

Dynamic IVRL on default VRF

AOS-CX 10.09

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Overview

Definitions

Acronyms

- IVRL **Inter VRF Route Leaking**
- DIVRL **Dynamic Inter VRF Route Leaking**
- SIVRL **Static Inter VRF Route Leaking**
- Routing table Valid routing entries selected from each active routing protocols based on the administrative distance
- FIB **Forwarding Information Base**,
 active forwarding entries programmed into ASIC based on the routing table
- RIB **Routing Information Base**,
 selected and non-selected candidate routes per routing protocol.

Overview

Reminder

- **IVRL or Inter-VRF Route Leaking** is a mechanism used to allow IP communication between VRFs and to “leak” IPv4/IPv6 routes from one VRF to one or multiple other VRFs.
- IVRL can be achieved either through:
 - **static IVRL** with usage of static routes:
A static route is configured in the destination VRF with both interface and IP Next-Hop from the source VRF.

```
switch(config)# ip route 10.1.1.0/24 1/1/1 10.2.1.1 vrf VRF2
```

leaks the prefix 10.1.1.0/24 into the “VRF2” VRF, which is reachable by the next-hop IP 10.2.1.1 on the interface 1/1/1 from “VRF1” VRF (not appearing in the static route command).
 - **Dynamic IVRL using MP-BGP**:
MP-BGP routes are exported from a source VRF with associated Route-Target, and imported on destination VRF with import Route-Target matching the value used for export.

```
vrf VRF1
  rd 192.168.1.1:1
  address-family ipv4 unicast
    route-target export 65001:1
    route-target import 65001:2
  exit-address-family
```

```
vrf VRF2
  rd 192.168.1.1:2
  address-family ipv4 unicast
    route-target export 65001:2
    route-target import 65001:1
  exit-address-family
```

Overview

Releases Comparison

AOS-CX 10.07

- Static route-leaking between VRFs (including “default” VRF) is supported.
- Dynamic IVRL is supported between tenant VRFs.
- Not possible for “default” VRF.
- No VRF route-map support.

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- Static route-leaking between VRFs (including “default” VRF) is supported.
- Dynamic IVRL is supported between tenant VRFs.
- CLI configuration for route-target and route-distinguisher of “default” VRF is possible but **not supported** (not tested).
- No VRF route-map support.

AOS-CX 10.09

- Static route-leaking between VRFs (including “default” VRF) is supported.
- Dynamic IVRL is supported between tenant and “default” VRFs.
- CLI configuration for route-target and route-distinguisher of “default” VRF is possible and **supported**.
- No VRF route-map support.



Use Cases

Use cases

Inter-VRFs use-cases

- Between tenant VRF1 and tenant VRF2: not so frequent, some services like DHCP.
- Between services VRF and tenant VRFs: main use-case
 - Used for multiple services: DHCP, DNS, in-band network management and monitoring
 - Services VRF can be configured as a dedicated VRF called “SERVICES” VRF
 - Services VRF can not be the “mgmt” OOBM VRF name

```
switch(config)# vrf mgmt  
VRF 'mgmt' already exists. Configurations under 'mgmt' vrf context are not allowed
```

- From AOS-CX 10.09, services VRF can now be the “default” VRF.
Useful during migration/transition from one flat default VRF network to multiple VRFFed/isolated networks.
Most services for DNS and network management are already configured in default VRF.

Details

AOS-CX 10.09 Enhancements

Dynamic IVRL on default VRF

- The previous configuration using non-default VRF have been extended to support default VRF.
- No schema change.
- Show running-config, show running-config vrf, show running-config vrf <name> have been enhanced to show vrf ‘default’.
- IPv4 and IPv6 Address-Families are supported under “default” VRF.
- EVPN route-targets are not supported under “default” VRF.

```
switch(config-vrf)# route-target both 1:1 evpn
EVPN configurations are not allowed under VRF default.
```

- 256 Route-Targets are supported in each VRF, including now in the default VRF context
- Redistribute local/connected/static/ospf can be used under “default” VRF context’s Address-Families to export routes from default VRF to tenant (non-default) VRF.

