Troubleshoot Firepower Threat Defense Routing

Contents

Introduction

This document describes how Firepower Threat Defense (FTD) forwards packets and implements various routing concepts.

Prerequisites

Requirements

- Basic routing knowledge

Components Used

The information in this document is based on these software and hardware versions:

- Cisco Firepower 41xx Threat Defense Version 7.1.x
- Firepower Management Center (FMC) Version 7.1.x

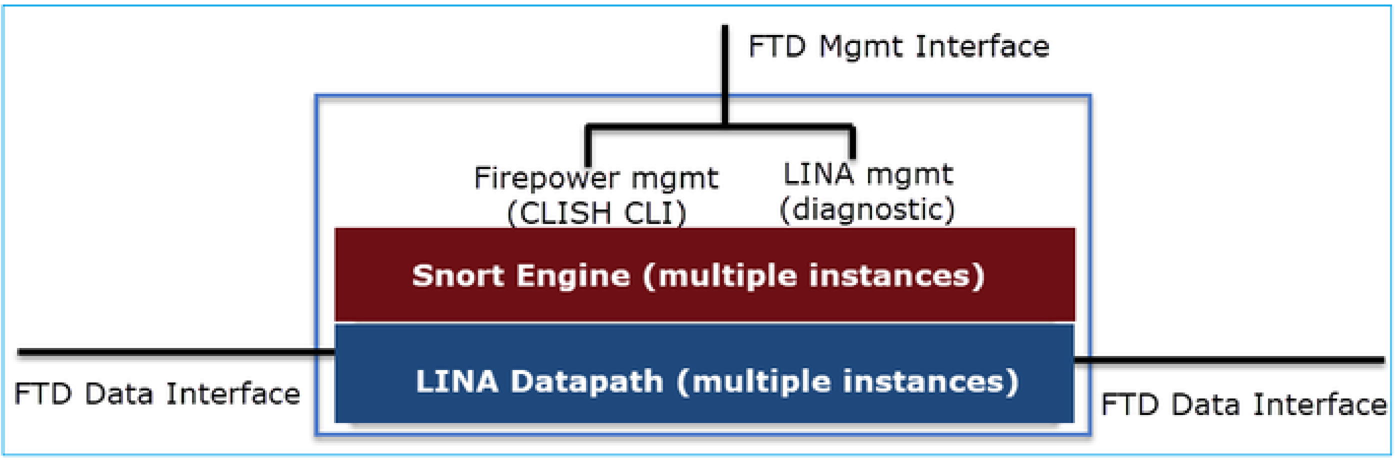
The information in this document was created from the devices in a specific lab environment. All of the devices used in this document started with a cleared (default) configuration. If your network is live, ensure that you understand the potential impact of any command.

Background Information

FTD Packet Forwarding Mechanisms

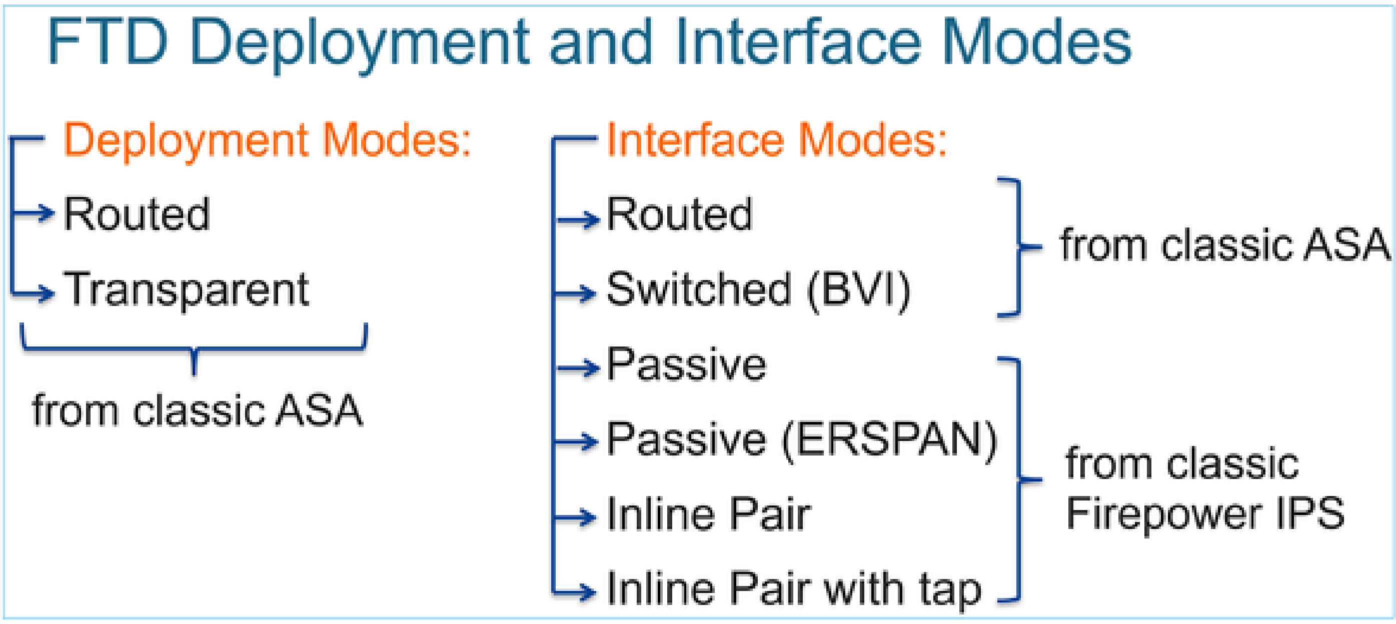
FTD is a unified software image that consists of 2 main engines:

- Datapath engine (LINA)
- Snort engine


FTD Mgmt Interface
Firepower mgmt (CLISH CLI)
LINA mgmt (diagnostic)
Snort Engine (multiple instances)
LINA Datapath (multiple instances)
FTD Data Interface
FTD Data Interface

The Datapath and the Snort Engine are the main parts of the FTD Data Plane.

The FTD Data Plane forwarding mechanism depends on the interface mode. The next picture summarizes the various interface modes along with the FTD deployment modes:



FTD Deployment and Interface Modes

Deployment Modes:

- Routed
- Transparent

from classic ASA

Interface Modes:

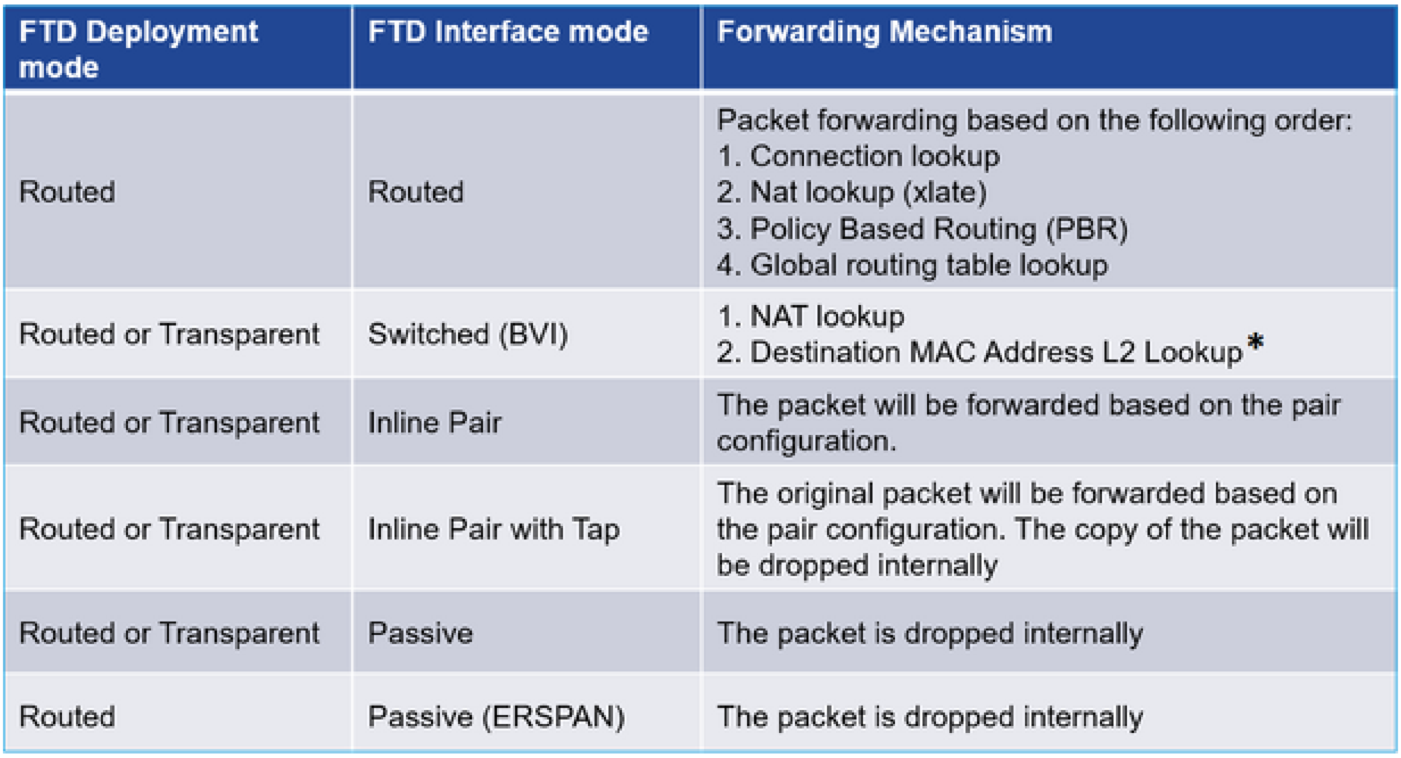
- Routed
- Switched (BVI)

from classic ASA

- Passive
- Passive (ERSPAN)
- Inline Pair
- Inline Pair with tap

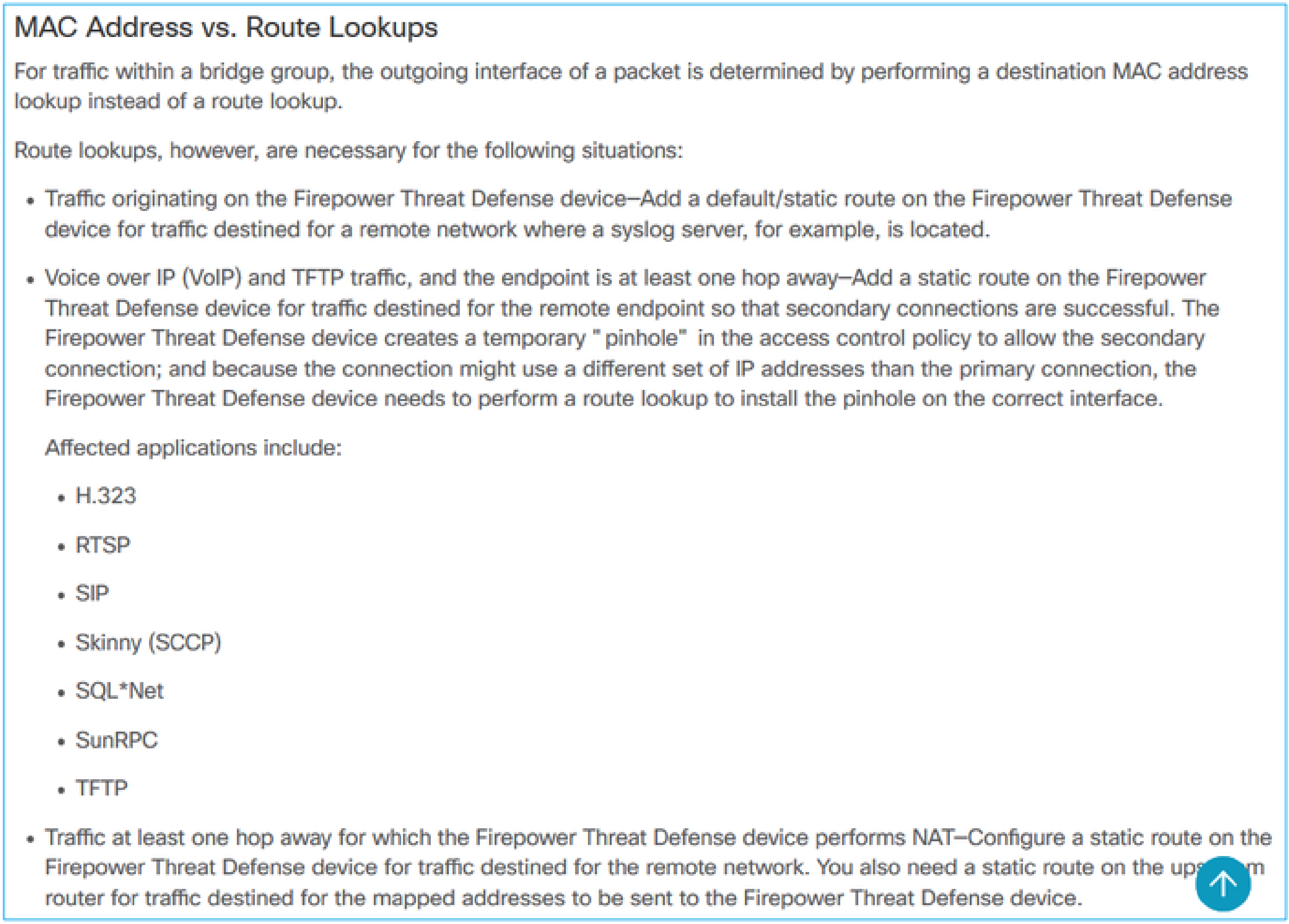
from classic Firepower IPS

The table summarizes how the FTD forwards packets in the data plane based on the interface mode. The forwarding mechanisms are listed in order of preference:



FTD Deployment mode	FTD Interface mode	Forwarding Mechanism
Routed	Routed	Packet forwarding based on the following order: 1. Connection lookup 2. Nat lookup (xlate) 3. Policy Based Routing (PBR) 4. Global routing table lookup
Routed or Transparent	Switched (BVI)	1. NAT lookup 2. Destination MAC Address L2 Lookup*
Routed or Transparent	Inline Pair	The packet will be forwarded based on the pair configuration.
Routed or Transparent	Inline Pair with Tap	The original packet will be forwarded based on the pair configuration. The copy of the packet will be dropped internally
Routed or Transparent	Passive	The packet is dropped internally
Routed	Passive (ERSPAN)	The packet is dropped internally

* An FTD in Transparent mode does a Route Lookup in some situations:



MAC Address vs. Route Lookups

For traffic within a bridge group, the outgoing interface of a packet is determined by performing a destination MAC address lookup instead of a route lookup.

