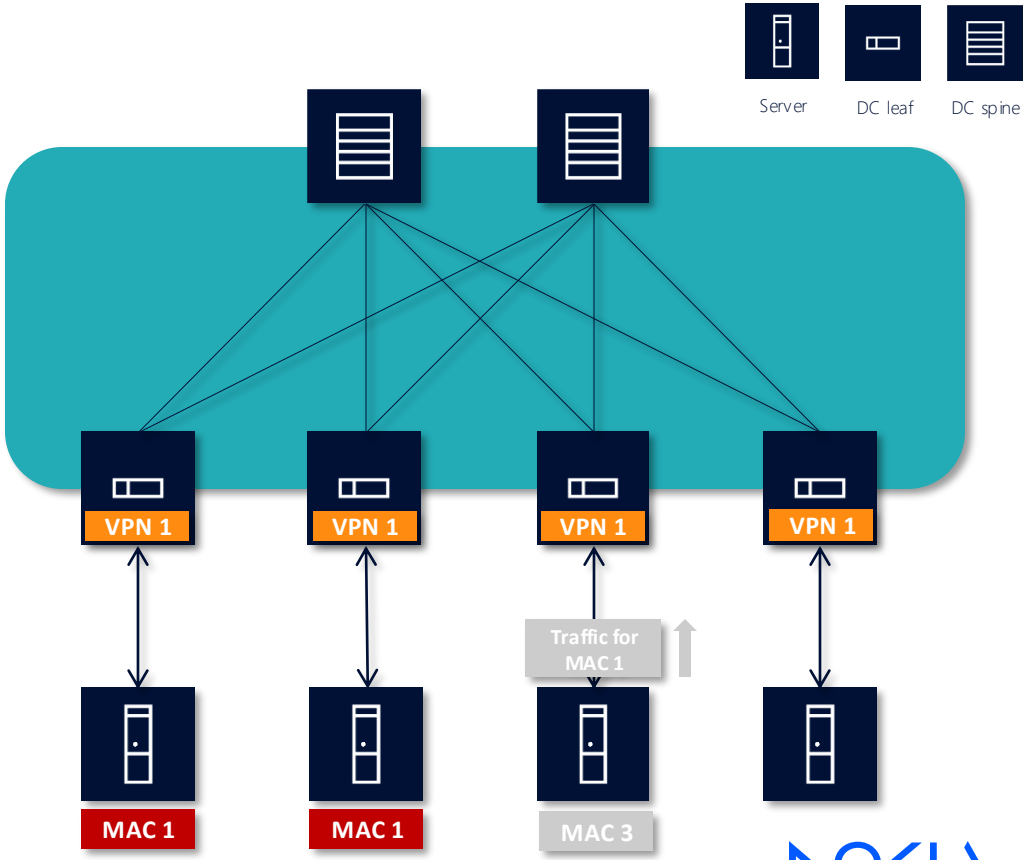
- The detection of duplicate MAC addresses and loops is a fundamental feature when extending a broadcast domain
- L2 loops or duplicate MACs are typically due to a configuration mistake or an intended spoofing attack.
- MAC duplication is the mechanism used by SR Linux for loop prevention. MAC duplication monitors MAC addresses that move between subinterfaces. It consists of detection, actions, and process restart.



Layer-2 services – MAC-duplication as loop protection mechanism

EVPN in data centers

- A MAC is declared **duplicate** if it is learnt on **different interfaces** and **the number of moves is higher than a certain value** (num-moves) within a certain interval (monitoring-window).
- A **configurable action** can be performed on the subinterface when a duplicate MAC is detected. One of three options can be selected (stop-learning, blackhole, oper-down).
- The **MAC remains "duplicate"** for the duration of the **hold-down-time** parameter. At the end of that interval, it is flushed from the bridge table and the action on the subinterface is cleared.



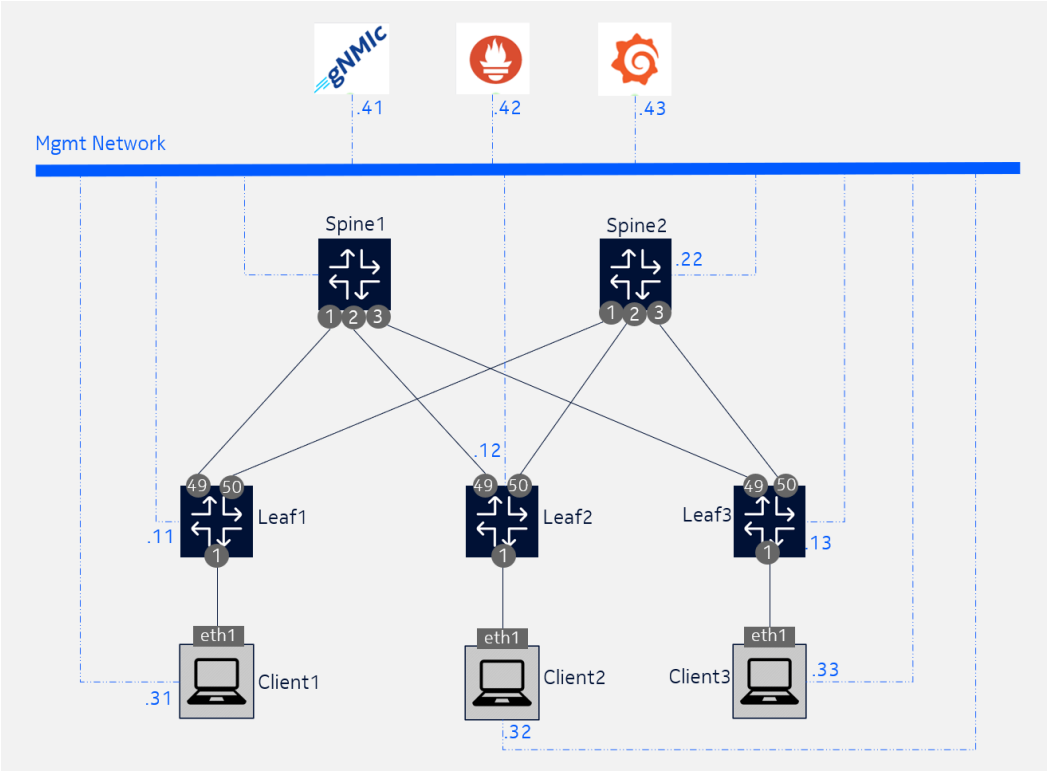
Agenda

1. Data center architectures
2. EVPN basics
3. **Live demo**
4. Reference information

DC fabric lab

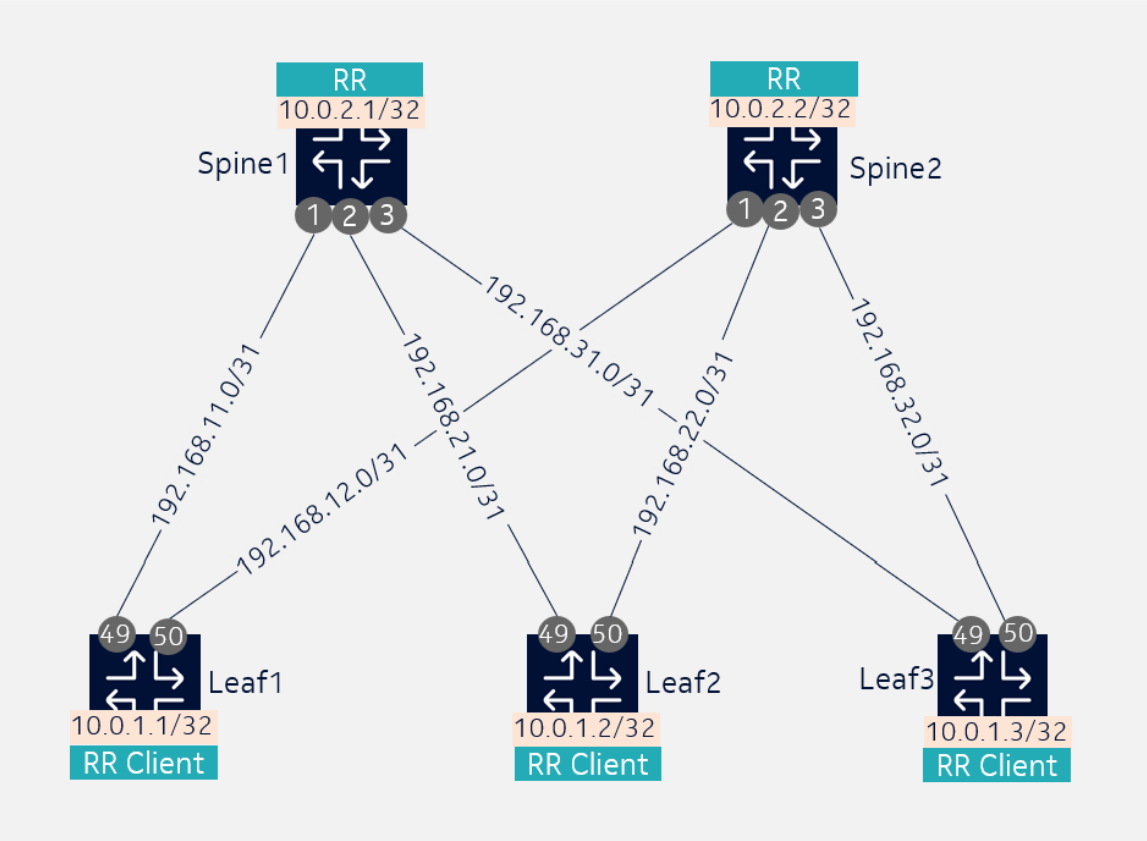
https://github.com/pkhatri-nokia/dcf-demo