10.09 Platform Support

Dynamic IVRL on default VRF

Platform	4100 6000 6100	6200	6300	6400	8320	8325	8360	8400	10000	Simulator
Dynamic IVRL on default VRF	No	No	Yes	Yes						

Caveats

AOS-CX 10.09

- Cascaded IVRL on the same switch
 - On the same switch, only one level of Inter-VRF route leaking is supported.
Examples: VRF1 to “default”
 VRF1 to VRF2
 - On the same switch, more than one level of Inter-VRF route leaking, or cascaded IVRL, is not supported.
Example: VRF1 to VRF2 with default being the intermediate VRF: VRF1 → default → VRF2
 VRF2 won’t get routes from VRF1
- Multicast route leaking is not supported.
- As there is no route-map support yet for route-targets import/export rules, route filtering on dynamically leaked routes is not possible.
- Extended Community are lost through the route-leaking process.
- The total number of dynamic leaked routes among all VRFs is validated up to 16K per platform.

Configuration

Dynamic IVRL

VRF configuration

For DIVRL

- To leak routes from/to default VRF, the following must be configured:
 - In “default” VRF context:
 - route distinguisher
 - export route-target: one instance for value associated with “default” VRF or multiple instances (one per destination VRFs)
 - import route-target: multiple instances (one per source VRFs) or one instance for value associated with “default” VRF
 - In BGP “default” VRF context:
 - Redistribution of “default” VRF routes from other protocols: local, connected, static, ospf
 - or network command
 - or BGP routes received from BGP neighbor in “default” VRF
 - In “tenant” VRF context:
 - route distinguisher
 - Import/export route-targets
 - In BGP “tenant” VRF context:
 - Redistribution of “tenant” VRF routes from other protocols: local, connected, static, ospf
 - or network command
 - or BGP routes received from BGP neighbor in “tenant” VRF
- Route-target **export** values must be different between IPv4 and IPv6 address-family.

VRF configuration

no vrf default

- The configurations under VRF cannot be deleted with “no vrf” command.
- Route-Distinguisher and Address-Family configurations have to be individually deleted under vrf context.

```
switch# show run vrf default
vrf default
  rd 192.168.2.1:0
  address-family ipv4 unicast
    route-target export 65001:0
    route-target import 65001:1
    route-target import 65001:2
  exit-address-family
```

```
switch(config)# no vrf default
All Layer 3 configurations associated with the VRF will be deleted.
Continue (y/n)? Y
Cannot delete default VRF.
switch(config)# show run vrf default
vrf default
  rd 192.168.2.1:0
  address-family ipv4 unicast
    route-target export 65001:0
    route-target import 65001:1
    route-target import 65001:2
  exit-address-family
```

DIVRL

Route leaking between default VRF and tenant VRFs

```
vrf default
  rd 192.168.2.1:0
  address-family ipv4 unicast
    route-target export 65001:0
    route-target import 65001:1
    route-target import 65001:2
  exit-address-family
  address-family ipv6 unicast
    route-target export 65001:100
    route-target import 65001:101
    route-target import 65001:102
  exit-address-family
!
vrf VRF1
  rd 192.168.2.1:1
  address-family ipv4 unicast
    route-target export 65001:1
    route-target import 65001:0
  exit-address-family
  address-family ipv6 unicast
    route-target export 65001:101
    route-target import 65001:100
  exit-address-family
!
vrf VRF2
  rd 192.168.2.1:2
  address-family ipv4 unicast
    route-target export 65001:2
    route-target import 65001:0
  exit-address-family
  address-family ipv6 unicast
    route-target export 65001:102
    route-target import 65001:100
  exit-address-family
```

```
router bgp 65001
  bgp router-id 192.168.2.1
!
  address-family ipv4 unicast
    redistribute local loopback
    redistribute connected
    redistribute static
    redistribute ospf
  exit-address-family
  address-family ipv6 unicast
    redistribute connected
    redistribute static
    redistribute ospfv3
  exit-address-family
!
  vrf VRF1
    address-family ipv4 unicast
      redistribute connected
      redistribute static
      redistribute ospf
    exit-address-family
    address-family ipv6 unicast
      redistribute connected
      redistribute static
      redistribute ospfv3
    exit-address-family
!
  vrf VRF2
    address-family ipv4 unicast
      redistribute connected
      redistribute static
      redistribute ospf
    exit-address-family
    address-family ipv6 unicast
      redistribute connected
      redistribute static
      redistribute ospfv3
    exit-address-family
```

- no bgp peering in this example. (Can be configured if needed).
- redistribution must be adjusted based on routing design per VRF, per AF.

Best Practices

Best Practices

Route-targets

- Route-Distinguisher value must be different on each switch and each VRF.
- One dedicated route-target import and export value per VRF, shared among every switch so that the same BGP extended community is used per VRF domain.