Route lookups, however, are necessary for the following situations:

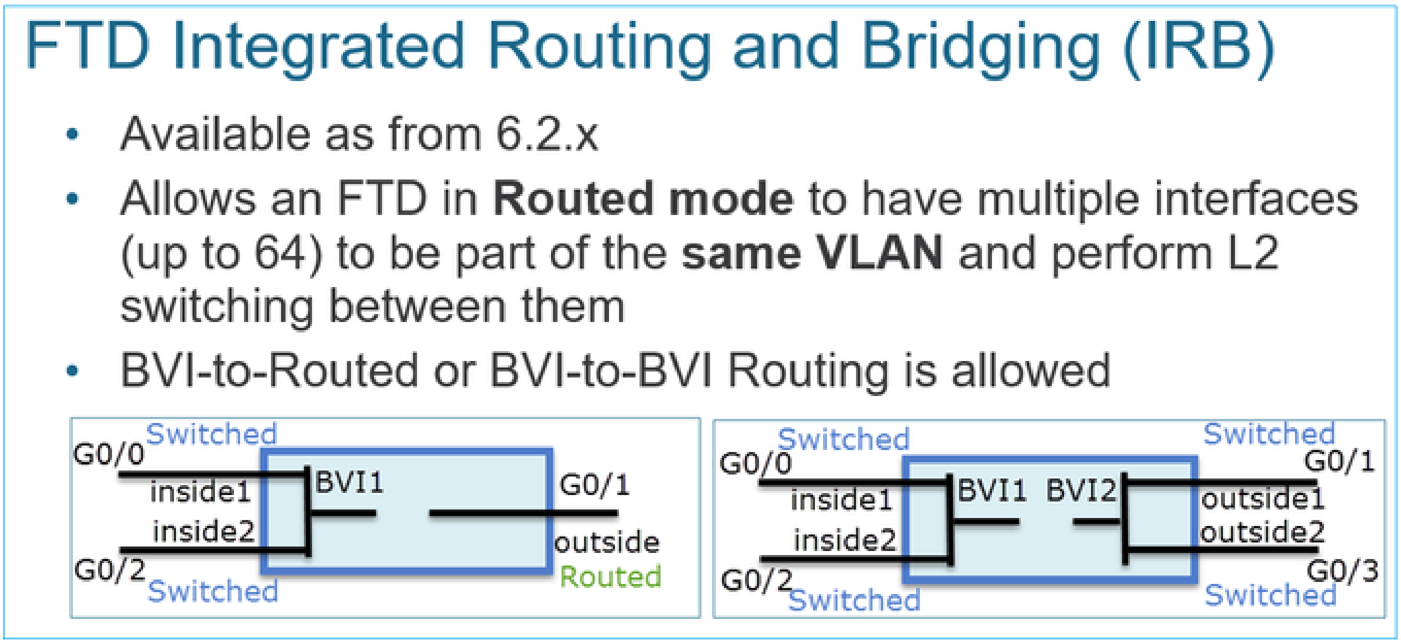
- Traffic originating on the Firepower Threat Defense device—Add a default/static route on the Firepower Threat Defense device for traffic destined for a remote network where a syslog server, for example, is located.
- Voice over IP (VoIP) and TFTP traffic, and the endpoint is at least one hop away—Add a static route on the Firepower Threat Defense device for traffic destined for the remote endpoint so that secondary connections are successful. The Firepower Threat Defense device creates a temporary "pinhole" in the access control policy to allow the secondary connection; and because the connection might use a different set of IP addresses than the primary connection, the Firepower Threat Defense device needs to perform a route lookup to install the pinhole on the correct interface.

  Affected applications include:

  - H.323
  - RTSP
  - SIP
  - Skinny (SCCP)
  - SQL*Net
  - SunRPC
  - TFTP
- Traffic at least one hop away for which the Firepower Threat Defense device performs NAT—Configure a static route on the Firepower Threat Defense device for traffic destined for the remote network. You also need a static route on the upstream router for traffic destined for the mapped addresses to be sent to the Firepower Threat Defense device.

Check the FMC guide for more details.

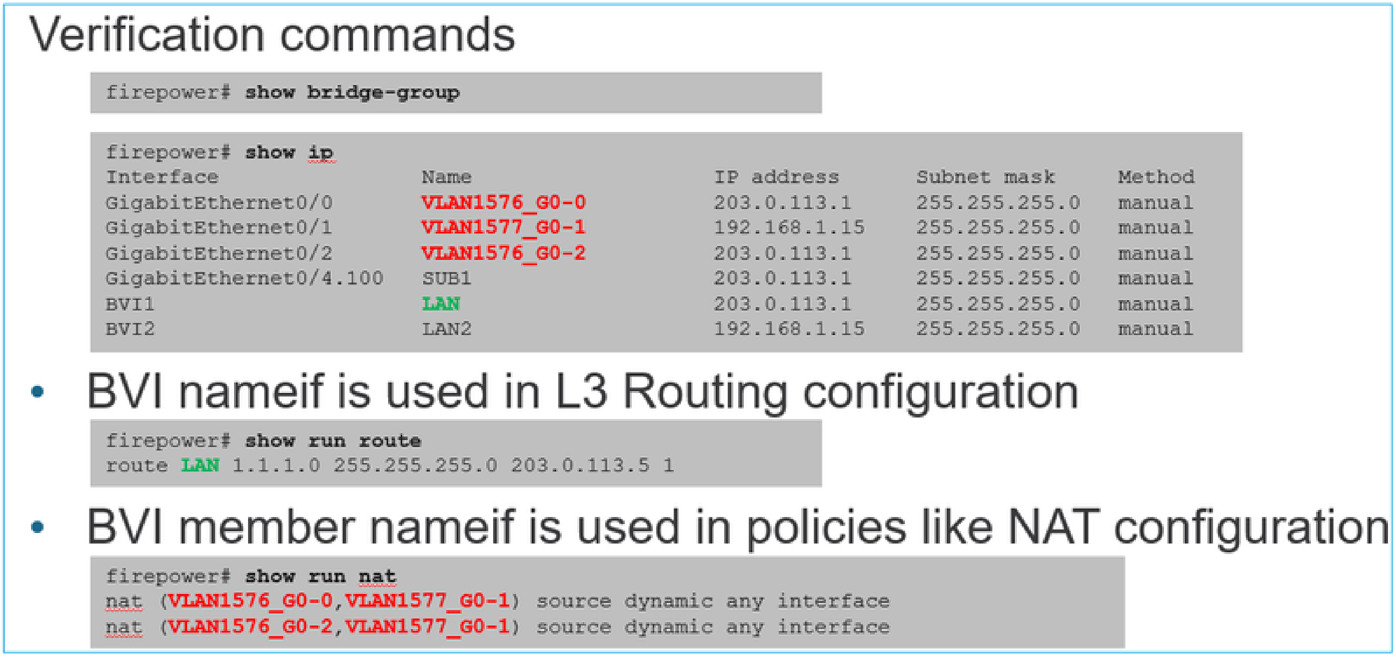
As from the 6.2.x version, the FTD supports Integrated Routing and Bridging (IRB):



FTD Integrated Routing and Bridging (IRB)

- Available as from 6.2.x
- Allows an FTD in **Routed mode** to have multiple interfaces (up to 64) to be part of the **same VLAN** and perform L2 switching between them
- BVI-to-Routed or BVI-to-BVI Routing is allowed

BVI verification commands:



Verification commands

```
firepower# show bridge-group
```

```
firepower# show ip
Interface                Name                   IP address      Subnet mask     Method
GigabitEthernet0/0       VLAN1576_G0-0          203.0.113.1     255.255.255.0   manual
GigabitEthernet0/1       VLAN1577_G0-1          192.168.1.15    255.255.255.0   manual
GigabitEthernet0/2       VLAN1576_G0-2          203.0.113.1     255.255.255.0   manual
GigabitEthernet0/4.100   SUB1                   203.0.113.1     255.255.255.0   manual
BVI1                     LAN                    203.0.113.1     255.255.255.0   manual
BVI2                     LAN2                   192.168.1.15    255.255.255.0   manual
```

- BVI nameif is used in L3 Routing configuration

```
firepower# show run route
route LAN 1.1.1.0 255.255.255.0 203.0.113.5 1
```

- BVI member nameif is used in policies like NAT configuration

```
firepower# show run nat
nat (VLAN1576_G0-0,VLAN1577_G0-1) source dynamic any interface
nat (VLAN1576_G0-2,VLAN1577_G0-1) source dynamic any interface
```

Key Point

For routed interfaces or BVIs (IRB) the packet forwarding is based on this order:

- Connection lookup
- NAT lookup (destination NAT, also known as UN-NAT)
- Policy-Based Routing (PBR)
- Global routing table lookup

What about source NAT?

The source NAT is checked after the Global routing lookup.

The rest of this document focuses on the Routed interface mode.

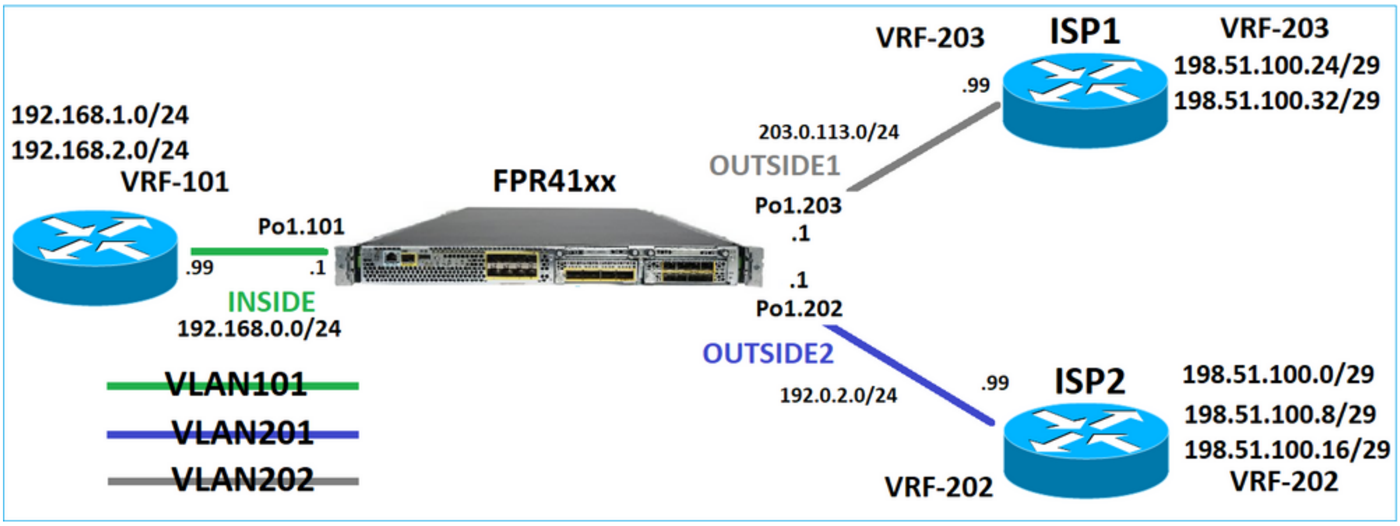
Data Plane (LINA) Routing Behavior

In routed interface mode FTD LINA forwards the packets in 2 phases:

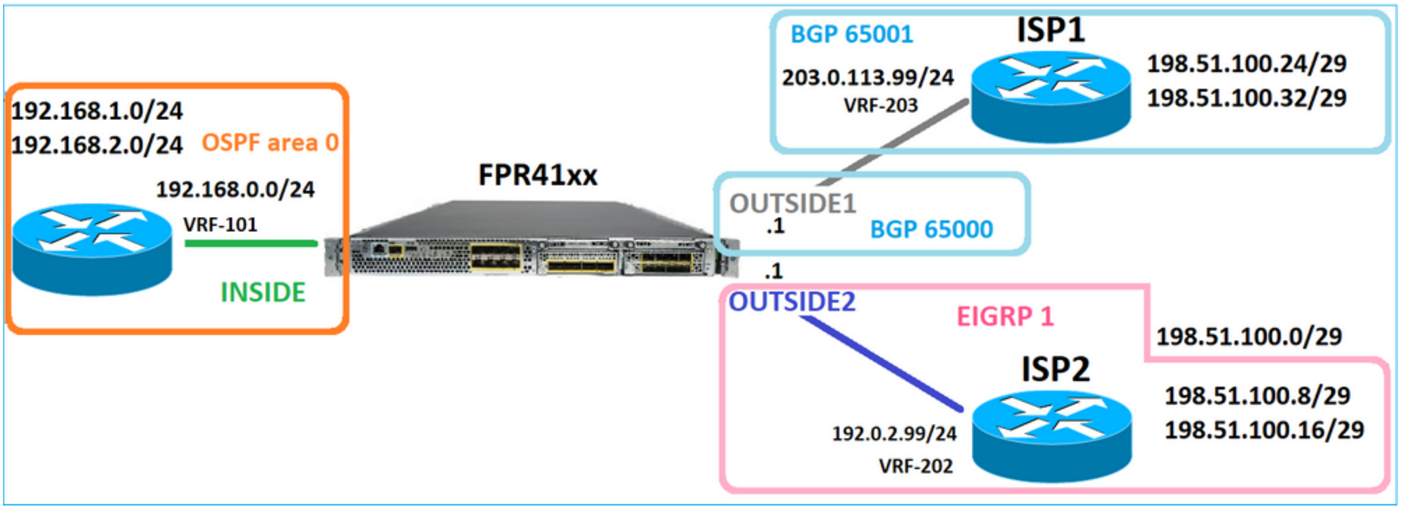
Phase 1 – Egress Interface Determination

Phase 2 – Next-Hop Selection

Consider this topology:



And this routing design:



The FTD routing configuration:

```
firepower# show run router
router ospf 1
network 192.168.0.0 255.255.255.0 area 0
log-adj-changes
!
router bgp 65000
bgp log-neighbor-changes
bgp router-id vrf auto-assign
address-family ipv4 unicast
neighbor 203.0.113.99 remote-as 65001
neighbor 203.0.113.99 ebgp-multihop 255
neighbor 203.0.113.99 transport path-mtu-discovery disable
neighbor 203.0.113.99 activate
no auto-summary
no synchronization
exit-address-family
!
router eigrp 1
no default-information in
no default-information out
no eigrp log-neighbor-warnings
no eigrp log-neighbor-changes
network 192.0.2.0 255.255.255.0
!
firepower# show run route
route OUTSIDE2 198.51.100.0 255.255.255.248 192.0.2.99 1
```

The FTD Routing Information Base (RIB) - Control Plane:

```
firepower# show route | begin Gate
Gateway of last resort is not set

C 192.0.2.0 255.255.255.0 is directly connected, OUTSIDE2
L 192.0.2.1 255.255.255.255 is directly connected, OUTSIDE2
C 192.168.0.0 255.255.255.0 is directly connected, INSIDE
L 192.168.0.1 255.255.255.255 is directly connected, INSIDE
O 192.168.1.1 255.255.255.255
[110/11] via 192.168.0.99, 01:11:25, INSIDE
O 192.168.2.1 255.255.255.255
[110/11] via 192.168.0.99, 01:11:15, INSIDE
S 198.51.100.0 255.255.255.248 [1/0] via 192.0.2.99, OUTSIDE2
D 198.51.100.8 255.255.255.248
[90/130816] via 192.0.2.99, 01:08:11, OUTSIDE2
D 198.51.100.16 255.255.255.248
[90/130816] via 192.0.2.99, 01:08:04, OUTSIDE2
B 198.51.100.24 255.255.255.248 [20/0] via 203.0.113.99, 00:28:29
B 198.51.100.32 255.255.255.248 [20/0] via 203.0.113.99, 00:28:16
C 203.0.113.0 255.255.255.0 is directly connected, OUTSIDE1
L 203.0.113.1 255.255.255.255 is directly connected, OUTSIDE1
```