DC fabric lab



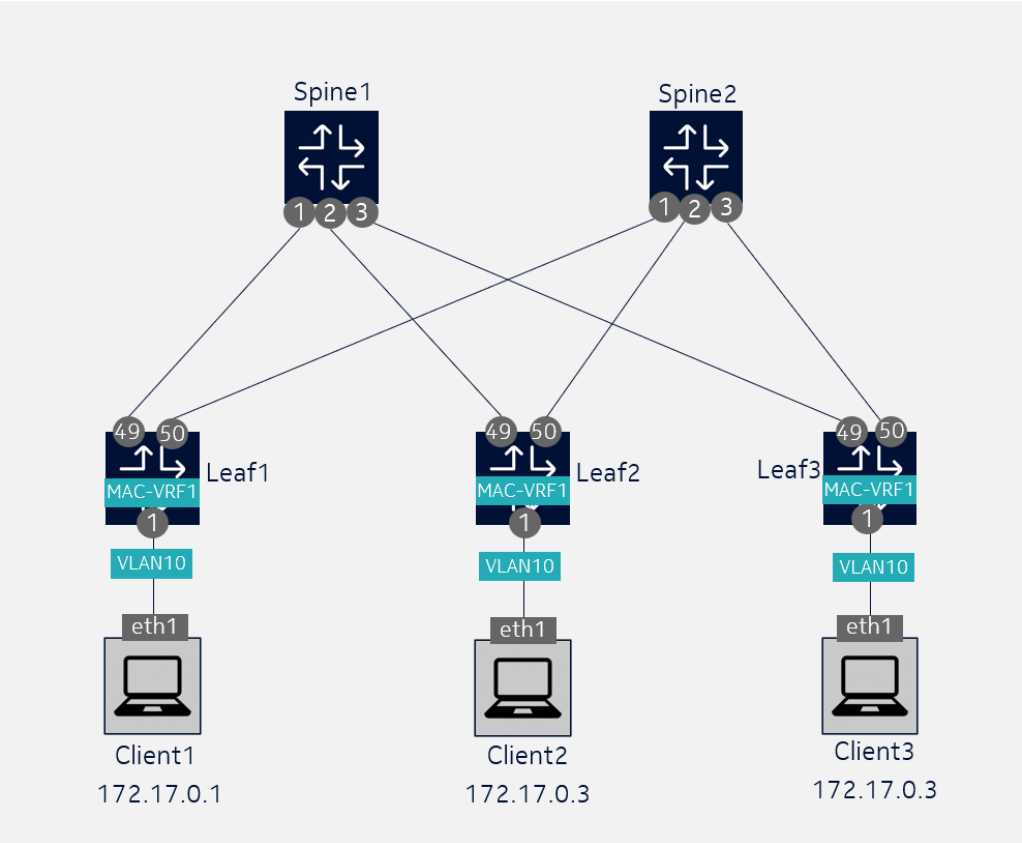
DC fabric lab

Underlay



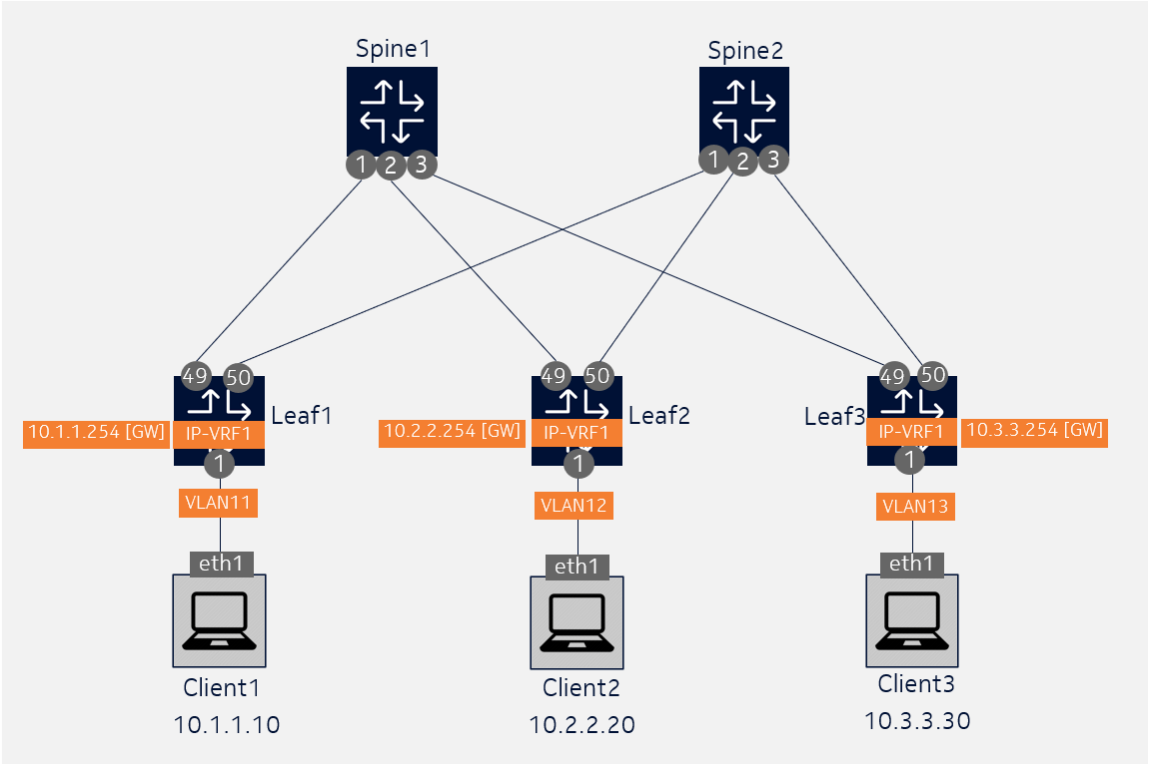
DC fabric lab

L2 service



DC fabric lab

L3 service



Agenda

1. Data center architectures
2. EVPN basics
3. Live demo
4. Reference information

Resources and documentation

- Official documentation, publicly accessible
  No account needed, no license
  https://documentation.nokia.com/srlinux/

- "Get started" guide, tutorials, exercises for free
  https://learn.srlinux.dev/

- Discord – online community of SR Linux users
  https://discord.gg/tZvgjQ6PZf

Agenda

1. Data center architectures
2. EVPN basics
3. Live demo
4. Reference information
    a. Containerlab
    b. SR-Linux CLI fundamentals
    c. EVPN on SR-Linux
    d. EVPN multi-homing

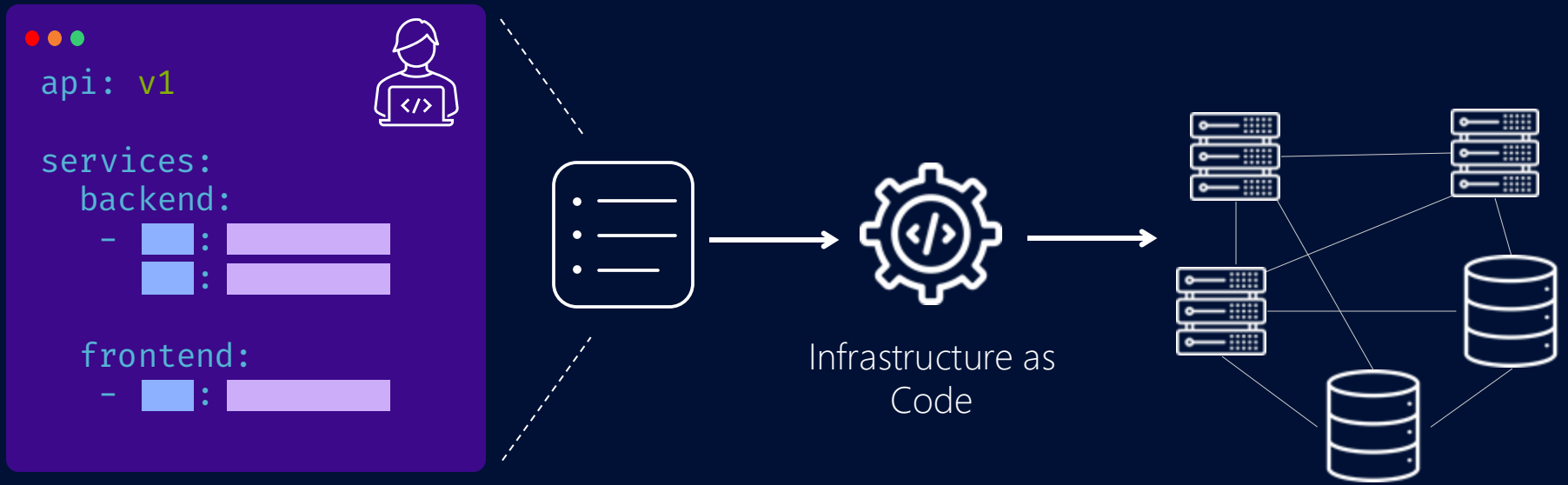
Containerlab

“Lab as code” way to deploy networking labs

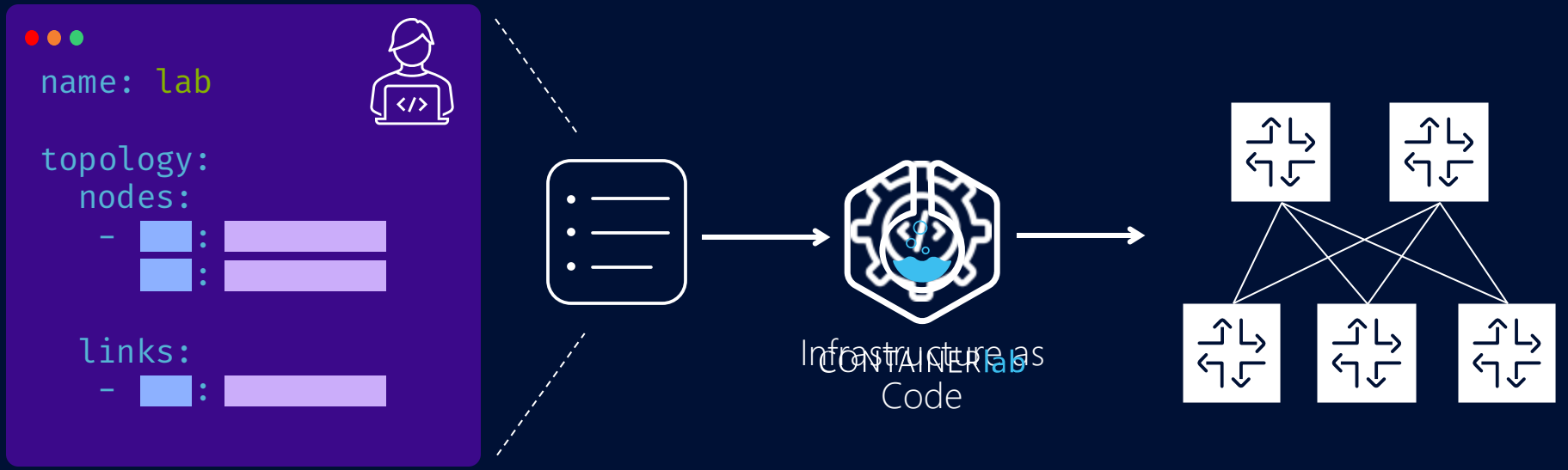
287K Installations	120+ Contributors
30+ Supported NOSes	24 Releases a year

How they deploy things over there?