Best Practices

Route-targets

“default” VRF route-target

```
vrf default
  rd 192.168.2.1:0
  address-family ipv4 unicast
    route-target export 65001:0
    route-target import 65001:1
    route-target import 65001:2
  exit-address-family
vrf VRF1
  rd 192.168.2.1:1
  address-family ipv4 unicast
    route-target export 65001:1
    route-target import 65001:0
  exit-address-family
vrf VRF2
  rd 192.168.2.1:2
  address-family ipv4 unicast
    route-target export 65001:2
    route-target import 65001:0
  exit-address-family
```

Recommended

Tenant VRF route-target

```
vrf default
  rd 192.168.2.1:0
  address-family ipv4 unicast
    route-target export 65001:1
    route-target export 65001:2
    route-target import 65001:1
    route-target import 65001:2
  exit-address-family
vrf VRF1
  rd 192.168.2.1:1
  address-family ipv4 unicast
    route-target export 65001:1
    route-target import 65001:1
  exit-address-family
vrf VRF2
  rd 192.168.2.1:2
  address-family ipv4 unicast
    route-target export 65001:2
    route-target import 65001:2
  exit-address-family
```

Not Recommended

- Better control and troubleshooting due to dedicated route-target for “default” VRF.
- Single point of configuration: No requirement for awareness of tenant VRFs on BGP peers in the default VRF.

- No configuration impact on tenant VRF.
- But, all BGP peers in the “default” VRF would need to get configured with all VRF Route-Targets.