The corresponding FTD Accelerated Security Path (ASP) Routing table - Data Plane:

```
firepower# show asp table routing
route table timestamp: 91
in 169.254.1.1 255.255.255.255 identity
in 192.168.0.1 255.255.255.255 identity
in 192.0.2.1 255.255.255.255 identity
in 192.168.1.1 255.255.255.255 via 192.168.0.99, INSIDE
in 192.168.2.1 255.255.255.255 via 192.168.0.99, INSIDE
in 203.0.113.1 255.255.255.255 identity
in 169.254.1.0 255.255.255.248 nlp_int_tap
in 198.51.100.0 255.255.255.248 via 192.0.2.99, OUTSIDE2
in 198.51.100.8 255.255.255.248 via 192.0.2.99, OUTSIDE2
in 198.51.100.16 255.255.255.248 via 192.0.2.99, OUTSIDE2
in 198.51.100.24 255.255.255.248 via 203.0.113.99 (unresolved, timestamp: 89)
in 198.51.100.32 255.255.255.248 via 203.0.113.99 (unresolved, timestamp: 90)
in 192.168.0.0 255.255.255.0 INSIDE
in 192.0.2.0 255.255.255.0 OUTSIDE2
in 203.0.113.0 255.255.255.0 OUTSIDE1
in ff02::1 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
in ff02::1:ff01:3 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
in ff02::1:ff00:1 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
in fe80::200:ff:fe01:3 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
in fd00:0:0:1::1 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
in fd00:0:0:1:: ffff:ffff:ffff:ffff:: nlp_int_tap
```

```
out 255.255.255.255 255.255.255.255 OUTSIDE1
out 203.0.113.1 255.255.255.255 OUTSIDE1
out 203.0.113.0 255.255.255.0 OUTSIDE1
out 224.0.0.0 240.0.0.0 OUTSIDE1
out 255.255.255.255 255.255.255.255 OUTSIDE2
out 192.0.2.1 255.255.255.255 OUTSIDE2
out 198.51.100.0 255.255.255.248 via 192.0.2.99, OUTSIDE2
out 198.51.100.8 255.255.255.248 via 192.0.2.99, OUTSIDE2
out 198.51.100.16 255.255.255.248 via 192.0.2.99, OUTSIDE2
out 192.0.2.0 255.255.255.0 OUTSIDE2
out 224.0.0.0 240.0.0.0 OUTSIDE2
out 255.255.255.255 255.255.255.255 INSIDE
out 192.168.0.1 255.255.255.255 INSIDE
out 192.168.1.1 255.255.255.255 via 192.168.0.99, INSIDE
out 192.168.2.1 255.255.255.255 via 192.168.0.99, INSIDE
out 192.168.0.0 255.255.255.0 INSIDE
out 224.0.0.0 240.0.0.0 INSIDE
out 255.255.255.255 255.255.255.255 cmi_mgmt_int_tap
out 224.0.0.0 240.0.0.0 cmi_mgmt_int_tap
out 255.255.255.255 255.255.255.255 ha_ctl_nlp_int_tap
out 224.0.0.0 240.0.0.0 ha_ctl_nlp_int_tap
out 255.255.255.255 255.255.255.255 ccl_ha_nlp_int_tap
out 224.0.0.0 240.0.0.0 ccl_ha_nlp_int_tap
out 255.255.255.255 255.255.255.255 nlp_int_tap
out 169.254.1.1 255.255.255.255 nlp_int_tap
out 169.254.1.0 255.255.255.248 nlp_int_tap
out 224.0.0.0 240.0.0.0 nlp_int_tap
out fd00:0:0:1::1 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff nlp_int_tap
out fd00:0:0:1:: ffff:ffff:ffff:ffff:: nlp_int_tap
out fe80:: ffc0:: nlp_int_tap
out ff00:: ff00:: nlp_int_tap
out 0.0.0.0 0.0.0.0 via 0.0.0.0, identity
out :: :: via 0.0.0.0, identity
```

Key Points

The FTD (in a way similar to an Adaptive Security Appliance - ASA), first determines the exit (egress) interface of a packet (for that, it looks at the 'in' entries of the ASP routing table). Then for the determined interface, it tries to find the next-hop (for that, it looks at the 'out' entries of the ASP routing table). For example:

```
firepower# show asp table routing | include in.*198.51.100.0
in 198.51.100.0 255.255.255.248 via 192.0.2.99, OUTSIDE2
firepower#
firepower# show asp table routing | include out.*OUTSIDE2
out 255.255.255.255 255.255.255.255 OUTSIDE2
out 192.0.2.1 255.255.255.255 OUTSIDE2
out 198.51.100.0 255.255.255.248 via 192.0.2.99, OUTSIDE2
out 198.51.100.8 255.255.255.248 via 192.0.2.99, OUTSIDE2
out 198.51.100.16 255.255.255.248 via 192.0.2.99, OUTSIDE2
out 192.0.2.0 255.255.255.0 OUTSIDE2
out 224.0.0.0 240.0.0.0 OUTSIDE2
```

Finally, for the resolved next-hop the LINA checks the ARP cache for a valid adjacency.

The FTD packet-tracer tool confirms this process:

```
firepower# packet-tracer input INSIDE icmp 192.168.1.1 8 0 198.51.100.1

Phase: 1
Type: ACCESS-LIST
Subtype:
Result: ALLOW
Elapsed time: 7582 ns
Config:
Implicit Rule
Additional Information:
MAC Access list

Phase: 2
Type: INPUT-ROUTE-LOOKUP
Subtype: Resolve Egress Interface
Result: ALLOW
Elapsed time: 8474 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)

Phase: 3
Type: ACCESS-LIST
Subtype: log
Result: ALLOW
Elapsed time: 5017 ns
Config:
access-group CSM_FW_ACL_ global
access-list CSM_FW_ACL_ advanced permit ip any any rule-id 268434433
access-list CSM_FW_ACL_ remark rule-id 268434433: ACCESS POLICY: mzafeiro_empty - Default
access-list CSM_FW_ACL_ remark rule-id 268434433: L4 RULE: DEFAULT ACTION RULE
Additional Information:
This packet will be sent to snort for additional processing where a verdict will be reached

Phase: 4
Type: CONN-SETTINGS
Subtype:
Result: ALLOW
Elapsed time: 5017 ns
Config:
class-map class-default
match any
policy-map global_policy
class class-default
set connection advanced-options UM_STATIC_TCP_MAP
service-policy global_policy global
Additional Information:

Phase: 5
Type: NAT
Subtype: per-session
Result: ALLOW
Elapsed time: 5017 ns
Config:
Additional Information:

Phase: 6
Type: IP-OPTIONS
```

```
Subtype:
Result: ALLOW
Elapsed time: 5017 ns
Config:
Additional Information:

Phase: 7
Type: INSPECT
Subtype: np-inspect
Result: ALLOW
Elapsed time: 57534 ns
Config:
class-map inspection_default
match default-inspection-traffic
policy-map global_policy
class inspection_default
inspect icmp
service-policy global_policy global
Additional Information:

Phase: 8
Type: INSPECT
Subtype: np-inspect
Result: ALLOW
Elapsed time: 3122 ns
Config:
Additional Information:

Phase: 9
Type: NAT
Subtype: per-session
Result: ALLOW
Elapsed time: 29882 ns
Config:
Additional Information:

Phase: 10
Type: IP-OPTIONS
Subtype:
Result: ALLOW
Elapsed time: 446 ns
Config:
Additional Information:

Phase: 11
Type: FLOW-CREATION
Subtype:
Result: ALLOW
Elapsed time: 20962 ns
Config:
Additional Information:
New flow created with id 178, packet dispatched to next module

Phase: 12
Type: EXTERNAL-INSPECT
Subtype:
Result: ALLOW
Elapsed time: 20070 ns
Config:
Additional Information:
Application: 'SNORT Inspect'
```

```
Phase: 13
Type: SNORT
Subtype:
Result: ALLOW
Elapsed time: 870592 ns
Config:
Additional Information:
Snort Trace:
Packet: ICMP
Session: new snort session
Snort id 1, NAP id 1, IPS id 0, Verdict PASS
Snort Verdict: (pass-packet) allow this packet

Phase: 14
Type: INPUT-ROUTE-LOOKUP-FROM-OUTPUT-ROUTE-LOOKUP
Subtype: Resolve Preferred Egress interface
Result: ALLOW
Elapsed time: 6244 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)

Phase: 15
Type: ADJACENCY-LOOKUP
Subtype: Resolve Nexthop IP address to MAC
Result: ALLOW
Elapsed time: 1784 ns
Config:
Additional Information:
Found adjacency entry for Next-hop 192.0.2.99 on interface OUTSIDE2
Adjacency :Active
MAC address 4c4e.35fc.fcd8 hits 5 reference 1

Result:
input-interface: INSIDE(vrfid:0)
input-status: up
input-line-status: up
output-interface: OUTSIDE2(vrfid:0)
output-status: up
output-line-status: up
Action: allow
Time Taken: 1046760 ns
```

The FTD ARP table as it is seen in the Control Plane:

```
firepower# show arp
OUTSIDE1 203.0.113.99 4c4e.35fc.fcd8 3051
OUTSIDE2 192.0.2.99 4c4e.35fc.fcd8 5171
```

To force the ARP resolution:

```
firepower# ping 192.168.0.99
Type escape sequence to abort.
```

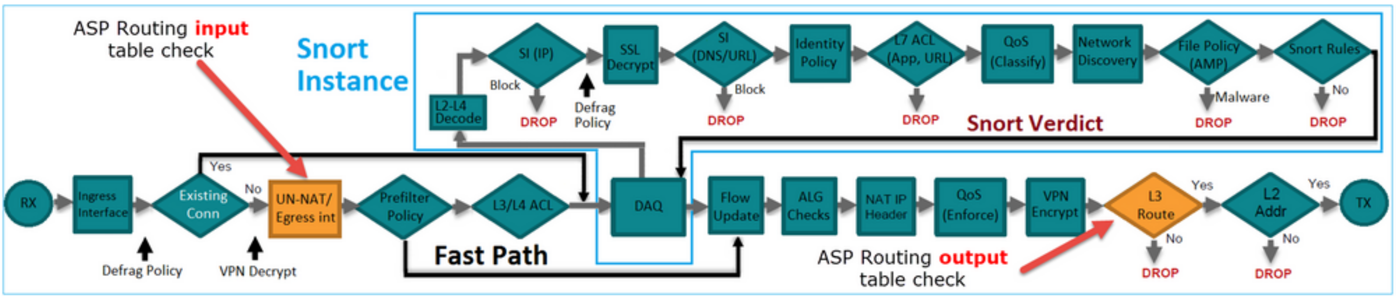
```
Sending 5, 100-byte ICMP Echos to 192.168.0.99, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
firepower# show arp
INSIDE 192.168.0.99 4c4e.35fc.fcd8 45
OUTSIDE1 203.0.113.99 4c4e.35fc.fcd8 32
OUTSIDE2 192.0.2.99 4c4e.35fc.fcd8 1
```

The FTD ARP table as it is seen in the Data Plane:

```
firepower# show asp table arp

Context: single_vf, Interface: OUTSIDE1
203.0.113.99 Active 4c4e.35fc.fcd8 hits 2 reference 1

Context: single_vf, Interface: OUTSIDE2
192.0.2.99 Active 4c4e.35fc.fcd8 hits 5 reference 0

Context: single_vf, Interface: INSIDE
192.168.0.99 Active 4c4e.35fc.fcd8 hits 5 reference 0

Context: single_vf, Interface: identity
:: Active 0000.0000.0000 hits 0 reference 0
0.0.0.0 Active 0000.0000.0000 hits 848 reference 0

Last clearing of hits counters: Never
```

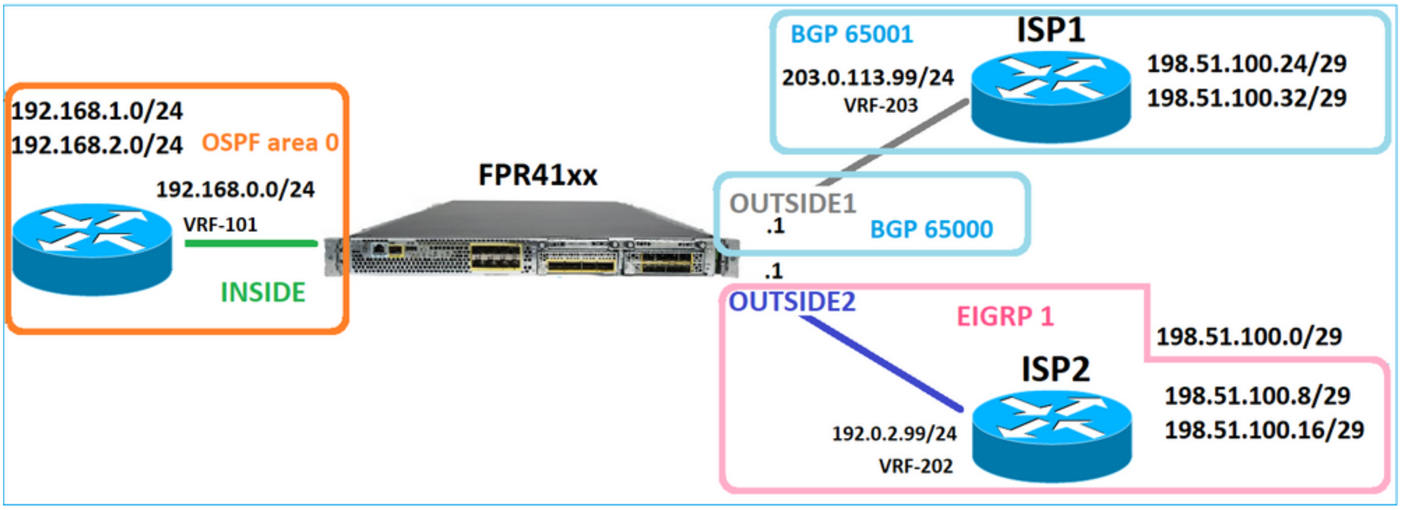
FTD Order of Operations

The image shows the order of operations and where the input and output ASP Routing checks are done:



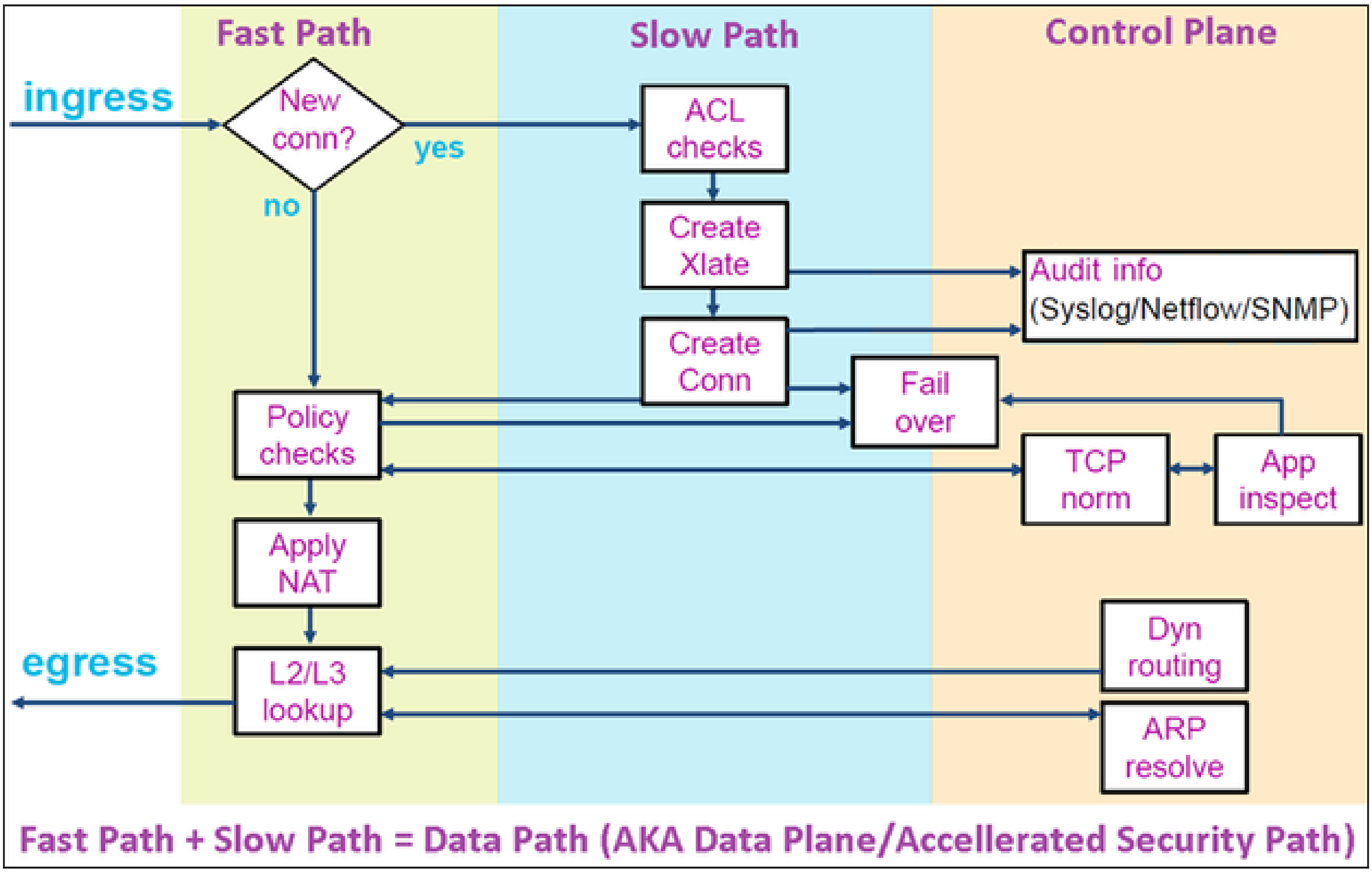
Configure

Case 1 – Forwarding Based on Connection Lookup



As was mentioned already, the main component of the FTD LINA Engine is the Datapath process (multiple instances based on the number of device cores). Furthermore, the Datapath (also known as Accelerated Security Path – ASP) consists of 2 Paths:

1. Slow Path = Responsible for new connection establishment (it populates the Fast Path).
2. Fast Path = Handles packets that belong to established connections.