Declarative, infrastructure as code approach

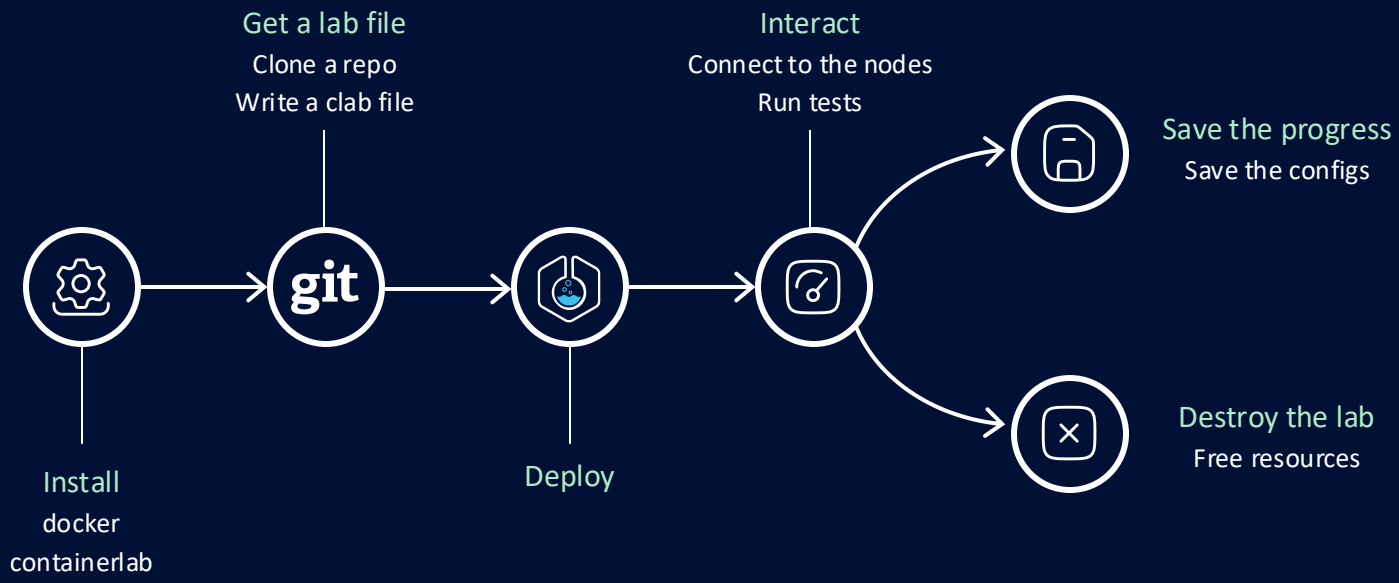


Lab as code with Containerlab



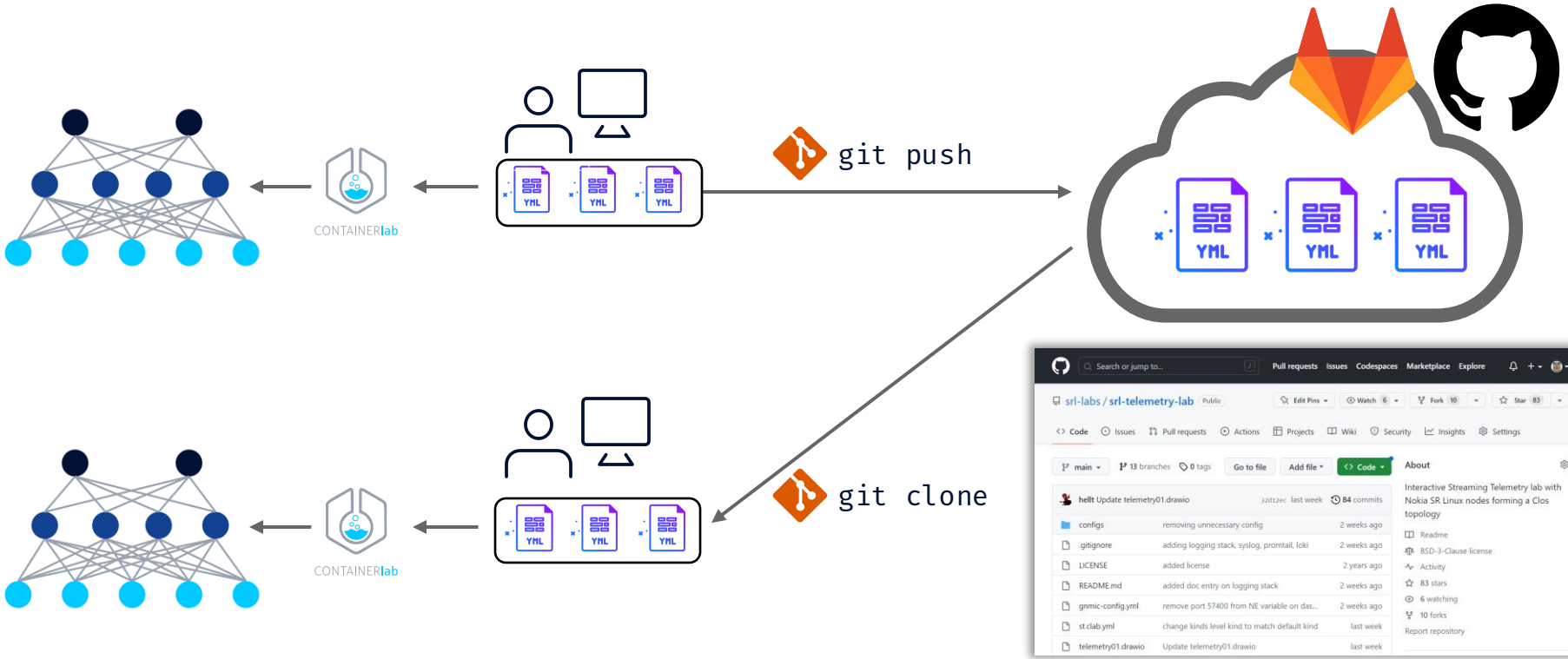
Containerlab

The Workflow



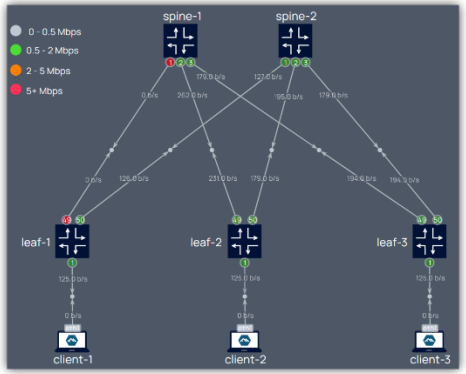
Share your labs

Lab As Code

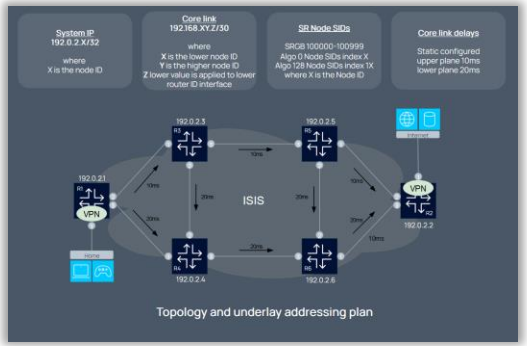


Lab examples

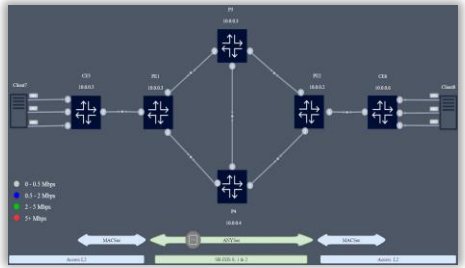
Streaming Telemetry



Segment Routing

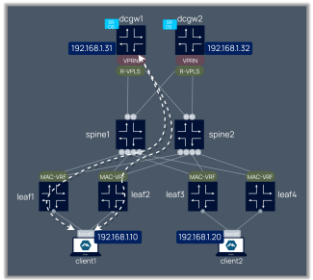


AnySec/MACSec



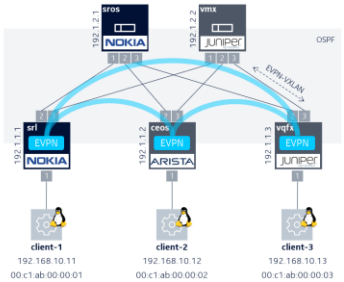
More labs!

Nokia EVPN Interop



srl-labs/nokia-evpn-lab

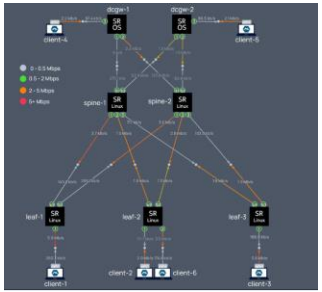
Multivendor EVPN



srl-labs/multivendor-evpn-lab

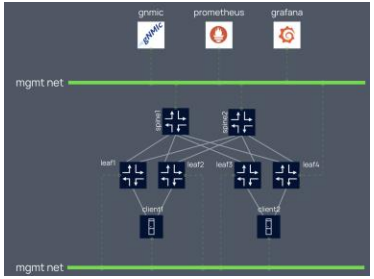
CONTAINERlab

SR Linux & SROS Telemetry



srl-labs/srl-sros-telemetry-lab

SR Linux Oper-Group



srl-labs/opergroup-lab

Codespaces

Free compute*

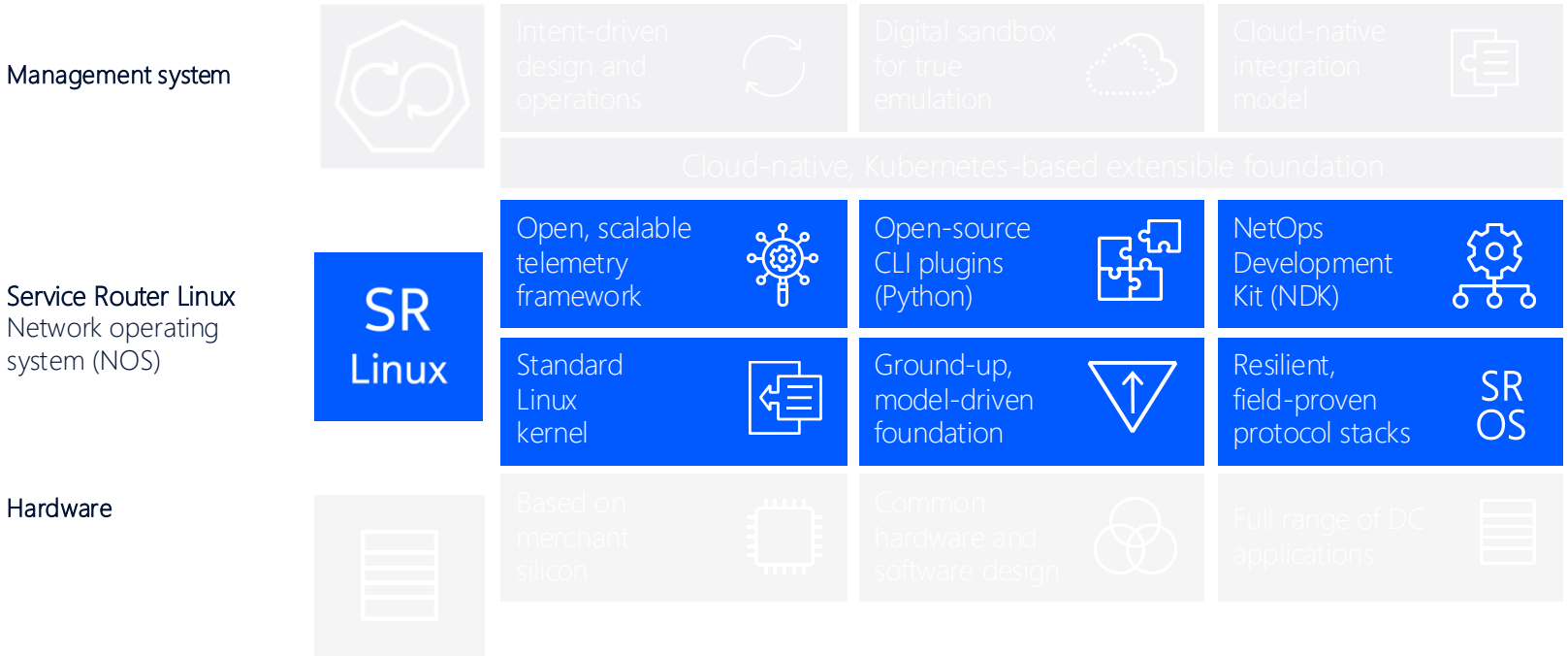
- Microsoft-backed compute cloud
- Generous free tier with a monthly quota reset
- 120cpu/hours a month FREE
- Containerlab integrated with Codespaces
- No $$$ until explicitly committed

Agenda

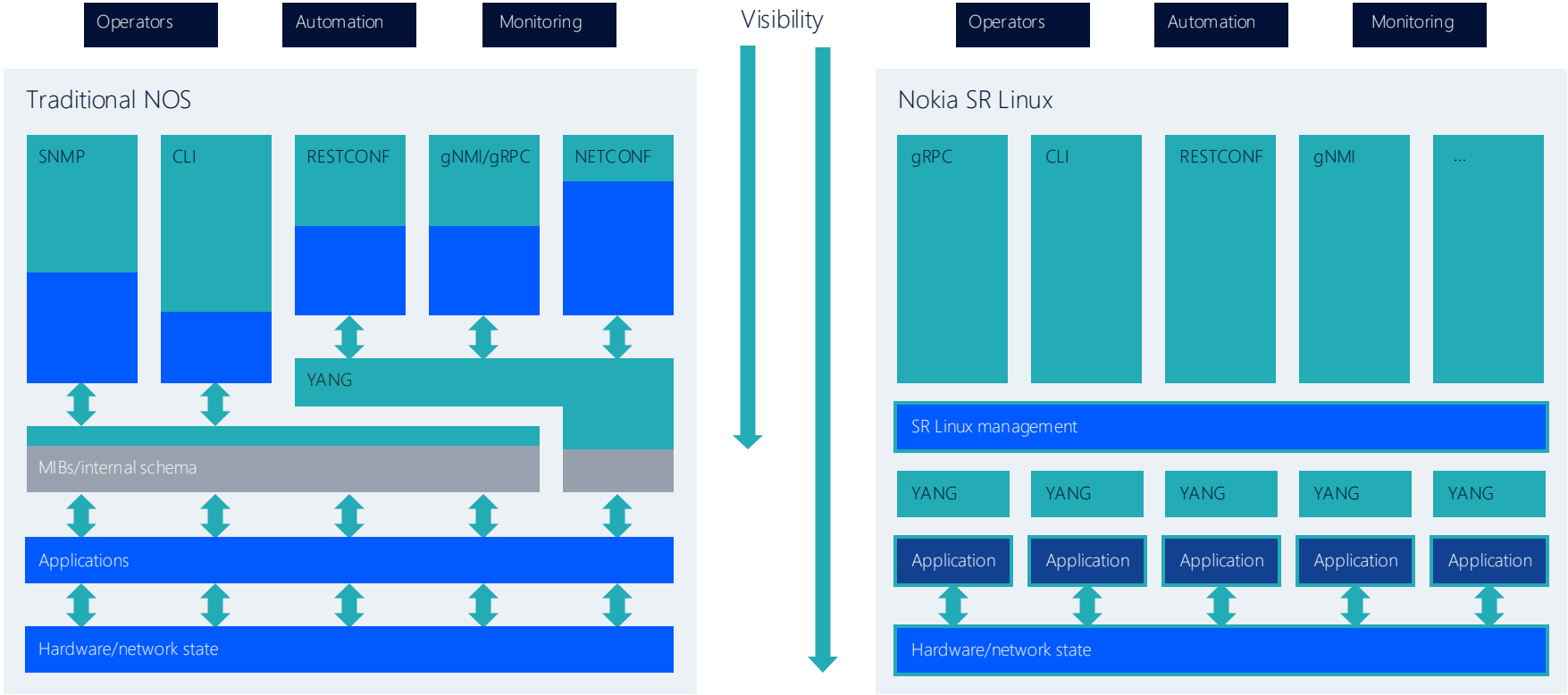
1. Data center architectures
2. EVPN basics
3. Live demo
4. Reference information
    a. Containerlab
    b. SR-Linux CLI fundamentals
    c. EVPN on SR-Linux
    d. EVPN multi-homing

Running data centres on Nokia SR Linux

A fresh look at the Operating System for Network devices



Fully modelled Network OS



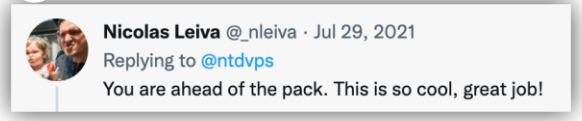
SR Linux Container Image

A key ingredient for our community

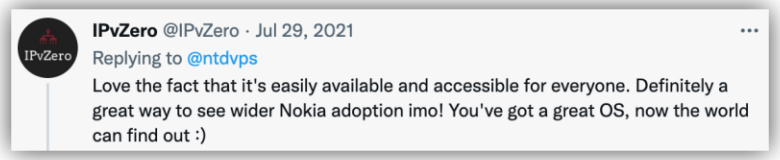
Open and free to use container image is a game changer for the industry.