Troubleshooting

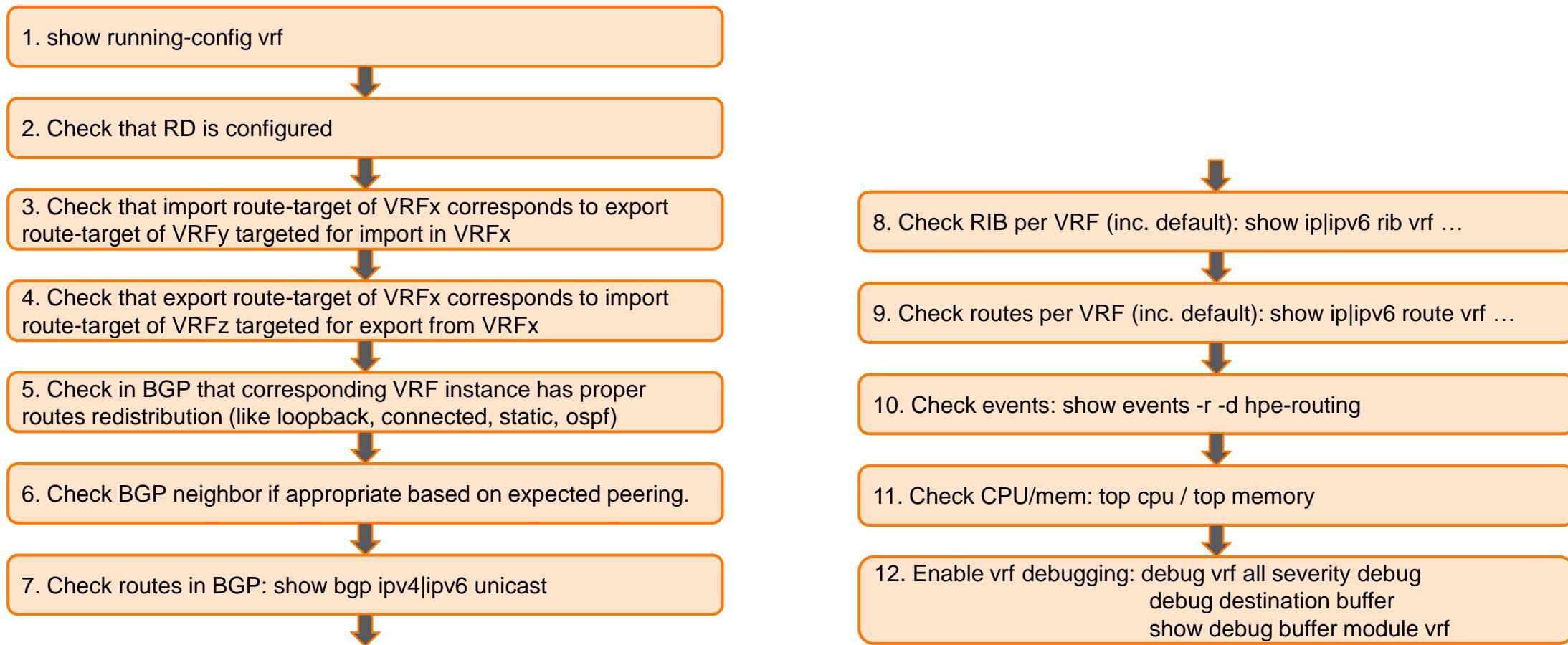
Route-Leaking Troubleshooting

Troubleshooting Pre-requisite

1. Have a topology diagram with identified switch, interfaces ID and IP details (ROPs, Loopbacks, SVIs).
2. Generate a “show tech” when creating the TAC case.
3. Check physical cabling and transceivers/DACs (supported versus unsupported).
“show system inventory transceiver”
4. Check interface state: “show interface brief” and “show interface error-statistics non-zero”
5. Check LLDP neighbor information “show LLDP neighbor”
6. Ping and traceroute between loopbacks or SVIs if relevant for debug.