- Commands like show route and show arp show the contents of the Control Plane.
- On the other hand, commands like show asp table routing and show asp table arp show the contents of ASP (Datapath) which is what is actually applied.

Enable capture with trace on FTD INSIDE interface:

```
firepower# capture CAPI trace detail interface INSIDE match ip host 192.168.1.1 host 198.51.100.1
```

Open a Telnet session through the FTD:

```
Router1# telnet 198.51.100.1 /vrf VRF-101 /source-interface lo1
Trying 198.51.100.1 ... Open
```

The FTD captures show the packets from the beginning of the connection (TCP 3-way handshake is captured):

```
firepower# show capture CAPI

26 packets captured

1: 10:50:38.407190 802.1Q vlan#101 P0 192.168.1.1.57734 > 198.51.100.1.23: S 1306692135:1306692135(0) wi
2: 10:50:38.408929 802.1Q vlan#101 P0 198.51.100.1.23 > 192.168.1.1.57734: S 1412677784:1412677784(0) ac
3: 10:50:38.409265 802.1Q vlan#101 P0 192.168.1.1.57734 > 198.51.100.1.23: . ack 1412677785 win 4128
4: 10:50:38.409433 802.1Q vlan#101 P0 192.168.1.1.57734 > 198.51.100.1.23: P 1306692136:1306692154(18) a
5: 10:50:38.409845 802.1Q vlan#101 P0 192.168.1.1.57734 > 198.51.100.1.23: . ack 1412677785 win 4128
6: 10:50:38.410135 802.1Q vlan#101 P0 198.51.100.1.23 > 192.168.1.1.57734: . ack 1306692154 win 4110
7: 10:50:38.411355 802.1Q vlan#101 P0 198.51.100.1.23 > 192.168.1.1.57734: P 1412677785:1412677797(12) a
8: 10:50:38.413049 802.1Q vlan#101 P0 192.168.1.1.57734 > 198.51.100.1.23: P 1306692154:1306692157(3) ac
9: 10:50:38.413140 802.1Q vlan#101 P0 192.168.1.1.57734 > 198.51.100.1.23: P 1306692157:1306692166(9) ac
10: 10:50:38.414071 802.1Q vlan#101 P0 198.51.100.1.23 > 192.168.1.1.57734: . 1412677797:1412678322(525)
...
```

Trace the first packet (TCP SYN). This packet goes through the FTD LINA Slow Path, and a Global Routing lookup is done in this case:

```
firepower# show capture CAPI packet-number 1 trace

26 packets captured

   1: 10:50:38.407190 802.1Q vlan#101 P0 192.168.1.1.57734 > 198.51.100.1.23: S 1306692135:1306692135(0)
Phase: 1
Type: CAPTURE
Subtype:
Result: ALLOW
Elapsed time: 4683 ns
Config:
Additional Information:
Forward Flow based lookup yields rule:
in id=0x1505f1d17940, priority=13, domain=capture, deny=false
hits=1783, user_data=0x1505f2096910, cs_id=0x0, l3_type=0x0
src mac=0000.0000.0000, mask=0000.0000.0000
dst mac=0000.0000.0000, mask=0000.0000.0000
input_ifc=INSIDE, output_ifc=any
```

```
Phase: 2
Type: ACCESS-LIST
Subtype:
Result: ALLOW
Elapsed time: 4683 ns
Config:
Implicit Rule
Additional Information:
Forward Flow based lookup yields rule:
in id=0x1502a7ba4d40, priority=1, domain=permit, deny=false
hits=28, user_data=0x0, cs_id=0x0, l3_type=0x8
src mac=0000.0000.0000, mask=0000.0000.0000
dst mac=0000.0000.0000, mask=0100.0000.0000
input_ifc=INSIDE, output_ifc=any

Phase: 3
Type: INPUT-ROUTE-LOOKUP
Subtype: Resolve Egress Interface
Result: ALLOW
Elapsed time: 5798 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)

Phase: 4
Type: ACCESS-LIST
Subtype: log
Result: ALLOW
Elapsed time: 3010 ns
Config:
access-group CSM_FW_ACL_ global
access-list CSM_FW_ACL_ advanced permit ip any any rule-id 268434433
access-list CSM_FW_ACL_ remark rule-id 268434433: ACCESS POLICY: mzafeiro_empty - Default
access-list CSM_FW_ACL_ remark rule-id 268434433: L4 RULE: DEFAULT ACTION RULE
Additional Information:
This packet will be sent to snort for additional processing where a verdict will be reached
Forward Flow based lookup yields rule:
in id=0x1505f1e2e980, priority=12, domain=permit, deny=false
hits=4, user_data=0x15024a56b940, cs_id=0x0, use_real_addr, flags=0x0, protocol=0
src ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any, ifc=any
dst ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any, ifc=any,, dscp=0x0, nsg_id=none
input_ifc=any, output_ifc=any

Phase: 5
Type: CONN-SETTINGS
Subtype:
Result: ALLOW
Elapsed time: 3010 ns
Config:
class-map class-default
match any
policy-map global_policy
class class-default
set connection advanced-options UM_STATIC_TCP_MAP
service-policy global_policy global
Additional Information:
Forward Flow based lookup yields rule:
in id=0x1505f1f18bc0, priority=7, domain=conn-set, deny=false
hits=4, user_data=0x1505f1f13f70, cs_id=0x0, use_real_addr, flags=0x0, protocol=0
src ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any
dst ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any, dscp=0x0, nsg_id=none
input_ifc=INSIDE(vrfid:0), output_ifc=any
```

```
Phase: 6
Type: NAT
Subtype: per-session
Result: ALLOW
Elapsed time: 3010 ns
Config:
Additional Information:
Forward Flow based lookup yields rule:
in id=0x15052e96b150, priority=0, domain=nat-per-session, deny=false
hits=125, user_data=0x0, cs_id=0x0, reverse, use_real_addr, flags=0x0, protocol=6
src ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any
dst ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any, dscp=0x0, nsg_id=none
input_ifc=any, output_ifc=any

Phase: 7
Type: IP-OPTIONS
Subtype:
Result: ALLOW
Elapsed time: 3010 ns
Config:
Additional Information:
Forward Flow based lookup yields rule:
in id=0x1502a7bacde0, priority=0, domain=inspect-ip-options, deny=true
hits=19, user_data=0x0, cs_id=0x0, reverse, flags=0x0, protocol=0
src ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any
dst ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any, dscp=0x0, nsg_id=none
input_ifc=INSIDE(vrfid:0), output_ifc=any

Phase: 8
Type: NAT
Subtype: per-session
Result: ALLOW
Elapsed time: 52182 ns
Config:
Additional Information:
Reverse Flow based lookup yields rule:
in id=0x15052e96b150, priority=0, domain=nat-per-session, deny=false
hits=127, user_data=0x0, cs_id=0x0, reverse, use_real_addr, flags=0x0, protocol=6
src ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any
dst ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any, dscp=0x0, nsg_id=none
input_ifc=any, output_ifc=any

Phase: 9
Type: IP-OPTIONS
Subtype:
Result: ALLOW
Elapsed time: 892 ns
Config:
Additional Information:
Reverse Flow based lookup yields rule:
in id=0x1502a7f9b460, priority=0, domain=inspect-ip-options, deny=true
hits=38, user_data=0x0, cs_id=0x0, reverse, flags=0x0, protocol=0
src ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any
dst ip/id=0.0.0.0, mask=0.0.0.0, port=0, tag=any, dscp=0x0, nsg_id=none
input_ifc=OUTSIDE2(vrfid:0), output_ifc=any

Phase: 10
Type: FLOW-CREATION
Subtype:
Result: ALLOW
Elapsed time: 25422 ns
```

```
Config:
Additional Information:
New flow created with id 244, packet dispatched to next module
Module information for forward flow ...
snp_fp_inspect_ip_options
snp_fp_tcp_normalizer
snp_fp_tcp_proxy
snp_fp_snort
snp_fp_tcp_proxy
snp_fp_translate
snp_fp_tcp_normalizer
snp_fp_adjacency
snp_fp_fragment
snp_ifc_stat

Module information for reverse flow ...
snp_fp_inspect_ip_options
snp_fp_tcp_normalizer
snp_fp_translate
snp_fp_tcp_proxy
snp_fp_snort
snp_fp_tcp_proxy
snp_fp_tcp_normalizer
snp_fp_adjacency
snp_fp_fragment
snp_ifc_stat

Phase: 11
Type: EXTERNAL-INSPECT
Subtype:
Result: ALLOW
Elapsed time: 36126 ns
Config:
Additional Information:
Application: 'SNORT Inspect'

Phase: 12
Type: SNORT
Subtype:
Result: ALLOW
Elapsed time: 564636 ns
Config:
Additional Information:
Snort Trace:
Packet: TCP, SYN, seq 182318660
Session: new snort session
AppID: service unknown (0), application unknown (0)
Snort id 28, NAP id 1, IPS id 0, Verdict PASS
Snort Verdict: (pass-packet) allow this packet

Phase: 13
Type: INPUT-ROUTE-LOOKUP-FROM-OUTPUT-ROUTE-LOOKUP
Subtype: Resolve Preferred Egress interface
Result: ALLOW
Elapsed time: 7136 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)

Phase: 14
Type: ADJACENCY-LOOKUP
Subtype: Resolve Nexthop IP address to MAC
```

```
Result: ALLOW
Elapsed time: 2230 ns
Config:
Additional Information:
Found adjacency entry for Next-hop 192.0.2.99 on interface OUTSIDE2
Adjacency :Active
MAC address 4c4e.35fc.fcd8 hits 10 reference 1

Phase: 15
Type: CAPTURE
Subtype:
Result: ALLOW
Elapsed time: 5352 ns
Config:
Additional Information:
Forward Flow based lookup yields rule:
out id=0x150521389870, priority=13, domain=capture, deny=false
hits=1788, user_data=0x1505f1d2b630, cs_id=0x0, l3_type=0x0
src mac=0000.0000.0000, mask=0000.0000.0000
dst mac=0000.0000.0000, mask=0000.0000.0000
input_ifc=OUTSIDE2, output_ifc=any

Result:
input-interface: INSIDE(vrfid:0)
input-status: up
input-line-status: up
output-interface: OUTSIDE2(vrfid:0)
output-status: up
output-line-status: up
Action: allow
Time Taken: 721180 ns

1 packet shown
firepower#
```

Trace another ingress packet from the same flow. The packet that matches an active connection:

```
firepower# show capture CAPI packet-number 3 trace

33 packets captured

3: 10:50:38.409265 802.1Q vlan#101 P0 192.168.1.1.57734 > 198.51.100.1.23: . ack 1412677785 win 4128
Phase: 1
Type: CAPTURE
Subtype:
Result: ALLOW
Elapsed time: 2676 ns
Config:
Additional Information:
Forward Flow based lookup yields rule:
in id=0x1505f1d17940, priority=13, domain=capture, deny=false
hits=105083, user_data=0x1505f2096910, cs_id=0x0, l3_type=0x0
src mac=0000.0000.0000, mask=0000.0000.0000
dst mac=0000.0000.0000, mask=0000.0000.0000
input_ifc=INSIDE, output_ifc=any

Phase: 2
```

```
Type: ACCESS-LIST
Subtype:
Result: ALLOW
Elapsed time: 2676 ns
Config:
Implicit Rule
Additional Information:
Forward Flow based lookup yields rule:
in id=0x1502a7ba4d40, priority=1, domain=permit, deny=false
hits=45, user_data=0x0, cs_id=0x0, l3_type=0x8
src mac=0000.0000.0000, mask=0000.0000.0000
dst mac=0000.0000.0000, mask=0100.0000.0000
input_ifc=INSIDE, output_ifc=any

Phase: 3
Type: FLOW-LOOKUP
Subtype:
Result: ALLOW
Elapsed time: 1338 ns
Config:
Additional Information:
Found flow with id 2552, using existing flow
Module information for forward flow ...
snp_fp_inspect_ip_options
snp_fp_tcp_normalizer
snp_fp_snort
snp_fp_translate
snp_fp_tcp_normalizer
snp_fp_adjacency
snp_fp_fragment
snp_ifc_stat

Module information for reverse flow ...
snp_fp_inspect_ip_options
snp_fp_tcp_normalizer
snp_fp_translate
snp_fp_snort
snp_fp_tcp_normalizer
snp_fp_adjacency
snp_fp_fragment
snp_ifc_stat

Phase: 4
Type: EXTERNAL-INSPECT
Subtype:
Result: ALLOW
Elapsed time: 16502 ns
Config:
Additional Information:
Application: 'SNORT Inspect'

Phase: 5
Type: SNORT
Subtype:
Result: ALLOW
Elapsed time: 12934 ns
Config:
Additional Information:
Snort Trace:
Packet: TCP, ACK, seq 1306692136, ack 1412677785
AppID: service unknown (0), application unknown (0)
Snort id 19, NAP id 1, IPS id 0, Verdict PASS
Snort Verdict: (pass-packet) allow this packet

Result:
input-interface: INSIDE(vrfid:0)
input-status: up
input-line-status: up
Action: allow
Time Taken: 36126 ns

1 packet shown
firepower#
```