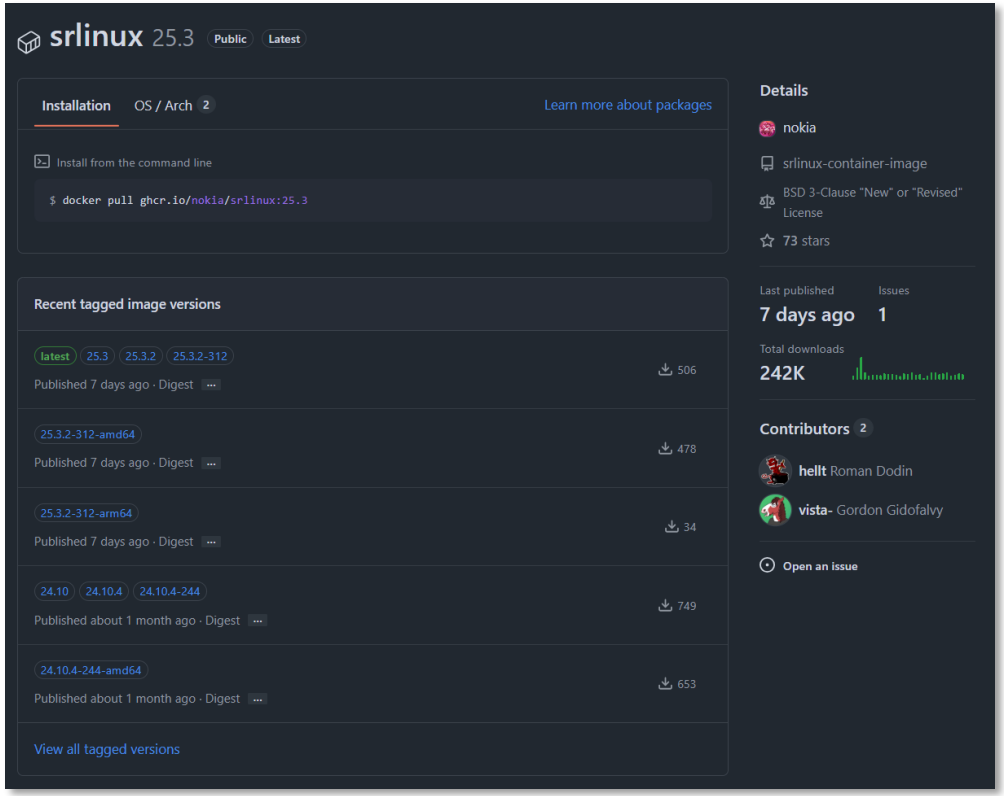
Effortless process to obtain the image made SR Linux so compelling to users.

redhat



CBTnuggets



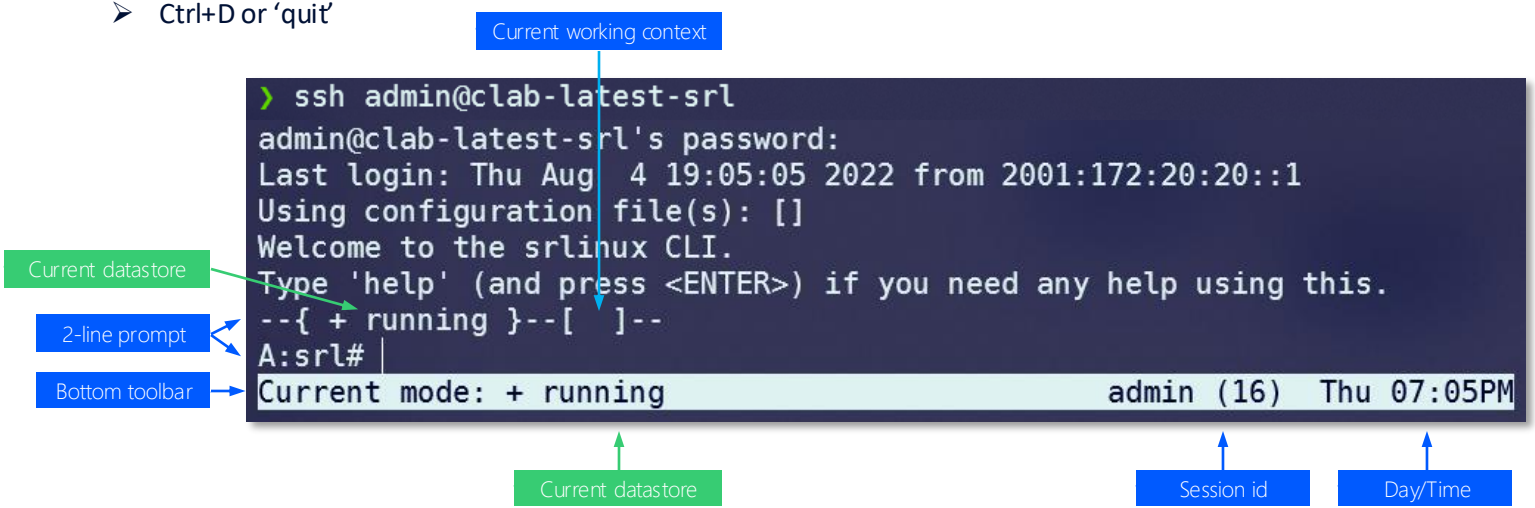



```
$ docker pull ghcr.io/nokia/srlinux:25.3.2
```

Diving into the CLI

Accessing the CLI

- Prompt and bottom toolbar can be customized
- Possibility to add pre- or post-login messages
- Exit CLI by typing
  - **Ctrl+D or 'quit'**



Datastores

Overview

- Configuration and state information reside in datastores on the SR Linux device.
- The following 4 datastores are available based on RFC 8342[1]:
  - **Running** – contains the currently active configuration.
  - **Candidate** – contains a user-configurable version of the running datastore. Once committed, the candidate datastore becomes the running datastore.
  - **State** – contains the running configuration, plus dynamically added data such as operational state of interfaces or BGP peers added via auto-discovery, as well as session states and routing tables.
  - **Tools** – contains executable commands that allow you to perform operations such as restarting the device and clearing interface statistics.
- **info** command is used to display information from a datastore.
  - ➢ **info from state** command (or entering the **info** command in state mode) displays configuration and statistics from the state datastore for the current context
  - ➢ **info from running** command (or the **info** command in running mode) displays configuration from the running datastore for the current context.

[1] Network management Datastore Architecture based on YANG

Diving into the CLI

Getting help from the CLI

- CLI provides context-based help:
  - Typing '?' shows all possible commands at that level
  - Typing '?' after a command displays the command usage

Current working context

Commands local to the current contest

```
--{ running }--[ system ]--
A:leaf1# ?
Local commands:
  aaa                 Top-level container for AAA services
  authentication      Container for protocol authentication options available system wide
  banner              Contains configuration and state related to system banners
  boot                Top-level container for configuration and state data related to booting the system
  bridge-table        system bridge-table information
  clock               Top-level container for system clock configuration and state
  configuration       Top-level container for configuration and state data related to the system
configuration
  dns                 Top-level container for DNS configuration and state
  ftp-server          Top-level container for FTP server configuration and state
  gnmi-server         Configures the gNMI server access API
  information         Top-level container for system information configuration and state
  json-rpc-server     Configures the JSON RPC access API
  lacp
<...>
Global commands:
  file                File related commands
  info                Show the values of all nodes and fields under the current context
  list                Show the keys of all nodes under the current context

Output modifier commands:
  #                   Comment out the rest of the line

--{ running }--[ system ]--
A:leaf1#

Current mode: running                                                    admin(20) Tue 11:18AM
```

Global commands

Help text extracted from YANG models description fields

```
--{ running }--[  ]--
A:leaf1# system ntp server ?
usage: server <address>

List of NTP servers to use for system clock synchronization

Positional arguments:
  address           [IP address, range IPv4|IPv6] IP address
of the NTP server, may be either IPv4 or IPv6

Current mode: running                    admin(20) Tue 11:19AM
```

Diving into the CLI

CLI navigation

- Enter a <tab> to auto-complete the next command level

```
--{ running }--[  ]--
A:leaf1# system ssh-server
```

Non-ambiguous completion is displayed while typing

- If multiple options are available, a popup will appear

```
--{ running }--[  ]--
A:leaf1# interface ethernet-1/
                              ethernet-1/11
                              ethernet-1/55
                              ethernet-1/56
```

All possible options displayed in a popup box

- The options can be navigated

```
--{ running }--[  ]--
A:leaf1# system dns
                    aaa              boot             configuration    gnmi-server
                    authentication   bridge-table     dns              information
                    banner           clock            ftp-server       json-rpc-server
```

Once all options are displayed in the popup, use the arrow keys or tab to select one

Diving into the CLI

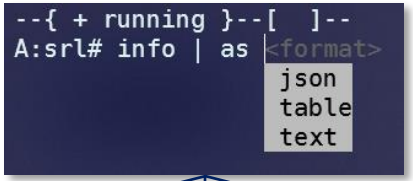
CLI navigation (2)

- To leave a context, use the **back** and **exit <all>** keywords
- **back** brings you back to the context you were before the last command
- **exit** leads you to the parent of the current context
- **exit all** leads you to the root context

```
--{ + running }--[ network-instance mgmt ]--
A:srl# protocols linux
--{ + running }--[ network-instance mgmt protocols linux ]--
A:srl# back
--{ + running }--[ network-instance mgmt ]--
A:srl# exit
--{ + running }--[  ]--
A:srl# network-instance mgmt protocols linux
--{ + running }--[ network-instance mgmt protocols linux ]--
A:srl# back
--{ + running }--[  ]--
A:srl# network-instance mgmt protocols linux
--{ + running }--[ network-instance mgmt protocols linux ]--
A:srl# exit all
--{ + running }--[  ]--
A:srl#
```

Diving into the CLI

Displaying information & possible formats



Text, by default

```
--{ + running }--[ network-instance mgmt ]--
A:srl# info
    type ip-vrf
    admin-state enable
    description "Management network instance"
    interface mgmt0.0 {
    }
    protocols {
        linux {
            import-routes true
            export-routes true
            export-neighbors true
        }
    }
```

JSON

```
--{ + running }--[ network-instance mgmt ]--
A:srl# info | as json
{
  "name": "mgmt",
  "type": "ip-vrf",
  "admin-state": "enable",
  "description": "Management network instance",
  "interface": [
    {
      "name": "mgmt0.0"
    }
  ],
  "protocols": {
    "linux": {
      "import-routes": true,
      "export-routes": true,
      "export-neighbors": true
    }
  }
}
```

Table

```
--{ + running }--[ network-instance mgmt ]--
A:srl# info | as table | filter protocols/linux fields *
+-------------+-------------+-------------+-------------+
|    Name     |  Protocols  |  Protocols  |  Protocols  |
|             |    linux    |    linux    |    linux    |
|             |   import-   |   export-   |   export-   |
|             |   routes    |   routes    |  neighbors  |
+=============+=============+=============+=============+
| mgmt        | true        | true        | true        |
+-------------+-------------+-------------+-------------+
```

Diving into the CLI

Displaying the default configuration

- Every context has a default configuration. When typing **info**, those default parameters are not displayed to facilitate reading.