Route-Leaking Troubleshooting

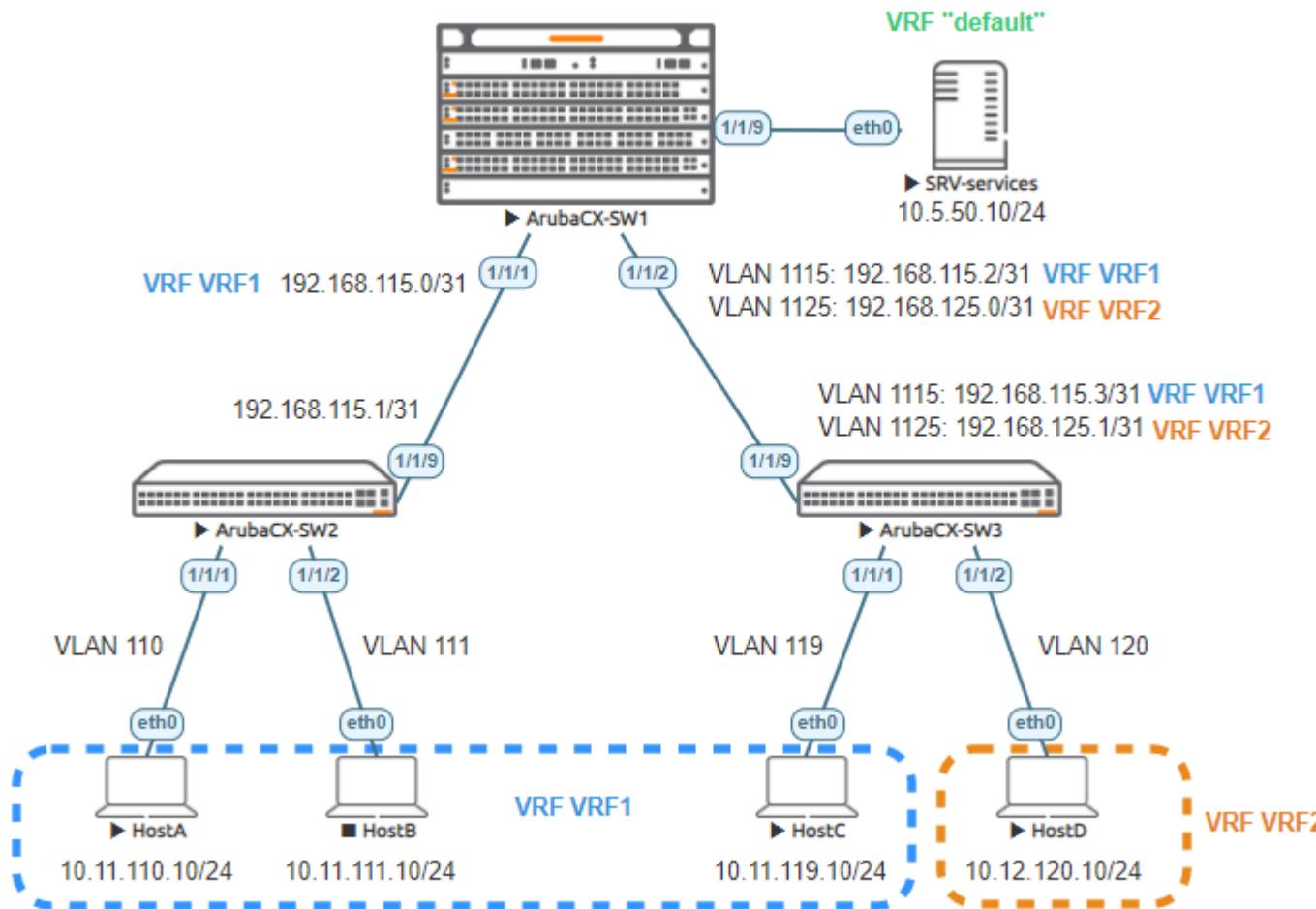
Troubleshooting Process



Demo

Topology

Simulator Lab: DIVRL with tenant VRF1 and VRF2 route-leaking to/from default VRF



- VRF1 Hosts should be able to communicate together in VRF1.
- No VRF1 Host should be able to communicate with VRF2 host.
- VRF1 and VRF2 Hosts should be able to communicate with Services Server located in “default” VRF.

Configuration

SW1

```
hostname SW1
!
vrf VRF1
    rd 192.168.2.1:1
    address-family ipv4 unicast
        route-target export 65001:1
        route-target import 65001:0
    exit-address-family
vrf VRF2
    rd 192.168.2.1:2
    address-family ipv4 unicast
        route-target export 65001:2
        route-target import 65001:0
    exit-address-family
vrf default
    rd 192.168.2.1:0
    address-family ipv4 unicast
        route-target export 65001:0
        route-target import 65001:1
        route-target import 65001:2
    exit-address-family
!
vlan 1,1115,1125
!
interface 1/1/1
    no shutdown
    vrf attach VRF1
    description to SW2
    ip address 192.168.115.0/31
interface 1/1/2
    no shutdown
    description to SW3
    no routing
    vlan trunk native 1
    vlan trunk allowed 1115,1125
interface 1/1/9
    no shutdown
    description to SRV
    ip address 10.5.50.1/24
```

```
interface vlan 1115
    vrf attach VRF1
    ip address 192.168.115.2/31
interface vlan 1125
    vrf attach VRF2
    ip address 192.168.125.0/31
!
ip route 10.11.96.0/20 192.168.115.1 vrf VRF1
ip route 10.11.119.0/24 192.168.115.3 vrf VRF1
ip route 10.12.0.0/16 192.168.125.1 vrf VRF2
!
router bgp 65001
    bgp router-id 192.168.2.1
    address-family ipv4 unicast
        redistribute connected
        redistribute static
    exit-address-family
!
vrf VRF1
    address-family ipv4 unicast
        redistribute connected
        redistribute static
    exit-address-family
!
vrf VRF2
    address-family ipv4 unicast
        redistribute connected
        redistribute static
    exit-address-family
```

Configuration

SW2 and SW3

```
hostname SW2
!
vlan 1,110-111
!
interface 1/1/1
    no shutdown
    description to HostA
    no routing
    vlan access 110
interface 1/1/2
    no shutdown
    description to HostB
    no routing
    vlan access 111
interface 1/1/9
    no shutdown
    description to SW1
    ip address 192.168.115.1/31
!
interface vlan 110
    ip address 10.11.110.1/24
interface vlan 111
    ip address 10.11.111.1/24
!
ip route 0.0.0.0/0 192.168.115.0
```

```
hostname SW3
vrf VRF1
vrf VRF2
!
vlan 1,119-120,1115,1125
!
interface 1/1/1
    no shutdown
    description to HostC
    no routing
    vlan access 119
interface 1/1/2
    no shutdown
    description to HostD
    no routing
    vlan access 120
interface 1/1/9
    no shutdown
    description to SW1
    no routing
    vlan trunk native 1
    vlan trunk allowed 1115,1125
!
interface vlan 119
    vrf attach VRF1
    ip address 10.11.119.1/24
interface vlan 120
    vrf attach VRF2
    ip address 10.12.120.1/24
interface vlan 1115
    vrf attach VRF1
    ip address 192.168.115.3/31
interface vlan 1125
    vrf attach VRF2
    ip address 192.168.125.1/31
!
ip route 0.0.0.0/0 192.168.115.2 vrf VRF1
ip route 0.0.0.0/0 192.168.125.0 vrf VRF2
```

SW1 BGP RIB

Per VRF

```
SW1# show bgp vrf VRF1 ipv4 unicast
Status codes: s suppressed, d damped, h history, * valid, > best, = multipath,
              i internal, e external S Stale, R Removed, a additional-paths
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```
VRF : VRF1
Local Router-ID 192.168.115.2
```