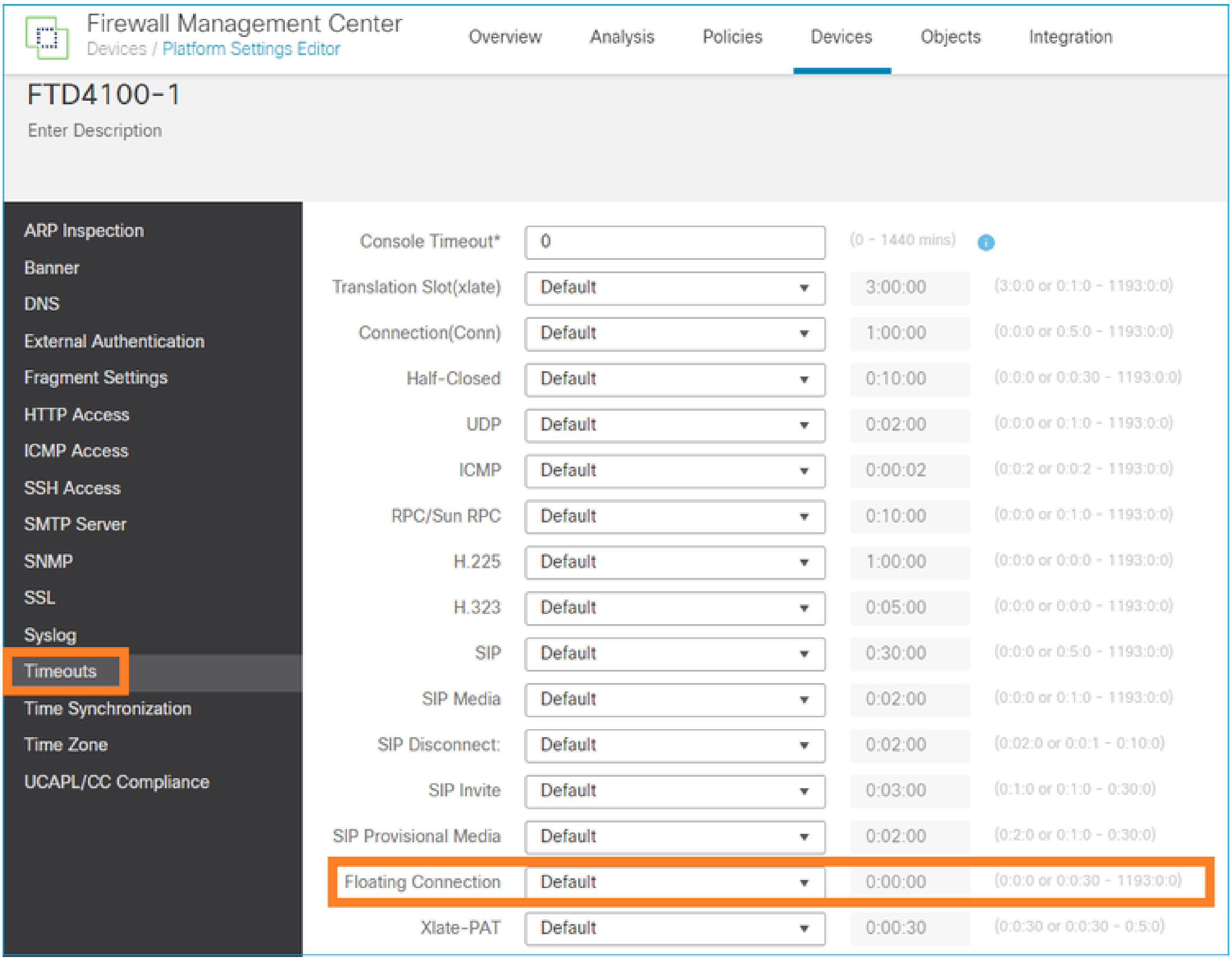
Floating Timeout

The Problem

Temporary route instability can cause long-lived (elephant) UDP connections through the FTD to be established through different FTD interfaces than desired.

The Solution

To remediate this, set the timeout floating-conn to a value different than the default which is disabled:

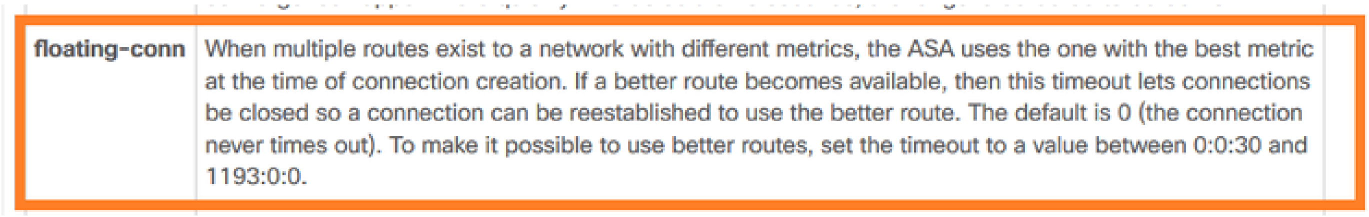


FTD4100-1

Enter Description

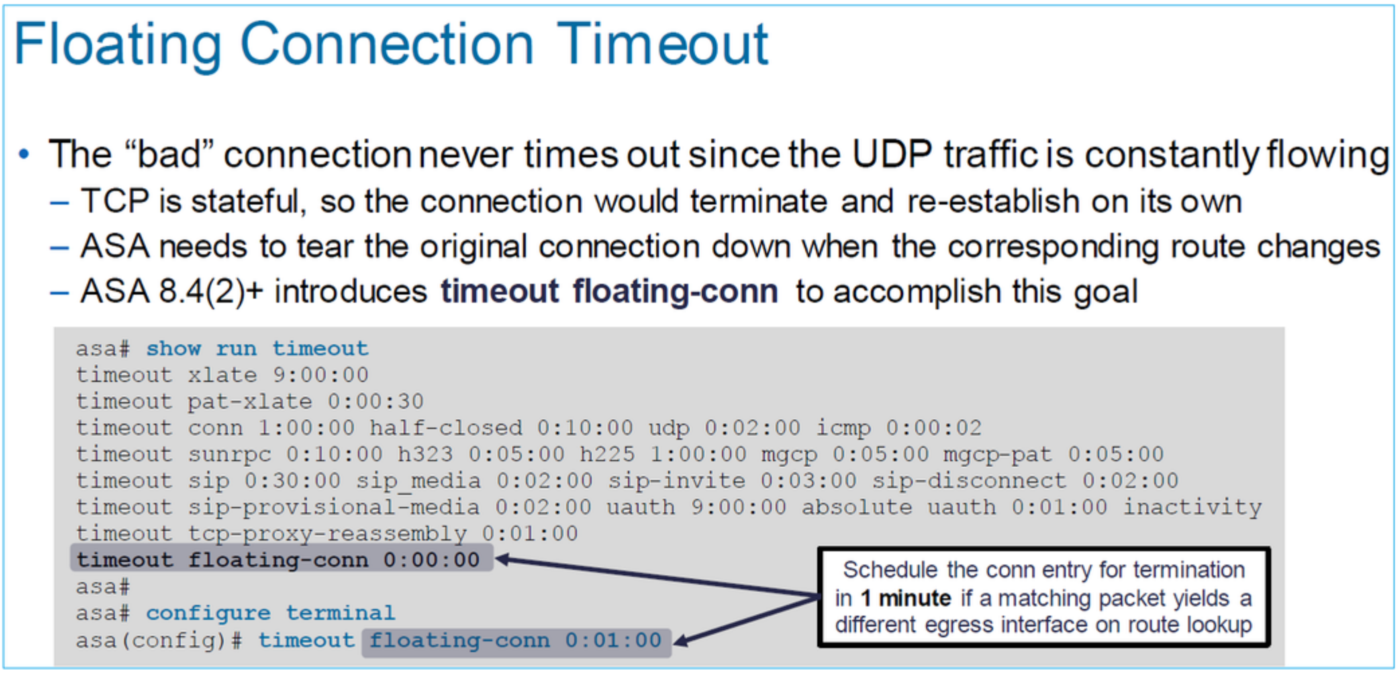
Console Timeout*	0	(0 - 1440 mins)	
Translation Slot(xlate)	Default	3:00:00	(3:0:0 or 0:1:0 - 1193:0:0)
Connection(Conn)	Default	1:00:00	(0:0:0 or 0:5:0 - 1193:0:0)
Half-Closed	Default	0:10:00	(0:0:0 or 0:0:30 - 1193:0:0)
UDP	Default	0:02:00	(0:0:0 or 0:1:0 - 1193:0:0)
ICMP	Default	0:00:02	(0:0:2 or 0:0:2 - 1193:0:0)
RPC/Sun RPC	Default	0:10:00	(0:0:0 or 0:1:0 - 1193:0:0)
H.225	Default	1:00:00	(0:0:0 or 0:0:0 - 1193:0:0)
H.323	Default	0:05:00	(0:0:0 or 0:0:0 - 1193:0:0)
SIP	Default	0:30:00	(0:0:0 or 0:5:0 - 1193:0:0)
SIP Media	Default	0:02:00	(0:0:0 or 0:1:0 - 1193:0:0)
SIP Disconnect:	Default	0:02:00	(0:02:0 or 0:0:1 - 0:10:0)
SIP Invite	Default	0:03:00	(0:1:0 or 0:1:0 - 0:30:0)
SIP Provisional Media	Default	0:02:00	(0:2:0 or 0:1:0 - 0:30:0)
Floating Connection	Default	0:00:00	(0:0:0 or 0:0:30 - 1193:0:0)
Xlate-PAT	Default	0:00:30	(0:0:30 or 0:0:30 - 0:5:0)

From the Command Reference:



floating-conn	When multiple routes exist to a network with different metrics, the ASA uses the one with the best metric at the time of connection creation. If a better route becomes available, then this timeout lets connections be closed so a connection can be reestablished to use the better route. The default is 0 (the connection never times out). To make it possible to use better routes, set the timeout to a value between 0:0:30 and 1193:0:0.

For more details, see Case Study: UDP Connections Fail After Reload from the CiscoLive BRKSEC-3020 session:



Floating Connection Timeout

- The "bad" connection never times out since the UDP traffic is constantly flowing
  - TCP is stateful, so the connection would terminate and re-establish on its own
  - ASA needs to tear the original connection down when the corresponding route changes
  - ASA 8.4(2)+ introduces **timeout floating-conn** to accomplish this goal

```
asa# show run timeout
timeout xlate 9:00:00
timeout pat-xlate 0:00:30
timeout conn 1:00:00 half-closed 0:10:00 udp 0:02:00 icmp 0:00:02
timeout sunrpc 0:10:00 h323 0:05:00 h225 1:00:00 mgcp 0:05:00 mgcp-pat 0:05:00
timeout sip 0:30:00 sip_media 0:02:00 sip-invite 0:03:00 sip-disconnect 0:02:00
timeout sip-provisional-media 0:02:00 uauth 9:00:00 absolute uauth 0:01:00 inactivity
timeout tcp-proxy-reassembly 0:01:00
timeout floating-conn 0:00:00
asa#
asa# configure terminal
asa(config)# timeout floating-conn 0:01:00
```

Schedule the conn entry for termination in **1 minute** if a matching packet yields a different egress interface on route lookup

Conn-holddown Timeout

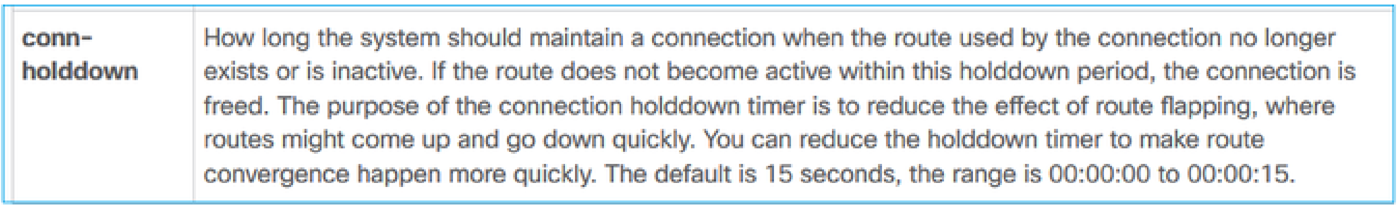
The Problem

A route goes down (is removed), but the traffic matches an established connection.

The Solution

Timeout **conn-holddown** feature was added on ASA 9.6.2. The feature is enabled by default, but currently (7.1.x) is unsupported by FMC UI or FlexConfig. Related enhancement: ENH: timeout conn-holddown not available for configuration in FMC

From the ASA CLI guide:



conn-holddown	How long the system should maintain a connection when the route used by the connection no longer exists or is inactive. If the route does not become active within this holddown period, the connection is freed. The purpose of the connection holddown timer is to reduce the effect of route flapping, where routes might come up and go down quickly. You can reduce the holddown timer to make route convergence happen more quickly. The default is 15 seconds, the range is 00:00:00 to 00:00:15.

```
firepower# show run all timeout
```

```
timeout xlate 3:00:00
timeout pat-xlate 0:00:30
timeout conn 1:00:00 half-closed 0:10:00 udp 0:02:00 sctp 0:02:00 icmp 0:00:02
timeout sunrpc 0:10:00 h323 0:05:00 h225 1:00:00 mgcp 0:05:00 mgcp-pat 0:05:00
timeout sip 0:30:00 sip_media 0:02:00 sip-invite 0:03:00 sip-disconnect 0:02:00
timeout sip-provisional-media 0:02:00 uauth 0:05:00 absolute
timeout tcp-proxy-reassembly 0:00:30
timeout floating-conn 0:00:00
timeout conn-holddown 0:00:15
timeout igp stale-route 0:01:10
```

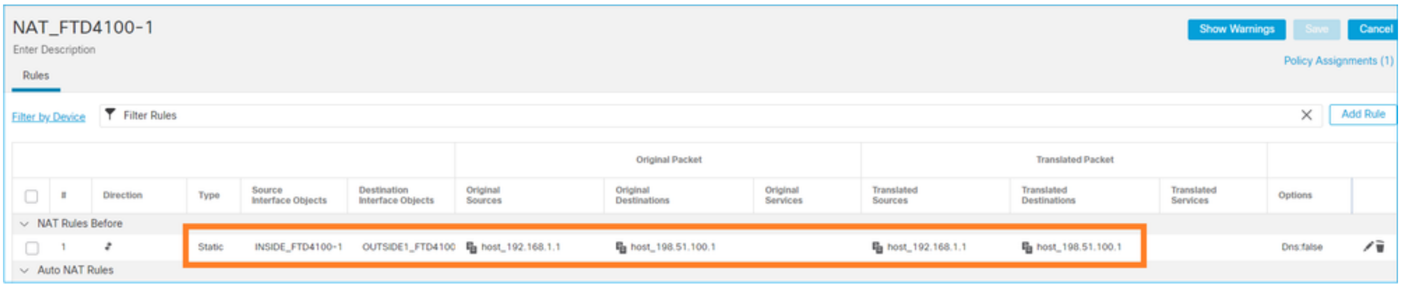
Case 2 – Forwarding Based on NAT Lookup

Requirement

Configure this NAT rule:

- Type: Static
- Source Interface: INSIDE
- Destination Interface: OUTSIDE1
- Original Source: 192.168.1.1
- Original Destination: 198.51.100.1
- Translated Source: 192.168.1.1
- Translated Destination: 198.51.100.1

Solution



						Original Packet			Translated Packet			
☐	#	Direction	Type	Source Interface Objects	Destination Interface Objects	Original Sources	Original Destinations	Original Services	Translated Sources	Translated Destinations	Translated Services	Options
NAT Rules Before												
☐	1	⇄	Static	INSIDE_FTD4100-1	OUTSIDE1_FTD4100	host_192.168.1.1	host_198.51.100.1		host_192.168.1.1	host_198.51.100.1		Dns:false
Auto NAT Rules												