- This implicit information can be displayed using **info detail**

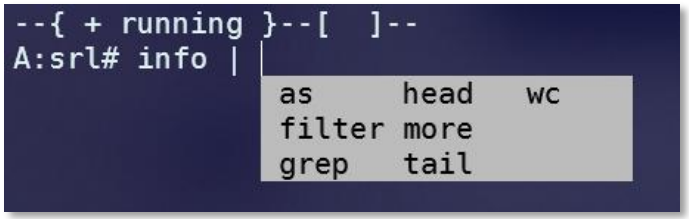
```
--{ + running }--[ network-instance default protocols bgp ]--
A:srl# info
    autonomous-system 4200000005
    router-id 10.10.10.10
    group underlay-group {
    }
```

```
--{ + running }--[ network-instance default protocols bgp ]--
A:srl# info detail
    admin-state enable
    autonomous-system 4200000005
    local-preference 100
    router-id 10.10.10.10
    as-path-options {
        allow-own-as 0
        remove-private-as {
            mode disabled
            leading-only false
            ignore-peer-as false
        }
    }
    authentication {
    }
    convergence {
        min-wait-to-advertise 0
    }
    dynamic-neighbors {
        accept {
            max-sessions 0
        }
    }
    ebgp-default-policy {
        import-reject-all true
        export-reject-all true
    }
    failure-detection {
        enable-bfd false
        fast-failover true
    }
    graceful-restart {
        admin-state disable
        stale-routes-time 360
    }
    group underlay-group {
        admin-state enable
        next-hop-self false
        as-path-options {
        }
        authentication {
        }
        failure-detection {
        }
        multihop {
        }
        graceful-restart {
        }
        ipv4-unicast {
            prefix-limit {
                max-receive
                warning-thr
            }
        }
        ipv6-unicast {
            prefix-limit {
                max-receive
                warning-thr
            }
        }
        evpn {
            prefix-limit {
                max-receive
                warning-thr
            }
        }
        route-reflector {
        }
        send-community {
        }
        send-default-route {
            ipv4-unicast false
            ipv6-unicast false
        }
```

Diving into the CLI

CLI goodies

- Several tools are directly available on the CLI to manipulate the output
  - Among them, several well-known Linux tools : **grep, head, tail, more, wc**



Diving into the CLI

CLI goodies (2)

➢ Part of the tools taken from Linux : watch

```
--{ + running }--[  ]--
A:srl# watch show network-instance mgmt route-table ipv4-unicast summary
Every 2.0s: show network-instance mgmt route-table ipv4-unicast summary                                                       (Executions 14, Thu 07:57:50PM)

-------------------------------------------------------------------------------------------------------------------------------------------------------------
IPv4 unicast route table of network instance mgmt
-------------------------------------------------------------------------------------------------------------------------------------------------------------
+-----------------------+-------+------------+----------------------+----------------------+----------+---------+--------------+--------------+
|        Prefix         |  ID   | Route Type |     Route Owner      |        Active        |  Metric  |  Pref   |   Next-hop   |   Next-hop   |
|                       |       |            |                      |                      |          |         |    (Type)    |  Interface   |
+=======================+=======+============+======================+======================+==========+=========+==============+==============+
| 0.0.0.0/0             | 1     | dhcp       | dhcp_client_mgr      | True                 | 0        | 5       | 172.20.20.1  | mgmt0.0      |
|                       |       |            |                      |                      |          |         | (direct)     |              |
| 172.20.20.0/24        | 0     | linux      | linux_mgr            | False                | 0        | 5       | 172.20.20.0  | mgmt0.0      |
|                       |       |            |                      |                      |          |         | (direct)     |              |
| 172.20.20.0/24        | 1     | local      | net_inst_mgr         | True                 | 0        | 0       | 172.20.20.2  | mgmt0.0      |
|                       |       |            |                      |                      |          |         | (direct)     |              |
| 172.20.20.2/32        | 1     | host       | net_inst_mgr         | True                 | 0        | 0       | None         | None         |
|                       |       |            |                      |                      |          |         | (extract)    |              |
| 172.20.20.255/32      | 1     | host       | net_inst_mgr         | True                 | 0        | 0       | None         |              |
|                       |       |            |                      |                      |          |         | (broadcast)  |              |
+-----------------------+-------+------------+----------------------+----------------------+----------+---------+--------------+--------------+
-------------------------------------------------------------------------------------------------------------------------------------------------------------
IPv4 routes total                   : 5
IPv4 prefixes with active routes    : 4
IPv4 prefixes with active ECMP routes: 0
-------------------------------------------------------------------------------------------------------------------------------------------------------------
```


Diving into the CLI

CLI goodies (3)

- Monitoring specific YANG nodes is also possible with : monitor

```
--{ + state }--[ system aaa authentication ]--
A:srl# /monitor system gnmi-server
[2022-08-04 20:12:39.613263]: update /system/gnmi-server/admin-state:enable
[2022-08-04 20:12:39.613629]: update /system/gnmi-server/timeout:7200
[2022-08-04 20:12:39.613907]: update /system/gnmi-server/rate-limit:60
[2022-08-04 20:12:39.614055]: update /system/gnmi-server/session-limit:20
[2022-08-04 20:12:39.614166]: update /system/gnmi-server/commit-confirmed-timeout:0
[2022-08-04 20:12:39.614291]: update /system/gnmi-server/commit-save:false
[2022-08-04 20:12:39.614392]: update /system/gnmi-server/include-defaults-in-config-only-responses:false
[2022-08-04 20:12:39.614491]: update /system/gnmi-server/unix-socket/admin-state:disable
[2022-08-04 20:12:39.614591]: update /system/gnmi-server/unix-socket/oper-state:down
[2022-08-04 20:12:39.614691]: update /system/gnmi-server/unix-socket/use-authentication:true
[2022-08-04 20:12:39.614790]: update /system/gnmi-server/unix-socket/socket-path:
[2022-08-04 20:12:54.608966]: update /system/gnmi-server/admin-state:disable
[2022-08-04 20:13:04.961993]: update /system/gnmi-server/admin-state:enable
```

Diving into the CLI

Configuring and committing changes to SR Linux

- To modify the existing configuration, enter the candidate datastore, modify the configuration, and commit the changes.

```
--{ + running }--[  ]--
A:srl# enter candidate
--{ + candidate shared default }--[  ]--
A:srl#
```

Apply your changes, and optionally check the differences with the **diff** command

```
--{ +* candidate shared default }--[  ]--
A:srl# diff
      network-instance default {
+         description "Main network instance created by Bastien on 4/08/2022"
      }
```

After verifying, commit the changes to the running datastore

```
--{ +* candidate shared default }--[ network-instance default ]--
A:srl# commit stay
All changes have been committed. Starting new transaction.
--{ + candidate shared default }--[ network-instance default ]--
A:srl#
```

Diving into the CLI

Configuring and committing changes to SR Linux (2)

- Advanced commands can be used to configure or commit the configuration
  - Configuration can be loaded from existing startup, rescue, factory configurations, from checkpoints or files, or can be typed in json format directly.

```
--{ + candidate shared default }--[ network-instance default ]--
A:srl# load
            checkpoint json
            factory    rescue
            file       startup
```

  - When committing, multiple options are available :

```
--{ + candidate shared default }--[ network-instance default ]--
A:srl# commit
usage: commit

Apply all changes. Will update the applications if successful

Local commands:
  checkpoint        Save the configuration to a checkpoint after successful commit
  confirmed         Start confirmation timer (will revert changes if not confirmed)
  now               Leave the current context
  save              Save the configuration as startup configuration after successful commit and leave the current context
  stay              Stay in the current context and open new configuration session
  validate          Validate all changes
```

Diving into the CLI

Useful show commands

```
A:linx-spine-1# /show interface ethernet-1/7 detail
===============================================================================
Interface: ethernet-1/7
-------------------------------------------------------------------------------
  Description      : <None>
  Oper state       : up
  Down reason      : N/A
  Last change      : 1d18h45m53s ago, 3 flaps since last clear
  Speed            : 100G
  Flow control     : Rx is enabled
  MTU              : 8950
  VLAN tagging     : false
  VLAN TPID        : TPID_0X8100
  Queues           : 8 output queues supported, 6 used since the last clear
  Last stats clear: never
  Breakout mode    : false
-------------------------------------------------------------------------------
L2CP transparency rule for ethernet-1/7
-------------------------------------------------------------------------------
  Lldp             : trap-to-cpu-untagged
  Lacp             : trap-to-cpu-untagged
  xStp             : drop-tagged-and-untagged
  Dot1x            : drop-tagged-and-untagged
  Ptp              : drop-tagged-and-untagged
  Non-specified l2cp: false
-------------------------------------------------------------------------------
Traffic statistics for ethernet-1/7
-------------------------------------------------------------------------------
       counter             Rx              Tx
  Octets              21263736028626  21382073138556
  Unicast packets     15147017826     22762664074
  Broadcast packets   24              22
  Multicast packets   91312           91304
  Errored packets     0               0
  FCS error packets   0               N/A
  MAC pause frames    0               0
  Oversize frames     0               N/A
  Jabber frames       0               N/A
  Fragment frames     0               N/A
  CRC errors          0               N/A
```

```
-------------------------------------------------------------------------------
Traffic rate statistics for ethernet-1/7
-------------------------------------------------------------------------------
    units     Rx   Tx
  kbps rate   3    5
-------------------------------------------------------------------------------
Frame length statistics for ethernet-1/7
-------------------------------------------------------------------------------
  Frame length(Octets)       Rx            Tx
  64 bytes                76            72
  65-127 bytes            1778378       3696884
  128-255 bytes           1567842241    3933508496
  256-511 bytes           89            7070740861
  512-1023 bytes          18            78
  1024-1518 bytes         7             13227573
  1519+ bytes             13577488353   11741581436
-------------------------------------------------------------------------------
Transceiver detail for ethernet-1/7
-------------------------------------------------------------------------------
  Status           : Transceiver is present and operational
  Form factor      : QSFP28
  Channels used    : 4
  Connector type   : LC
  Vendor           : NOKIA
  Vendor part      : 3HE10550AARA01
  PMD type         : 100GBASE-LR4
  Fault condition : false
  Temperature      : 34
  Voltage          : 3.2322
===============================================================================
  Subinterface: ethernet-1/7.0
-------------------------------------------------------------------------------
  Description            : <None>
  Network-instance       : default
  Type                   : routed
  Oper state             : up
  Down reason            : N/A
  Last change            : 1d18h45m53s ago
  Encapsulation          : null
  IP MTU                 : 8830
  Last stats clear       : never
  MAC duplication action: -
  IPv4 addr     : 100.70.0.143/31 (static, preferred, primary)
-------------------------------------------------------------------------------
```

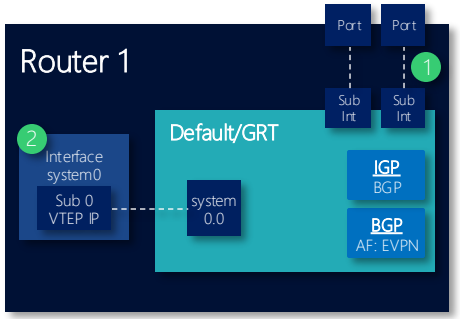
Diving into the CLI

Useful show commands

```
---------------------------------------------------
ARP/ND summary for ethernet-1/7.0
---------------------------------------------------
  IPv4 ARP entries : 0 static, 1 dynamic
---------------------------------------------------
ACL filters applied to ethernet-1/7.0
---------------------------------------------------
     Summary       In    Out
  IPv4 ACL Name   none   none
  IPv6 ACL Name   none   none
---------------------------------------------------
QOS Policies applied to ethernet-1/7.0
---------------------------------------------------
      Summary         In        Out
  DSCP classifier   default   -
  DSCP rewrite      -         default
---------------------------------------------------
Traffic statistics for ethernet-1/7.0
---------------------------------------------------
     Statistics             Rx              Tx
  Packets             15147109154      22762487268
  Octets              21263713694717   21382050772480
  Discarded packets   268195           0
  Forwarded packets   15146840959      22762487268
  Forwarded octets    21263713694717   21382050772480
  CPM packets         -                0
  CPM octets          -                0
  Statistics   Rx   Tx
  Statistics   Rx   Tx
  Statistics   Rx   Tx
```