Network	Nexthop	Metric	LocPrf	Weight	Path
Route Distinguisher: 192.168.2.1:1					
*> 10.5.50.0/24	0.0.0.0	0	100	0	?
*> 10.11.96.0/20	192.168.115.1	0	100	0	?
*> 10.11.119.0/24	192.168.115.3	0	100	0	?
*> 192.168.115.0/31	0.0.0.0	0	100	0	?
*> 192.168.115.2/31	0.0.0.0	0	100	0	?
Total number of entries	5				

```
SW1# show bgp vrf VRF2 ipv4 unicast
Status codes: s suppressed, d damped, h history, * valid, > best, = multipath,
              i internal, e external S Stale, R Removed, a additional-paths
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```
VRF : VRF2
Local Router-ID 192.168.125.0
```

Network	Nexthop	Metric	LocPrf	Weight	Path
Route Distinguisher: 192.168.2.1:2					
*> 10.5.50.0/24	0.0.0.0	0	100	0	?
*> 10.12.0.0/16	192.168.125.1	0	100	0	?
*> 192.168.125.0/31	0.0.0.0	0	100	0	?
Total number of entries	3				

```
SW1# show bgp ipv4 unicast
Status codes: s suppressed, d damped, h history, * valid, > best, = multipath,
              i internal, e external S Stale, R Removed, a additional-paths
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```
VRF : default
Local Router-ID 192.168.2.1
```

Network	Nexthop	Metric	LocPrf	Weight	Path
Route Distinguisher: 192.168.2.1:0					
*> 10.5.50.0/24	0.0.0.0	0	100	0	?
*> 10.11.96.0/20	192.168.115.1	0	100	0	?
*> 10.11.119.0/24	192.168.115.3	0	100	0	?
*> 10.12.0.0/16	192.168.125.1	0	100	0	?
*> 192.168.115.0/31	0.0.0.0	0	100	0	?
*> 192.168.115.2/31	0.0.0.0	0	100	0	?
*> 192.168.125.0/31	0.0.0.0	0	100	0	?
Total number of entries	7				

SW1 FIB

Per VRF

```
SW1# sh ip route vrf VRF1
```

Displaying ipv4 routes selected for forwarding

Origin Codes: C - connected, S - static, L - local
R - RIP, B - BGP, O - OSPF

Type Codes: E - External BGP, I - Internal BGP, V - VPN, EV - EVPN
IA - OSPF internal area, E1 - OSPF external type 1
E2 - OSPF external type 2

VRF: VRF1

Prefix	Nexthop	Interface	VRF(egress)	Origin/ Type	Distance/ Metric	Age
10.5.50.0/24	-	1/1/9	default	B/I	[200/0]	00h:42m:01s
10.11.96.0/20	192.168.115.1	1/1/1	-	S	[1/0]	03h:28m:24s
10.11.119.0/24	192.168.115.3	vlan1115	-	S	[1/0]	03h:28m:24s
192.168.115.0/31	-	1/1/1	-	C	[0/0]	-
192.168.115.0/32	-	1/1/1	-	L	[0/0]	-
192.168.115.2/31	-	vlan1115	-	C	[0/0]	-
192.168.115.2/32	-	vlan1115	-	L	[0/0]	-

Total Route Count : 7

```
SW1# sh ip route vrf VRF2
```

Displaying ipv4 routes selected for forwarding

Origin Codes: C - connected, S - static, L - local
R - RIP, B - BGP, O - OSPF

Type Codes: E - External BGP, I - Internal BGP, V - VPN, EV - EVPN
IA - OSPF internal area, E1 - OSPF external type 1
E2 - OSPF external type 2

VRF: VRF2

Prefix	Nexthop	Interface	VRF(egress)	Origin/ Type	Distance/ Metric	Age
10.5.50.0/24	-	1/1/9	default	B/I	[200/0]	00h:42m:31s
10.12.0.0/16	192.168.125.1	vlan1125	-	S	[1/0]	03h:28m:54s
192.168.125.0/31	-	vlan1125	-	C	[0/0]	-
192.168.125.0/32	-	vlan1125	-	L	[0/0]	-

Total Route Count : 4

```
SW1# sh ip route
```

Displaying ipv4 routes selected for forwarding

Origin Codes: C - connected, S - static, L - local
R - RIP, B - BGP, O - OSPF

Type Codes: E - External BGP, I - Internal BGP, V - VPN, EV - EVPN
IA - OSPF internal area, E1 - OSPF external type 1
E2 - OSPF external type 2