The deployed NAT rule on the FTD CLI:

```
firepower# show run nat
nat (INSIDE,OUTSIDE1) source static host_192.168.1.1 host_192.168.1.1 destination static host_198.51.10
firepower# show nat
Manual NAT Policies (Section 1)
1 (INSIDE) to (OUTSIDE1) source static host_192.168.1.1 host_192.168.1.1 destination static host_198.51
translate_hits = 0, untranslate_hits = 0
```

Configure 3 captures:

```
firepower# capture CAPI trace detail interface INSIDE match ip host 192.168.1.1 host 198.51.100.1
firepower# capture CAPO1 interface OUTSIDE1 match ip host 192.168.1.1 any
firepower# capture CAPO2 interface OUTSIDE2 match ip host 192.168.1.1 any
firepower# show capture
capture CAPI type raw-data trace detail interface INSIDE [Capturing - 0 bytes]
match ip host 192.168.1.1 host 198.51.100.1
capture CAPO1 type raw-data interface OUTSIDE1 [Capturing - 0 bytes]
match ip host 192.168.1.1 any
capture CAPO2 type raw-data interface OUTSIDE2 [Capturing - 0 bytes]
match ip host 192.168.1.1 any
```

Initiate a telnet session from 192.168.1.1 to 198.51.100.1:

```
Router1# telnet 198.51.100.1 /vrf VRF-101 /source-interface lo1
Trying 198.51.100.1 ...
% Connection timed out; remote host not responding
```

Packets arrive on FTD, but nothing leaves OUTSIDE1 nor OUTSIDE2 interfaces:

```
firepower# show capture
capture CAPI type raw-data trace detail interface INSIDE [Capturing - 156 bytes]
match ip host 192.168.1.1 host 198.51.100.1
capture CAPO1 type raw-data interface OUTSIDE1 [Capturing - 0 bytes]
match ip host 192.168.1.1 any
capture CAPO2 type raw-data interface OUTSIDE2 [Capturing - 0 bytes]
match ip host 192.168.1.1 any
```

Trace the TCP SYN packet. Phase 3 (UN-NAT) shows that NAT (UN-NAT specifically) diverted the packet to the OUTSIDE1 interface for next-hop lookup:

```
firepower# show capture CAPI
2 packets captured
1: 11:22:59.179678 802.1Q vlan#101 P0 192.168.1.1.38790 > 198.51.100.1.23: S 1174675193:1174675193(0) w
2: 11:23:01.179632 802.1Q vlan#101 P0 192.168.1.1.38790 > 198.51.100.1.23: S 1174675193:1174675193(0) w
2 packets shown
firepower#
```

```
firepower# show capture CAPI packet-number 1 trace detail

2 packets captured

1: 11:22:59.179678 4c4e.35fc.fcd8 00be.75f6.1dae 0x8100 Length: 62
802.1Q vlan#101 P0 192.168.1.1.38790 > 198.51.100.1.23: S [tcp sum ok] 1174675193:1174675193(0) win 412
...
```

```
Phase: 3
Type: UN-NAT
Subtype: static
Result: ALLOW
Elapsed time: 6244 ns
Config:
nat (INSIDE,OUTSIDE1) source static host_192.168.1.1 host_192.168.1.1 destination static host_198.51.10
Additional Information:
NAT divert to egress interface OUTSIDE1(vrfid:0)
Untranslate 198.51.100.1/23 to 198.51.100.1/23

...
Phase: 12
Type: FLOW-CREATION
Subtype:
Result: ALLOW
Elapsed time: 25422 ns
Config:
Additional Information:
New flow created with id 2614, packet dispatched to next module
Module information for forward flow ...
snp_fp_inspect_ip_options
snp_fp_tcp_normalizer
snp_fp_tcp_proxy
snp_fp_snort
snp_fp_tcp_proxy
snp_fp_translate
snp_fp_tcp_normalizer
snp_fp_adjacency
snp_fp_fragment
snp_ifc_stat


Phase: 15
Type: INPUT-ROUTE-LOOKUP-FROM-OUTPUT-ROUTE-LOOKUP
Subtype: Resolve Preferred Egress interface
Result: ALLOW
Elapsed time: 8028 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)

Phase: 16
Type: SUBOPTIMAL-LOOKUP
Subtype: suboptimal next-hop
Result: ALLOW
Elapsed time: 446 ns
Config:
Additional Information:
Input route lookup returned ifc OUTSIDE2 is not same as existing ifc OUTSIDE1

Result:
input-interface: INSIDE(vrfid:0)
input-status: up
input-line-status: up
output-interface: OUTSIDE1(vrfid:0)
output-status: up
output-line-status: up
Action: drop
Time Taken: 777375 ns
Drop-reason: (no-adjacency) No valid adjacency, Drop-location: frame 0x00005577204a7287 flow (NA)/NA
```

```
1 packet shown
```

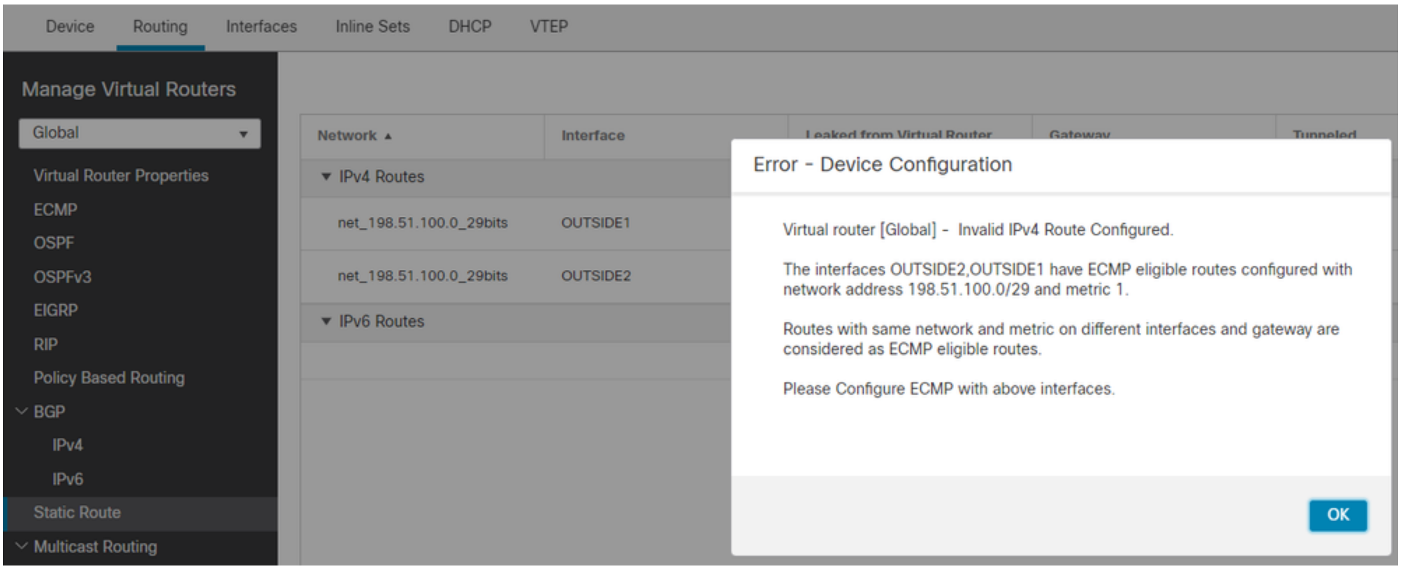
In this case, the SUBOPTIMAL-LOOKUP means that the egress interface determined by the NAT process (OUTSIDE1) is different than the egress interface specified in the ASP input table:

```
firepower# show asp table routing | include 198.51.100.0
in 198.51.100.0 255.255.255.248 via 192.0.2.99, OUTSIDE2
out 198.51.100.0 255.255.255.248 via 192.0.2.99, OUTSIDE2
```

A possible workaround is to add a floating static route on the OUTSIDE1 interface:

```
firepower# show run route
route OUTSIDE2 198.51.100.0 255.255.255.248 192.0.2.99 1
route OUTSIDE1 198.51.100.0 255.255.255.248 203.0.113.99 200
```

Note: If you try to add a static route with the same metric as the one that already exists, this error appears:



Network	Interface
net_198.51.100.0_29bits	OUTSIDE1
net_198.51.100.0_29bits	OUTSIDE2

Error - Device Configuration

Virtual router [Global] - Invalid IPv4 Route Configured.

The interfaces OUTSIDE2,OUTSIDE1 have ECMP eligible routes configured with network address 198.51.100.0/29 and metric 1.

Routes with same network and metric on different interfaces and gateway are considered as ECMP eligible routes.

Please Configure ECMP with above interfaces.

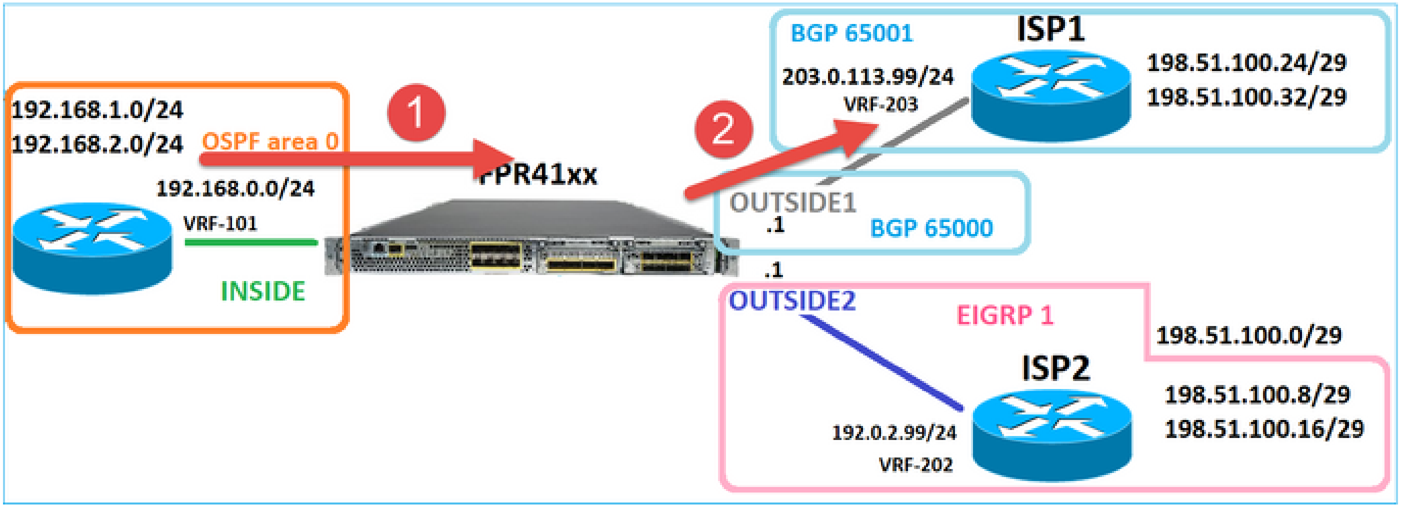
Note: Floating route with a Distance Metric of 255 is not installed in the routing table.

Try to telnet that there are packets sent through the FTD:

```
Router1# telnet 198.51.100.1 /vrf VRF-101 /source-interface lo1
Trying 198.51.100.1 ...
% Connection timed out; remote host not responding
```

```
firepower# show capture
capture CAPI type raw-data trace detail interface INSIDE [Capturing - 156 bytes]
match ip host 192.168.1.1 host 198.51.100.1
capture CAPO1 type raw-data interface OUTSIDE1 [Capturing - 312 bytes]
match ip host 192.168.1.1 any
capture CAPO2 type raw-data interface OUTSIDE2 [Capturing - 386 bytes]
match ip host 192.168.1.1 any
```

Packet trace shows that the packets are forwarded to ISP1 (OUTSIDE1) interface instead of ISP2 due to NAT Lookup:



```
firepower# show capture CAPI packet-number 1 trace

2 packets captured

1: 09:03:02.773962 802.1Q vlan#101 P0 192.168.1.1.16774 > 198.51.100.1.23: S 2910053251:2910053251(0) w
...

Phase: 3
Type: UN-NAT
Subtype: static
Result: ALLOW
Elapsed time: 4460 ns
Config:
nat (INSIDE,OUTSIDE1) source static host_192.168.1.1 host_192.168.1.1 destination static host_198.51.10
Additional Information:
NAT divert to egress interface OUTSIDE1(vrfid:0)
Untranslate 198.51.100.1/23 to 198.51.100.1/23

...

Phase: 12
Type: FLOW-CREATION
Subtype:
Result: ALLOW
Elapsed time: 29436 ns
Config:
Additional Information:
New flow created with id 2658, packet dispatched to next module
```

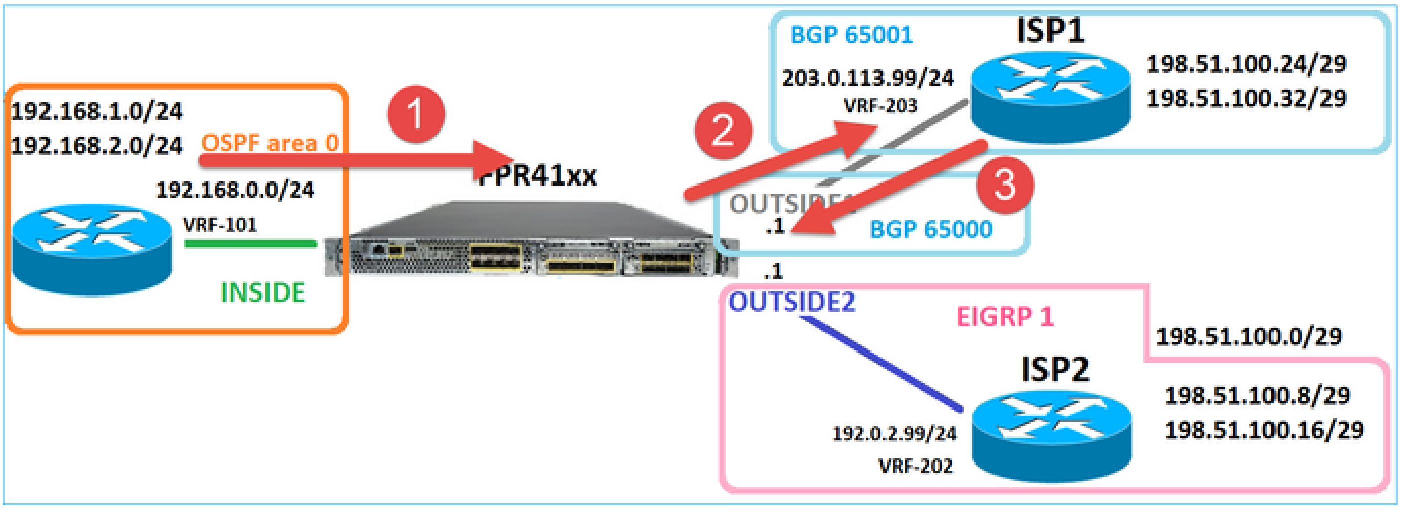
```
Module information for forward flow ...
snp_fp_inspect_ip_options
snp_fp_tcp_normalizer
snp_fp_snort
snp_fp_translate
snp_fp_tcp_normalizer
snp_fp_adjacency
snp_fp_fragment
snp_ifc_stat

Phase: 15
Type: INPUT-ROUTE-LOOKUP-FROM-OUTPUT-ROUTE-LOOKUP
Subtype: Resolve Preferred Egress interface
Result: ALLOW
Elapsed time: 5798 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)

Phase: 16
Type: SUBOPTIMAL-LOOKUP
Subtype: suboptimal next-hop
Result: ALLOW
Elapsed time: 446 ns
Config:
Additional Information:
Input route lookup returned ifc OUTSIDE2 is not same as existing ifc OUTSIDE1

Phase: 17
Type: NEXTHOP-LOOKUP-FROM-OUTPUT-ROUTE-LOOKUP
Subtype: Lookup Nexthop on interface
Result: ALLOW
Elapsed time: 1784 ns
Config:
Additional Information:
Found next-hop 203.0.113.99 using egress ifc OUTSIDE1(vrfid:0)

Phase: 18
Type: ADJACENCY-LOOKUP
Subtype: Resolve Nexthop IP address to MAC
Result: ALLOW
Elapsed time: 1338 ns
Config:
Additional Information:
Found adjacency entry for Next-hop 203.0.113.99 on interface OUTSIDE1
Adjacency :Active
MAC address 4c4e.35fc.fcd8 hits 106 reference 2
...

Result:
input-interface: INSIDE(vrfid:0)
input-status: up
input-line-status: up
output-interface: OUTSIDE1(vrfid:0)
output-status: up
output-line-status: up
Action: allow
Time Taken: 723409 ns


1 packet shown
firepower#
```