Configuring an interface on SR Linux

Basic IPv4 interface configuration



1

```
# info interface ethernet-1/55
    interface ethernet-1/55 {
        admin-state enable
        vlan-tagging true
        subinterface 1 {
            ipv4 {
                address 101.1.1.0/31 {
                }
            }
            ipv6 {
                address 2002::101:1:1:0/127 {
                }
            }
            vlan {
                encap {
                    single-tagged {
                        vlan-id 1
                    }
```

ethernet-1/55 is an uplink interface, i.e. towards the fabric

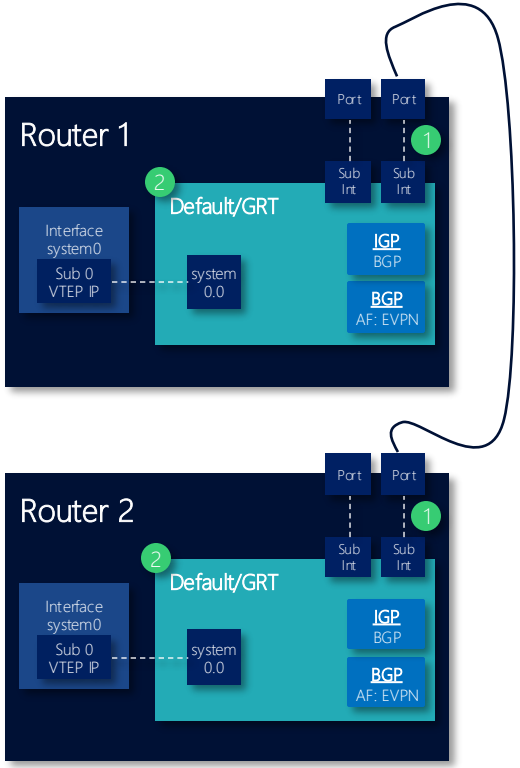
system0.0 is the loopback interface used to originate and terminate VxLAN packets

2

```
# info interface system0
    interface system0 {
        admin-state enable
        subinterface 0 {
            admin-state enable
            ipv4 {
                address 192.1.1.1/32 {
                }
            }
            ipv6 {
                address 2000::192:1:1:1/128 {
                }
            }
        }
    }
```

Configuring an interface on SR Linux

Link-local IPv6 address and BGP auto-discovery configuration



1

```
# info interface ethernet-1/49
 admin-state enable
   subinterface 0 {
     ipv6 {
       admin-state enable
       router-advertisement {
         router-role {
           admin-state enable
         }
       }
     }
   }
```

Create a subinterface and enable **router-advertisement**

Add a subinterface to dynamic-neighbors in the BGP context to enable BGP unnumbered peers.

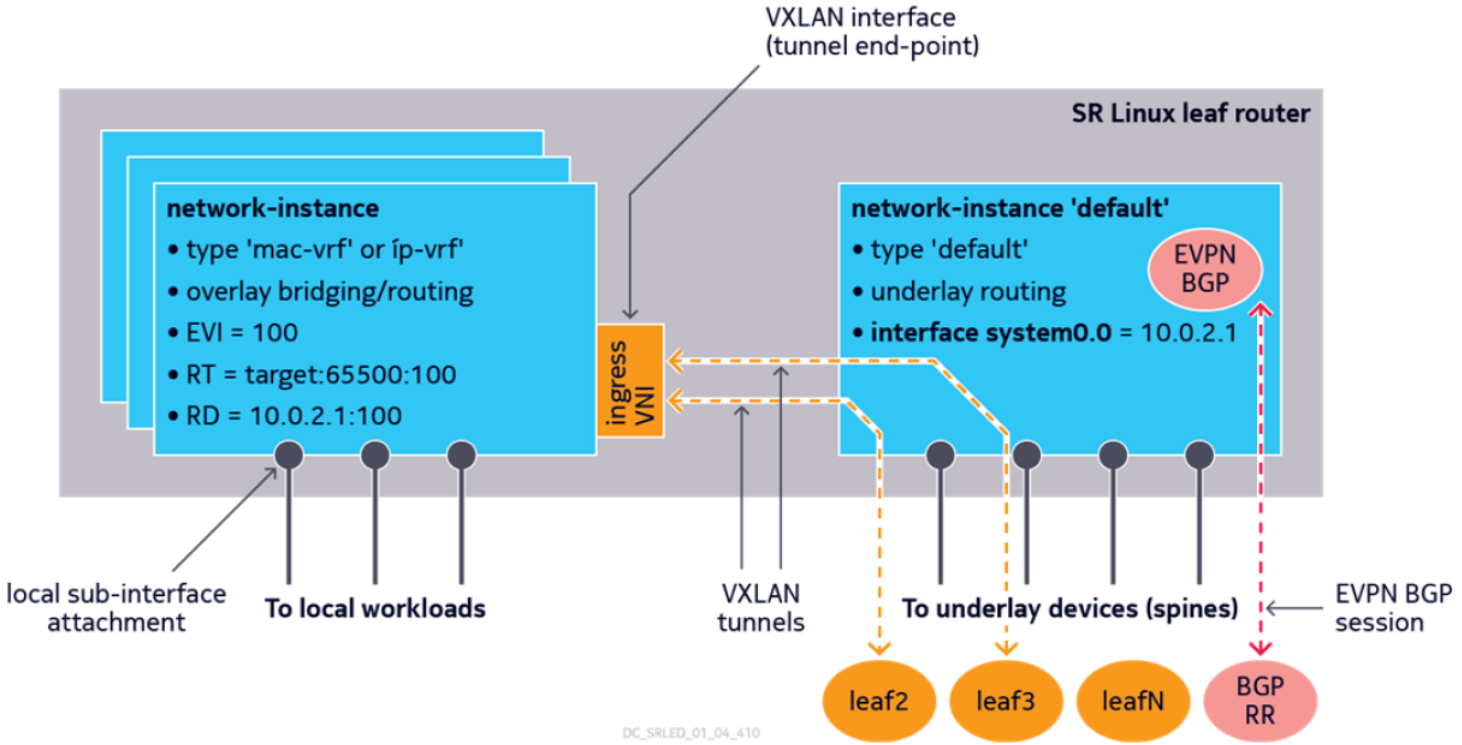
2

```
# info network-instance default
  admin-state enable
  router-id 192.1.1.1
   interface ethernet-1/49.0 {
   }
   interface system0.0 {
   }
   protocols {
     bgp {
       admin-state enable
       autonomous-system 65413
       router-id 10.0.1.3
       dynamic-neighbors {
         interface ethernet-1/49.0 {
           peer-group underlay
           allowed-peer-as [
             65500
           ]
         }
```

Agenda

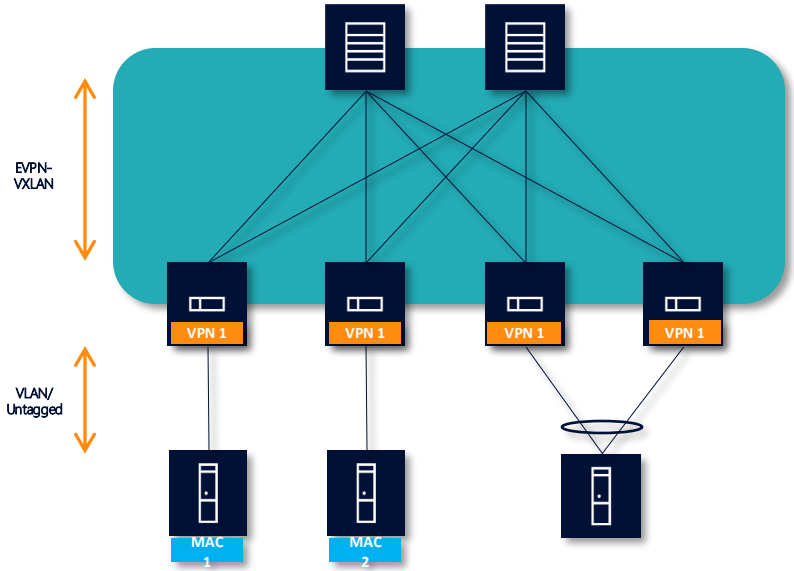
1. Data center architectures
2. EVPN basics
3. Live demo
4. Reference information
    a. Containerlab
    b. SR-Linux CLI fundamentals
    c. EVPN on SR-Linux
    d. EVPN multi-homing

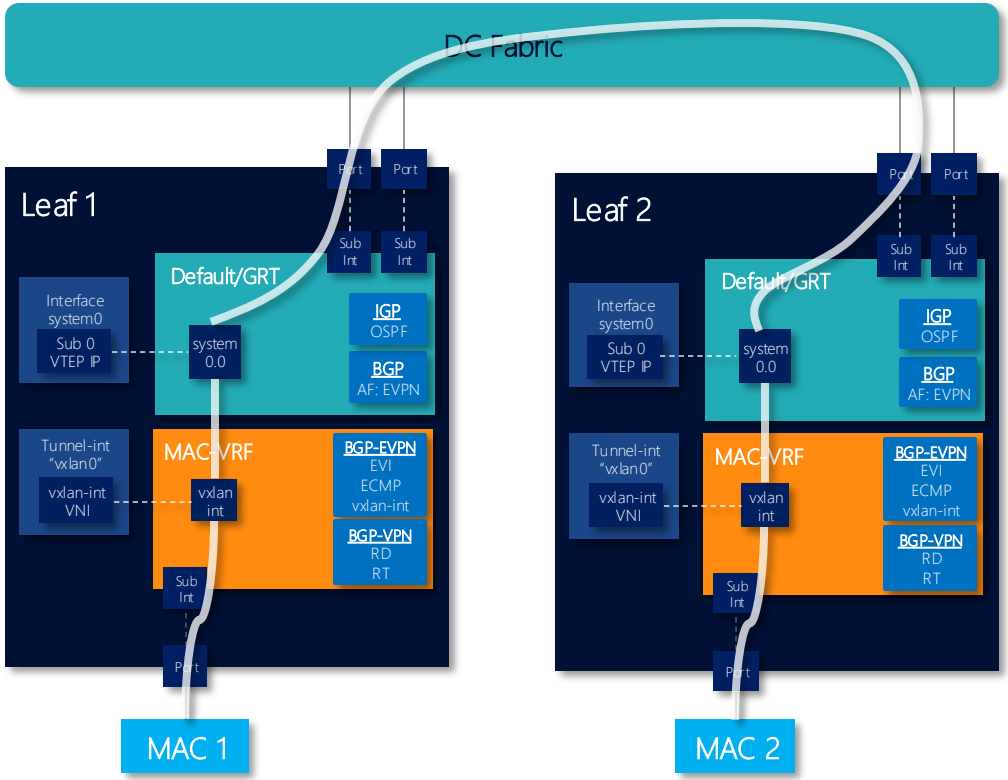
SR Linux EVPN – VXLAN configuration overview



Configuring an EVPN layer-2 service on SR Linux

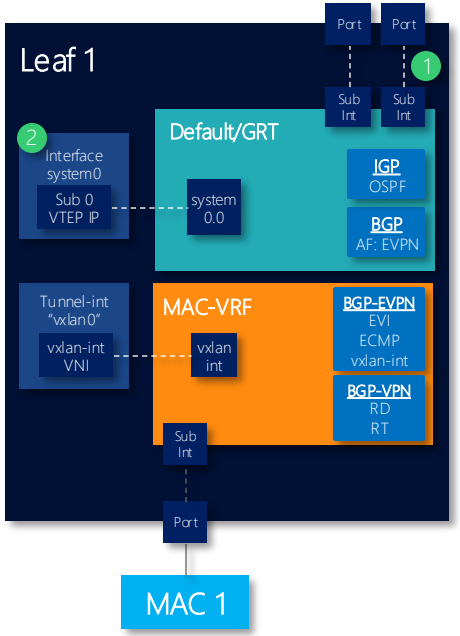
EVPN in data centers





Configuring an EVPN layer-2 service on SR Linux

EVPN in data centers



1

```
# info interface ethernet-1/55
    interface ethernet-1/55 {
        admin-state enable
        vlan-tagging true
        subinterface 1 {
            ipv4 {
                address 101.1.1.0/31 {
                }
            }
            ipv6 {
                address 2002::101:1:1:0/127 {
                }
            }
            vlan {
                encap {
                    single-tagged {
                        vlan-id 1
                    }
```

ethernet-1/55 is an uplink interface, i.e. towards the fabric

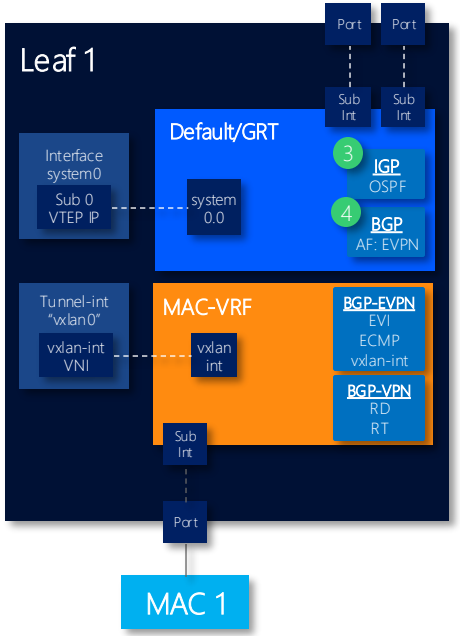
system0.0 is the loopback interface used to originate and terminate VxLAN packets

2

```
# info interface system0
    interface system0 {
        admin-state enable
        subinterface 0 {
            admin-state enable
            ipv4 {
                address 192.1.1.1/32 {
                }
            }
            ipv6 {
                address 2000::192:1:1:1/128 {
                }
            }
        }
    }
```

Configuring an EVPN layer-2 service on SR Linux

EVPN in data centers



3

```
# info network-instance default protocols ospf
    network-instance default {
        protocols {
            ospf {
                instance default {
                    admin-state enable
                    version ospf-v2
                    router-id 192.1.1.1
                    area 0.0.0.0 {
                        advertise-router-capability true
                        interface ethernet-1/55.1 {
                            interface-type point-to-point
                        }
                        interface ethernet-1/56.1 {
                            interface-type point-to-point
                        }
                        interface system0.0 {
                        }
```

OSPF is chosen as underlay protocol in this example, but IS-IS or eBGP (preferred) are also supported.