VRF: default

Prefix	Nexthop	Interface	VRF(egress)	Origin/ Type	Distance/ Metric	Age
10.5.50.0/24	-	1/1/9	-	C	[0/0]	-
10.5.50.1/32	-	1/1/9	-	L	[0/0]	-
10.11.96.0/20	192.168.115.1	1/1/1	VRF1	B/I	[200/0]	00h:41m:19s
10.11.119.0/24	192.168.115.3	vlan1115	VRF1	B/I	[200/0]	00h:41m:19s
10.12.0.0/16	192.168.125.1	vlan1125	VRF2	B/I	[200/0]	00h:41m:19s
192.168.115.0/31	-	1/1/1	VRF1	B/I	[200/0]	00h:41m:19s
192.168.115.2/31	-	vlan1115	VRF1	B/I	[200/0]	00h:41m:19s
192.168.125.0/31	-	vlan1125	VRF2	B/I	[200/0]	00h:41m:19s

Total Route Count : 8

Route-Targets in “default” VRF

```
SW1# sh bgp ipv4 unicast 10.5.50.0/24
```

Source VRF: default

```
VRF : default  
BGP Local AS 65001      BGP Router-id 192.168.2.1
```

```
Network      : 10.5.50.0/24      Nexthop      : 0.0.0.0  
Peer        : 0.0.0.0          Origin       : incomplete  
Metric       : 0                Local Pref   : 100  
Weight       : 0                Calc. Local Pref : 100  
Best         : Yes              Valid        : Yes  
Type         : external         Stale        : No  
Originator ID : 0.0.0.0        Path ID     : 0  
Aggregator ID :  
Aggregator AS :  
Atomic Aggregate :  
RFD Flaps    : 0                RFD Penalty : 0  
  
AS-Path      :  
Cluster List :  
Communities  :  
Ext-Communities : RT: 65001:0
```

```
SW1# sh bgp vrf VRF1 ipv4 unicast 10.5.50.0/24
```

Destination VRF: VRF1

```
VRF : VRF1  
BGP Local AS 65001      BGP Router-id 192.168.115.2
```

```
Network      : 10.5.50.0/24      Nexthop      : 0.0.0.0  
Peer        : 0.0.0.0          Origin       : incomplete  
Metric       : 0                Local Pref   : 100  
Weight       : 0                Calc. Local Pref : 100  
Best         : Yes              Valid        : Yes  
Type         : external         Stale        : No  
Originator ID : 0.0.0.0        Path ID     : 0  
Aggregator ID :  
Aggregator AS :  
Atomic Aggregate :  
RFD Flaps    : 0                RFD Penalty : 0  
  
AS-Path      :  
Cluster List :  
Communities  :  
Ext-Communities : :
```

Ext-Communities : :

Route-target is lost during import

```
SW1# sh bgp vrf VRF1 ipv4 unicast 10.11.119.0/24
```

Source VRF: VRF1

```
VRF : VRF1  
BGP Local AS 65001      BGP Router-id 192.168.115.2
```

```
Network      : 10.11.119.0/24      Nexthop      : 192.168.115.3  
Peer        : 0.0.0.0          Origin       : incomplete  
Metric       : 0                Local Pref   : 100  
Weight       : 0                Calc. Local Pref : 100  
Best         : Yes              Valid        : Yes  
Type         : external         Stale        : No  
Originator ID : 0.0.0.0        Path ID     : 0  
Aggregator ID :  
Aggregator AS :  
Atomic Aggregate :  
RFD Flaps    : 0                RFD Penalty : 0  
  
AS-Path      :  
Cluster List :  
Communities  :  
Ext-Communities : RT: 65001:1
```

```
SW1# sh bgp ipv4 unicast 10.11.119.0/24
```

Destination VRF: default

```
VRF : default  
BGP Local AS 65001      BGP Router-id 192.168.2.1
```