Interestingly, in this case, there are packets shown on INSIDE and both egress interfaces:

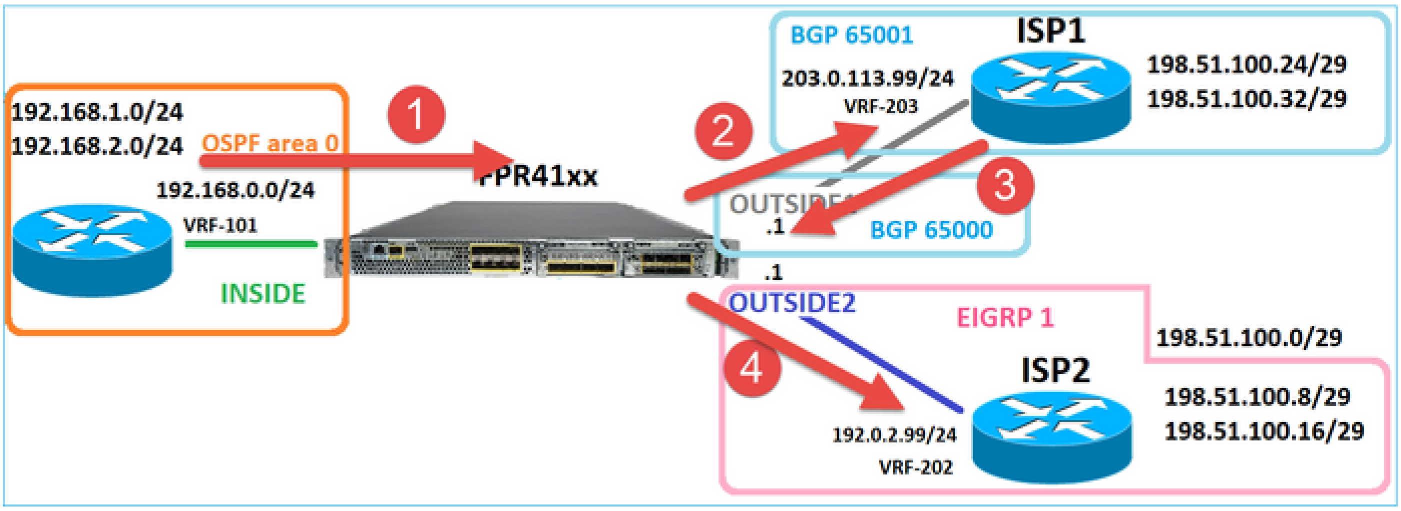
```
firepower# show capture CAPI

2 packets captured

1: 09:03:02.773962 802.1Q vlan#101 P0 192.168.1.1.32134 > 198.51.100.1.23: S 3031010184:3031010184(0) w
2: 09:03:05.176565 802.1Q vlan#101 P0 192.168.1.1.32134 > 198.51.100.1.23: S 3031010184:3031010184(0) w
2 packets shown
firepower# show capture CAPO1

4 packets captured

1: 09:03:02.774358 802.1Q vlan#203 P0 192.168.1.1.32134 > 198.51.100.1.23: S 3249840142:3249840142(0) w
2: 09:03:02.774557 802.1Q vlan#203 P0 192.168.1.1.32134 > 198.51.100.1.23: S 3249840142:3249840142(0) w
3: 09:03:05.176702 802.1Q vlan#203 P0 192.168.1.1.32134 > 198.51.100.1.23: S 3249840142:3249840142(0) w
4: 09:03:05.176870 802.1Q vlan#203 P0 192.168.1.1.32134 > 198.51.100.1.23: S 3249840142:3249840142(0) w
4 packets shown
firepower# show capture CAPO2

5 packets captured

1: 09:03:02.774679 802.1Q vlan#202 P0 192.168.1.1.32134 > 198.51.100.1.23: S 194652172:194652172(0) win
2: 09:03:02.775457 802.1Q vlan#202 P0 198.51.100.1.23 > 192.168.1.1.32134: S 4075003210:4075003210(0) a
3: 09:03:05.176931 802.1Q vlan#202 P0 192.168.1.1.32134 > 198.51.100.1.23: S 194652172:194652172(0) win
4: 09:03:05.177282 802.1Q vlan#202 P0 198.51.100.1.23 > 192.168.1.1.32134: . ack 194652173 win 4128
5: 09:03:05.180517 802.1Q vlan#202 P0 198.51.100.1.23 > 192.168.1.1.32134: S 4075003210:4075003210(0) a
```

The packet details include the MAC address info, and a trace of the packets on OUTSIDE1 and OUTSIDE2 interfaces reveals the path of the packets:

```
firepower# show capture CAPO1 detail

4 packets captured

1: 09:03:02.774358 00be.75f6.1dae 4c4e.35fc.fcd8 0x8100 Length: 62
802.1Q vlan#203 P0 192.168.1.1.32134 > 198.51.100.1.23: S [tcp sum ok] 3249840142:3249840142(0) win 412
2: 09:03:02.774557 4c4e.35fc.fcd8 00be.75f6.1dae 0x8100 Length: 62
802.1Q vlan#203 P0 192.168.1.1.32134 > 198.51.100.1.23: S [tcp sum ok] 3249840142:3249840142(0) win 412
3: 09:03:05.176702 00be.75f6.1dae 4c4e.35fc.fcd8 0x8100 Length: 62
802.1Q vlan#203 P0 192.168.1.1.32134 > 198.51.100.1.23: S [tcp sum ok] 3249840142:3249840142(0) win 412
4: 09:03:05.176870 4c4e.35fc.fcd8 00be.75f6.1dae 0x8100 Length: 62
802.1Q vlan#203 P0 192.168.1.1.32134 > 198.51.100.1.23: S [tcp sum ok] 3249840142:3249840142(0) win 412
4 packets shown
```



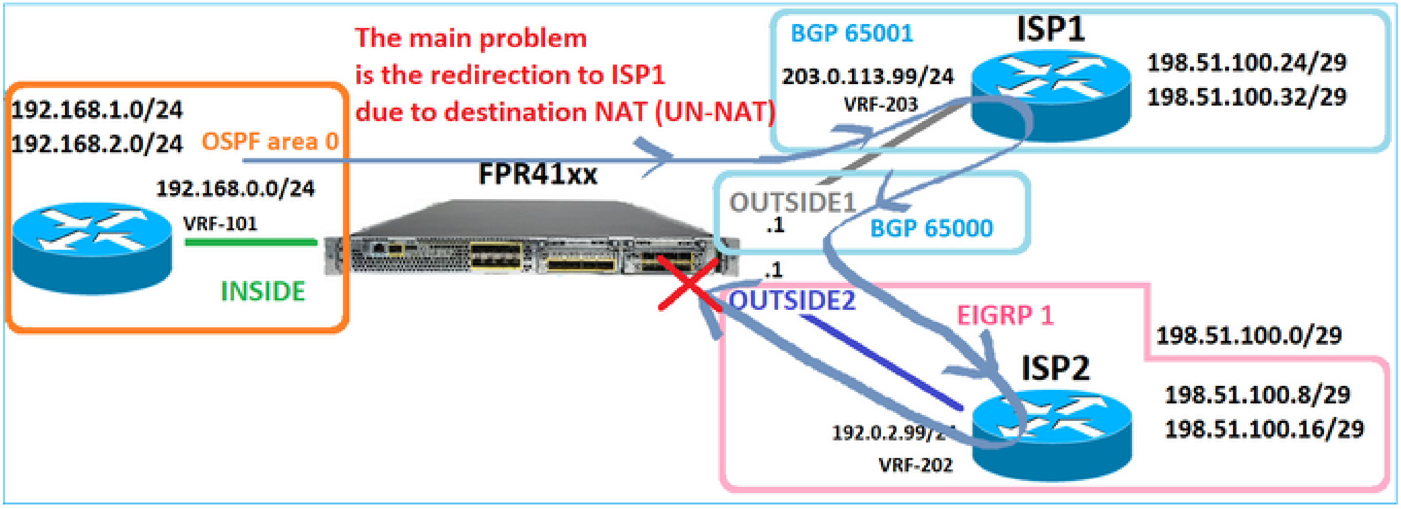
Trace of the packet that returns shows redirection to OUTSIDE2 interface due to Global Routing table Lookup:



```
firepower# show capture CAPO1 packet-number 2 trace

4 packets captured

2: 09:03:02.774557 802.1Q vlan#203 P0 192.168.1.1.32134 > 198.51.100.1.23: S 3249840142:3249840142(0) w
...

Phase: 3
Type: INPUT-ROUTE-LOOKUP
Subtype: Resolve Egress Interface
Result: ALLOW
Elapsed time: 7136 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)

...

Phase: 10
Type: FLOW-CREATION
Subtype:
Result: ALLOW
Elapsed time: 12488 ns
```

```
Config:
Additional Information:
New flow created with id 13156, packet dispatched to next module

...

Phase: 13
Type: INPUT-ROUTE-LOOKUP-FROM-OUTPUT-ROUTE-LOOKUP
Subtype: Resolve Preferred Egress interface
Result: ALLOW
Elapsed time: 3568 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)

Phase: 14
Type: ADJACENCY-LOOKUP
Subtype: Resolve Nexthop IP address to MAC
Result: ALLOW
Elapsed time: 1338 ns
Config:
Additional Information:
Found adjacency entry for Next-hop 192.0.2.99 on interface OUTSIDE2
Adjacency :Active
MAC address 4c4e.35fc.fcd8 hits 0 reference 1

...

Result:
input-interface: OUTSIDE1(vrfid:0)
input-status: up
input-line-status: up
output-interface: OUTSIDE2(vrfid:0)
output-status: up
output-line-status: up
Action: allow
Time Taken: 111946 ns


1 packet shown
firepower#
```

The ISP2 router sends the reply (SYN/ACK), but this packet is redirected to ISP1 because it matches the established connection. The packet is dropped by the FTD due to no L2 adjacency in the ASP out table:



```
firepower# show capture CAPO2 packet-number 2 trace

5 packets captured

2: 09:03:02.775457 802.1Q vlan#202 P0 198.51.100.1.23 > 192.168.1.1.32134: S 4075003210:4075003210(0) a
...

Phase: 3
Type: FLOW-LOOKUP
Subtype:
Result: ALLOW
Elapsed time: 2230 ns
Config:
Additional Information:
Found flow with id 13156, using existing flow

...

Phase: 7
Type: SUBOPTIMAL-LOOKUP
Subtype: suboptimal next-hop
Result: ALLOW
Elapsed time: 0 ns
Config:
Additional Information:
Input route lookup returned ifc INSIDE is not same as existing ifc OUTSIDE1

Result:
input-interface: OUTSIDE2(vrfid:0)
input-status: up
input-line-status: up
output-interface: INSIDE(vrfid:0)
output-status: up
output-line-status: up
Action: drop
Time Taken: 52628 ns
Drop-reason: (no-adjacency) No valid adjacency, Drop-location: frame 0x00005577204a7287 flow (NA)/NA
```

Case 3 – Forwarding Based on Policy Based Routing (PBR)

After the connection flow lookup and the destination NAT lookup, PBR is the next item that can influence the egress interface determination. PBR is documented in: Policy Based Routing

For the PBR configuration on FMC, it is important to be aware of this guideline:
FlexConfig was used to configure PBR in FMC for FTD versions earlier than 7.1. You can still use FlexConfig to configure PBR in all versions. However, for an ingress interface, you cannot configure PBR using both FlexConfig and FMC Policy Based Routing page.

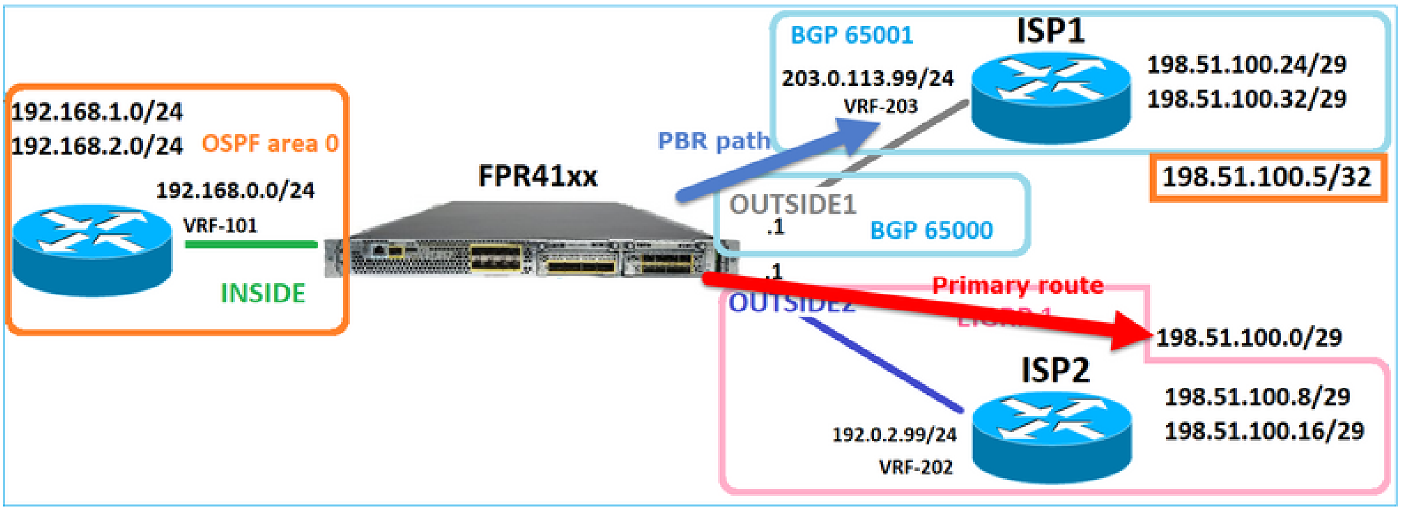
In this case study, the FTD has a route towards 198.51.100.0/24 that points towards ISP2:

```
firepower# show route | begin Gate
Gateway of last resort is not set

C 192.0.2.0 255.255.255.0 is directly connected, OUTSIDE2
L 192.0.2.1 255.255.255.255 is directly connected, OUTSIDE2
C 192.168.0.0 255.255.255.0 is directly connected, INSIDE
L 192.168.0.1 255.255.255.255 is directly connected, INSIDE
O 192.168.1.1 255.255.255.255 [110/11] via 192.168.0.99, 5d01h, INSIDE
O 192.168.2.1 255.255.255.255 [110/11] via 192.168.0.99, 5d01h, INSIDE
S 198.51.100.0 255.255.255.248 [1/0] via 192.0.2.99, OUTSIDE2
D 198.51.100.8 255.255.255.248
[90/130816] via 192.0.2.99, 5d01h, OUTSIDE2
D 198.51.100.16 255.255.255.248
[90/130816] via 192.0.2.99, 5d01h, OUTSIDE2
B 198.51.100.24 255.255.255.248 [20/0] via 203.0.113.99, 5d00h
B 198.51.100.32 255.255.255.248 [20/0] via 203.0.113.99, 5d00h
C 203.0.113.0 255.255.255.0 is directly connected, OUTSIDE1
L 203.0.113.1 255.255.255.255 is directly connected, OUTSIDE1
```

Requirement

Configure a PBR Policy with these characteristics:

- Traffic from IP 192.168.2.0/24 destined to 198.51.100.5 must be sent to ISP1 (next-hop 203.0.113.99) while other sources must use the OUTSIDE2 interface.