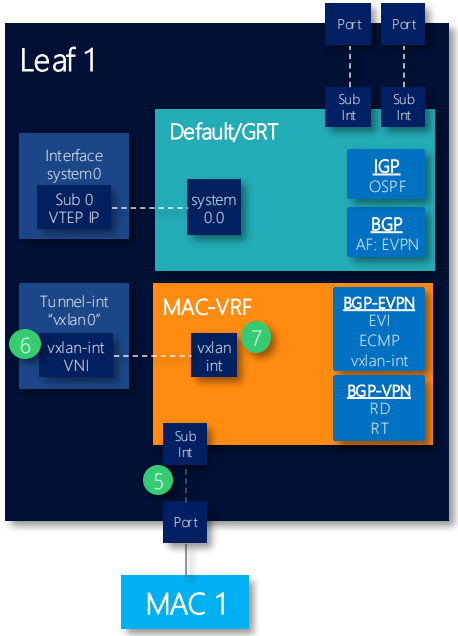
iBGP with address family EVPN is used to exchange the EVPN routes between the different VTEPs.

4

```
# info network-instance default protocols bgp
    network-instance default {
        protocols {
            bgp {
                autonomous-system 64500
                router-id 192.1.1.1
                group iBGPv4 {
                    admin-state enable
                    peer-as 64500
                    ipv4-unicast {
                        admin-state disable
                    }
                    ipv6-unicast {
                        admin-state disable
                    }
                    evpn {
                        admin-state enable
                    }
                    timers {
                        connect-retry 1
                        minimum-advertisement-interval 1
                    }
                }
                neighbor 192.1.2.1 {
                    peer-group iBGPv4
                }
                neighbor 192.1.2.2 {
                    peer-group iBGPv4
                }
```

Configuring an EVPN layer-2 service on SR Linux

EVPN in data centers



5

```
# info interface ethernet-1/3 subinterface 110
    interface ethernet-1/3 {
                vlan-tagging true
        subinterface 110 {
            type bridged
            admin-state enable
            vlan {
                encap {
                    single-tagged {
                        vlan-id 110
                    }
```

6

```
# info tunnel-interface vxlan0
    tunnel-interface vxlan0 {
        vxlan-interface 110 {
            type bridged
            ingress {
                vni 110
            }
            egress {
                source-ip use-system-ipv4-address
            }
        }
    }
```

7

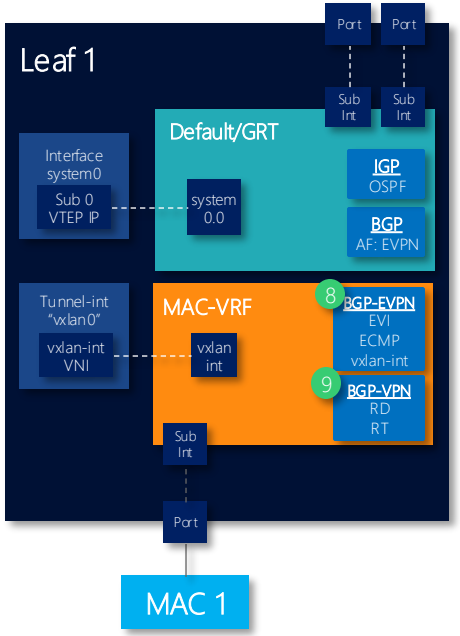
```
# info network-instance mac-vrf-110
    network-instance mac-vrf-110 {
        type mac-vrf
        admin-state enable
        description "Simple EVPN Layer 2"
        interface ethernet-1/3.110 {
        }
        vxlan-interface vxlan0.110 {
        }
```

Possible options:

- **single-tagged vlan-id any** – where 'any' captures all traffic for which no specific vlan-id has been defined.
- **untagged** – where 'untagged' captures traffic with no tags or vlan-tag 0.

Configuring an EVPN layer-2 service on SR Linux

EVPN in data centers



8

```
# info network-instance mac-vrf-110 protocols bgp-evpn
    network-instance mac-vrf-110 {
        protocols {
            bgp-evpn {
                bgp-instance 1 {
                    admin-state enable
                    vxlan-interface vxlan0.110
                    evi 110
                    ecmp 2
                    routes {
                        bridge-table {
                            next-hop use-system-ipv4-address
                            mac-ip {
                                advertise true
                            }
                            inclusive-mcast {
                                advertise true
                            }
```

9

```
# info network-instance mac-vrf-110 protocols bgp-vpn
    network-instance mac-vrf-110 {
        protocols {
            bgp-vpn {
                bgp-instance 1 {
                    route-distinguisher {
                        rd 110:11
                    }
                    route-target {
                        export-rt target:64500:110
                        import-rt target:64500:110
                    }
```

- RD can be auto-derived from EVI if not configured manually as <system-ip:evi>
- RT can be auto-derived from EVI if not configured manually as <AS:evi>

Agenda

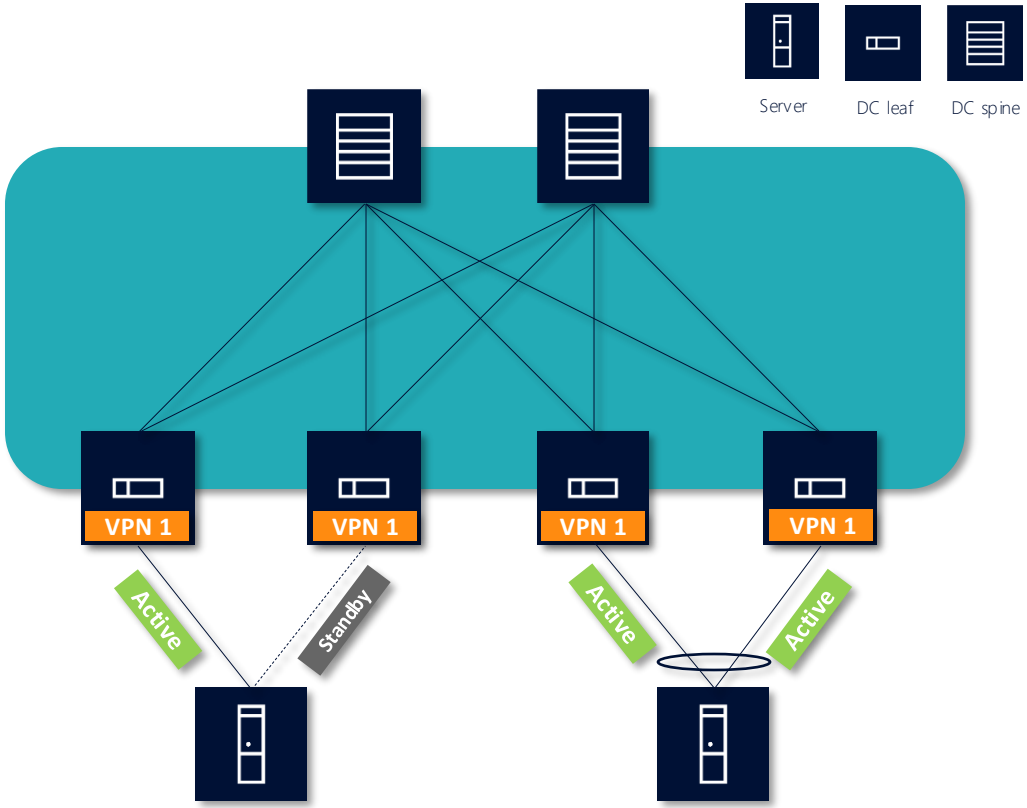
1. Data center architectures
2. EVPN basics
3. Live demo
4. Reference information
    a. Containerlab
    b. SR-Linux CLI fundamentals
    c. EVPN on SR-Linux
    d. EVPN multi-homing

Multi-homing - terminology

EVPN in data centers

- **Single-active** mode
  - Multi-homed with one-active leaf at any time. A single leaf forwards traffic to and from the client

- **All-active** mode
  - Multi-homed with **two or more active leafs** (up to 4 with SR Linux and 7750 SR)
  - **LAG is required** on the client side, to avoid duplicate packets and forwarding loops



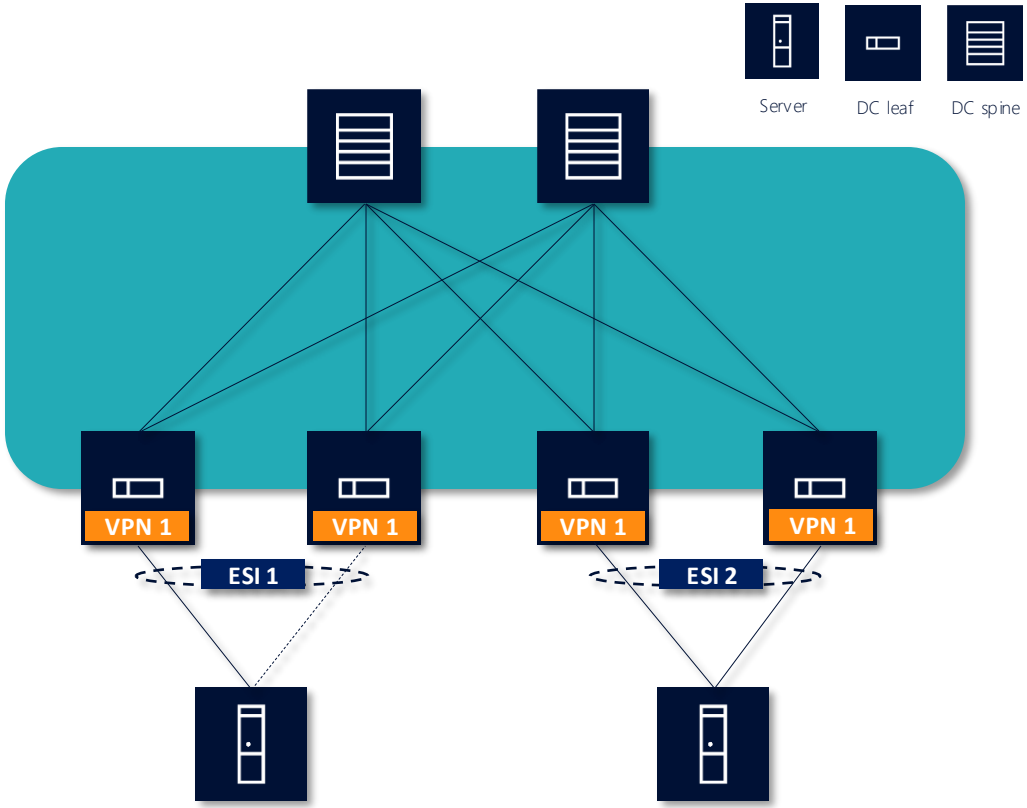
Multi-homing - terminology

EVPN in data centers

Multi-homing in EVPN is based on the concept of Ethernet Segment.