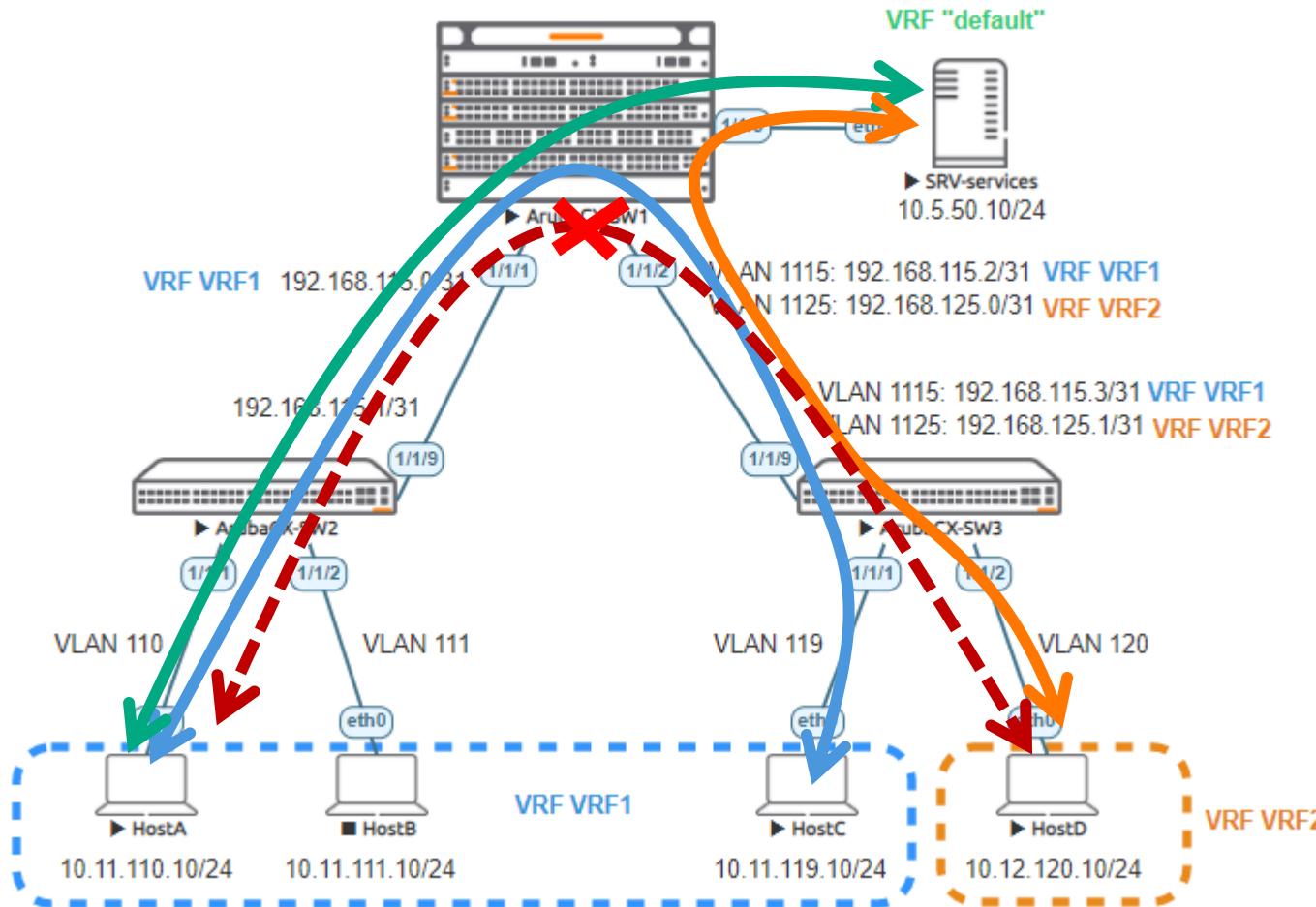
```
Network      : 10.11.119.0/24      Nexthop      : 192.168.115.3  
Peer        : 0.0.0.0          Origin       : incomplete  
Metric       : 0                Local Pref   : 100  
Weight       : 0                Calc. Local Pref : 100  
Best         : Yes              Valid        : Yes  
Type         : external         Stale        : No  
Originator ID : 0.0.0.0        Path ID     : 0  
Aggregator ID :  
Aggregator AS :  
Atomic Aggregate :  
RFD Flaps    : 0                RFD Penalty : 0  
  
AS-Path      :  
Cluster List :  
Communities  :  
Ext-Communities : :
```

Ext-Communities : :

Route-target is lost during import

Traffic objectives

ICMP tests



- VRF1 Hosts should be able to communicate together in VRF1.
- No VRF1 Host should be able to communicate with VRF2 host.
- VRF1 and VRF2 Hosts should be able to communicate with Services Server located in “default” VRF.

Resources

Thank you

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