- **Ethernet Segment** (ES)
  - Represents a set of links that connect a client to one or more leafs
  - In single-active or all-active mode
  - On leafs, an ES consists of physical or logical links (LAG, port, vlan ID, …)

- **ES identifier** (ESI)
  - Uniquely identifies an ES in the fabric
  - ESI 0 – indicates a single-homed site
  - ESI 0xFF – reserved, Max-ESI



Multi-homing – EVPN Routes

EVPN in data centers

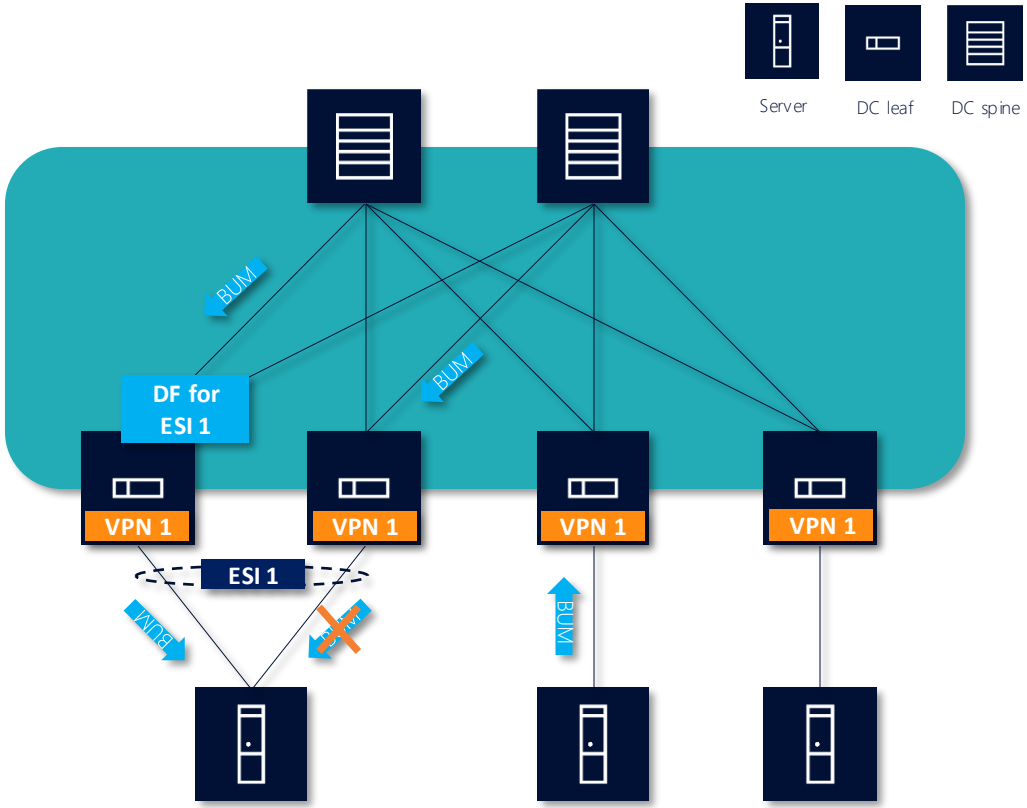
When it comes to multi-homing, leafs exchange **two important route types** between each other :

- Routes of type 1 Ethernet Auto-Discovery come in two flavours :
  - **A-D per ES** : used to **discover ES** and identify the list of leafs associated with an ES.
    It indicates the **ES redundancy mode** (all-active or single-active), and includes the **ESI label** required for split-horizon. Also used for mass withdrawal.
  - **A-D per EVI** : used to **advertise the ES availability in a given EVI**. It's mainly used to create aliasing lists and to create primary/backup lists of leafs that are part of a single-active ES.
- Routes of type 4 Ethernet Segment
  - Used to **discover leafs** attached to a given ES and to **elect a designated forwarder**.
  - A leaf advertises an **ES route for each locally provisioned ES** that has an operational service associated with it.
  - ES routes are advertised with a special RT derived from the ESI
    - Leafs that are part of the ES will import the route; if not, they won't.

Multi-homing – handling BUM traffic to All-Active clients

EVPN in data centers

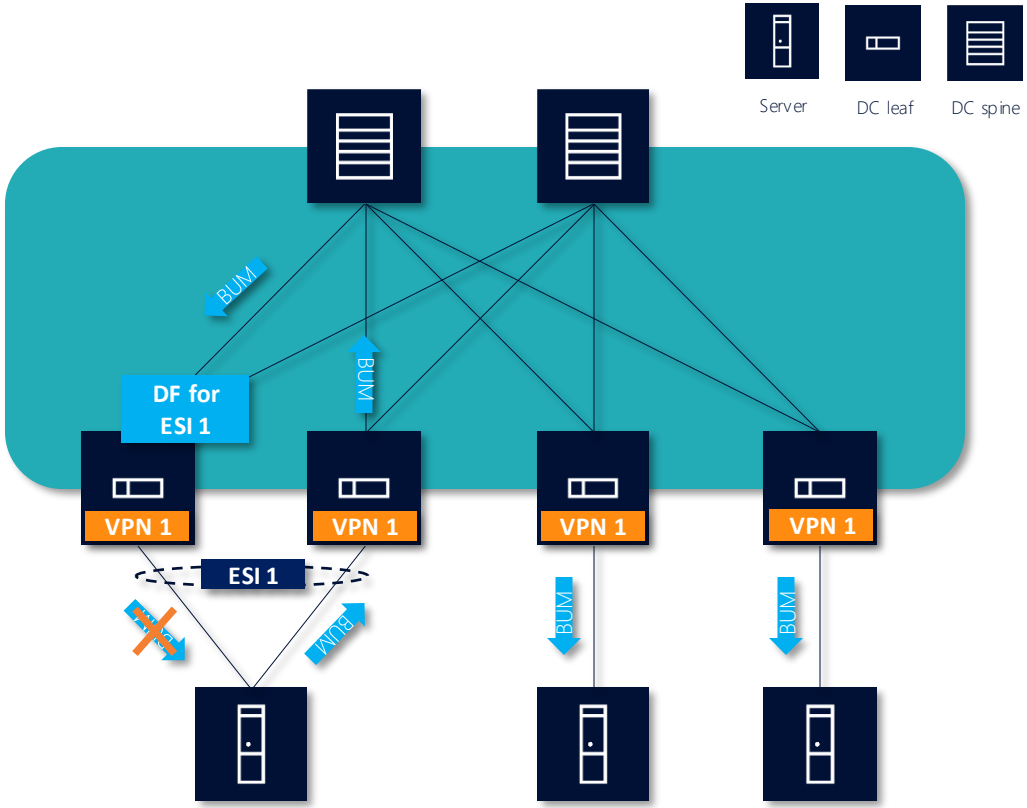
- Leafs connected to a multi-homed client discover each other
- One leaf is elected as Designated Forwarder (DF) per ESI
- Only the DF leaf floods BUM traffic to the Ethernet Segment.



Multi-homing – handling BUM traffic from All-Active clients

EVPN in data centers

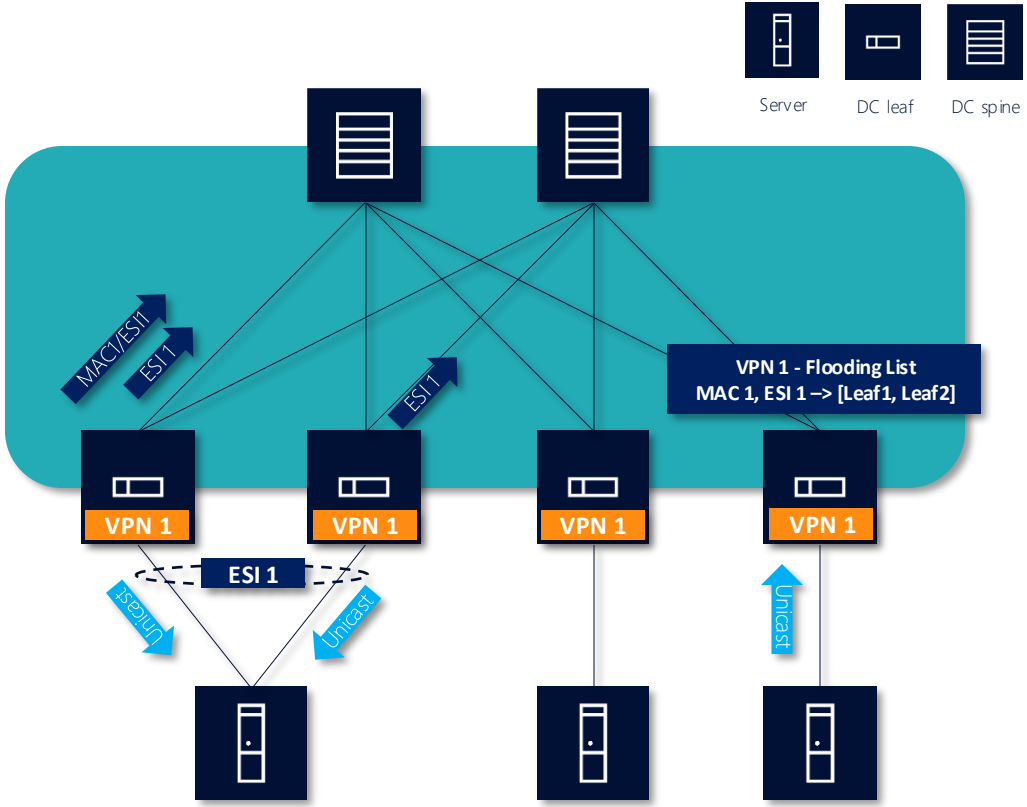
- Ingress leaf **encapsulates the BUM packet with an ESI label** and sends the packet to each member of its flooding list.
  - ESI label identifies the originating ES
- Egress leaf **does not forward packet** to the ES identified by the ESI label **if it is connected to that same ES**. This avoids replication of the traffic originated from an ES back to that same ES. Also called split-horizon, in EVPN, this specific mechanism is called **local bias**.



Multi-homing – aliasing for All-Active clients

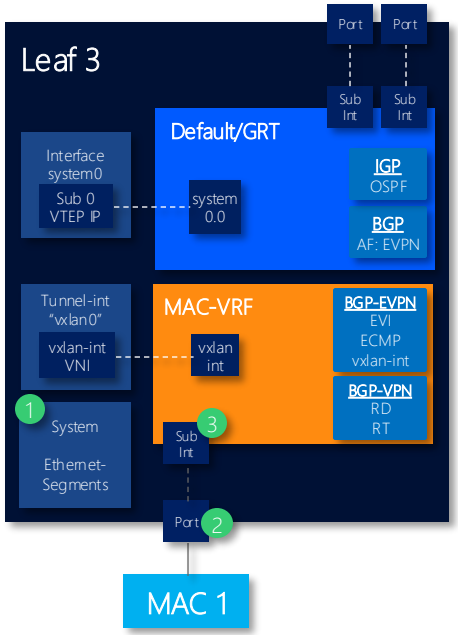
EVPN in data centers

- Leafs advertise their **local ESIs** in **Ethernet Auto-Discovery Routes** (EVPN Route Type 1)
- MAC/IP routes identify the ES of the advertised MAC, in the MAC-IP Advertisement Routes (EVPN Route Type 2)
- When sending unicast traffic, this list allows **load-balancing** to all the ES peers attached to that EVI. This mechanism is called **aliasing**.



MH - Configuring an EVPN layer-2 service on SR Linux

EVPN in data centers



1

```
A:leaf14# info system network-instance protocols evpn ethernet-segments bgp-instance 1 ethernet-segment ES-120
  system {
    network-instance {
      protocols {
        evpn {
          ethernet-segments {
            bgp-instance 1 {
                                        ethernet-segment ES-2 {
                                                admin-state enable
                                                esi 01:01:00:00:00:00:00:00:00:02
                                                multi-homing-mode all-active
                                                interface lag2 {
```

2

```
A:leaf14# info interface lag2
  interface lag2 {
    admin-state enable
    vlan-tagging true
    subinterface 120 {
      type bridged
      vlan {
        encap {
          single-tagged {
            vlan-id 120
    lag {
      lag-type lacp
      member-speed 10G
      lacp {
        interval FAST
        lacp-mode ACTIVE
        admin-key 2
        system-id-mac 00:00:00:00:00:02
```

3

```
A:leaf14# info network-instance mac-vrf-120
  network-instance mac-vrf-120 {
    type mac-vrf
    admin-state enable
    interface lag2.120 {
    }
```


NOKIA