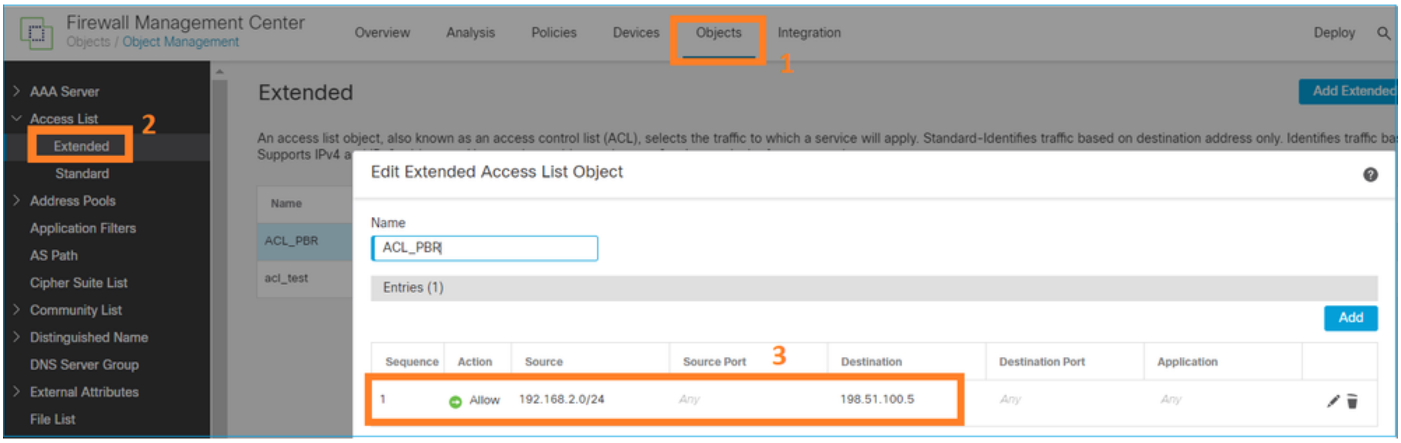
Solution

In pre-7.1 releases, to configure PBR:
1. Create an Extended ACL that matches the interesting traffic (for example, PBR_ACL).
2. Create a route-map that matches the ACL created in Step 1, and set the desired next hop.
3. Create a FlexConfig Object that enables PBR on the ingress interface using the route map created in Step 2.

In post-7.1 releases, you can configure PBR using the pre-7.1 way, or you can use the new Policy Based Routing option under the Device > Routing section:
1. Create an Extended ACL that matches the interesting traffic (for example, PBR_ACL).
2. Add a PBR policy and specify:
a. The matching traffic
b. The ingress interface
c. The next-hop

Configure PBR (new way)

Step 1 – Define an Access List for the matching traffic.



Extended

An access list object, also known as an access control list (ACL), selects the traffic to which a service will apply. Standard-Identifies traffic based on destination address only. Identifies traffic ba
Supports IPv4 a

Name
ACL_PBR
acl_test

Edit Extended Access List Object

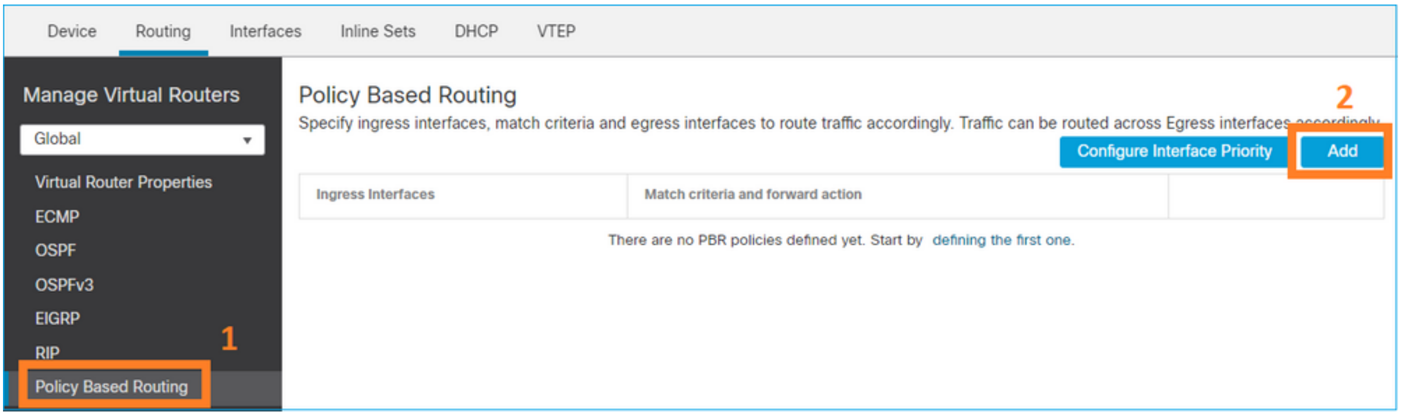
Name
ACL_PBR

Entries (1)

Sequence	Action	Source	Source Port	Destination	Destination Port	Application
1	Allow	192.168.2.0/24	Any	198.51.100.5	Any	Any

Step 2 – Add a PBR Policy

Navigate to Devices > Device Management and edit the FTD device. Choose Routing > Policy Based Routing, and on the Policy Based Routing page, select Add.



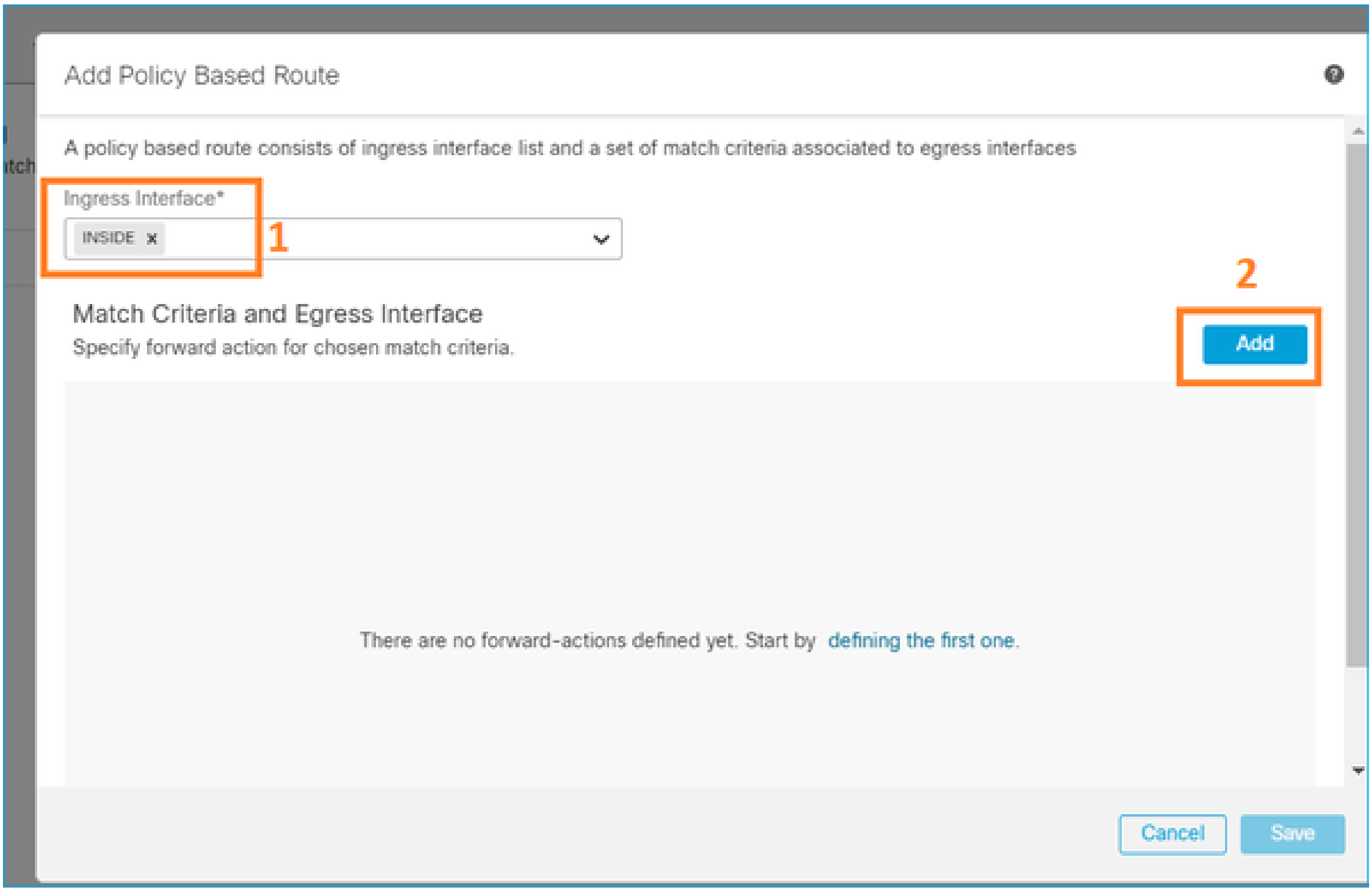
Policy Based Routing

Specify ingress interfaces, match criteria and egress interfaces to route traffic accordingly. Traffic can be routed across Egress interfaces accordingly.

Ingress Interfaces	Match criteria and forward action

There are no PBR policies defined yet. Start by defining the first one.

Specify the ingress interface:


Add Policy Based Route

A policy based route consists of ingress interface list and a set of match criteria associated to egress interfaces

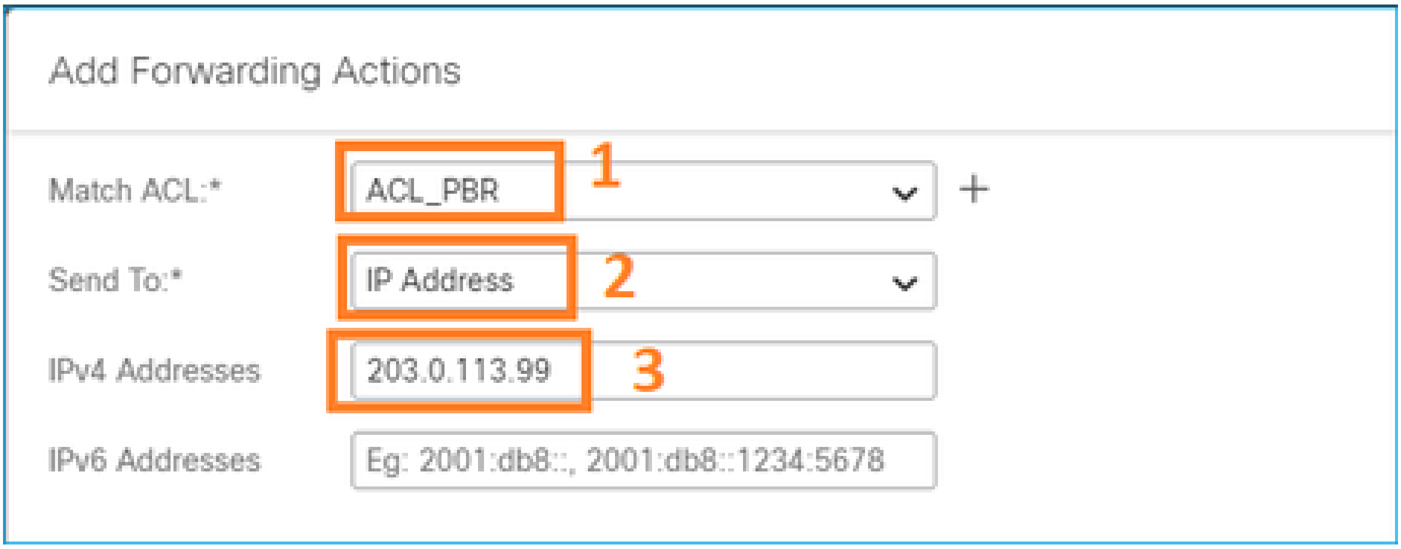
Ingress Interface*: INSIDE

Match Criteria and Egress Interface

Specify forward action for chosen match criteria.

There are no forward-actions defined yet. Start by defining the first one.

Specify the forwarding actions:


Add Forwarding Actions

Match ACL:* ACL_PBR

Send To:* IP Address

IPv4 Addresses 203.0.113.99

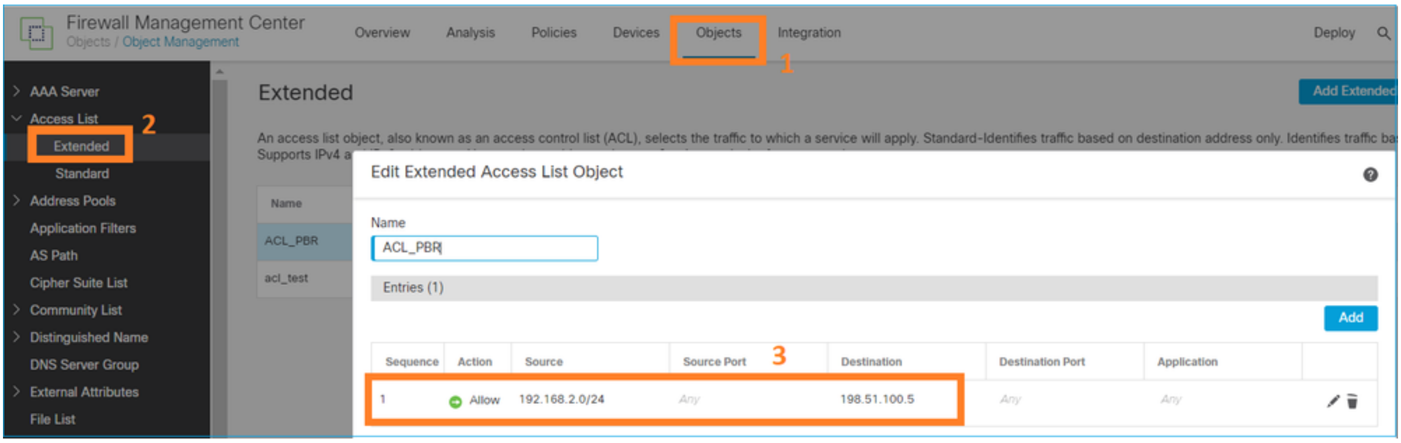
IPv6 Addresses Eg: 2001:db8::, 2001:db8::1234:5678

Save and **Deploy**.

Note: If you want to configure multiple egress interfaces you have to set in the 'Send To' field the 'Egress Interfaces' option (available as from version 7.0+). For more details check: [Configuration Example for Policy Based Routing]

Configure PBR (legacy way)

Step 1 – Define an Access List for the matching traffic.



Extended

An access list object, also known as an access control list (ACL), selects the traffic to which a service will apply. Standard-Identifies traffic based on destination address only. Identifies traffic ba
Supports IPv4 a

Edit Extended Access List Object

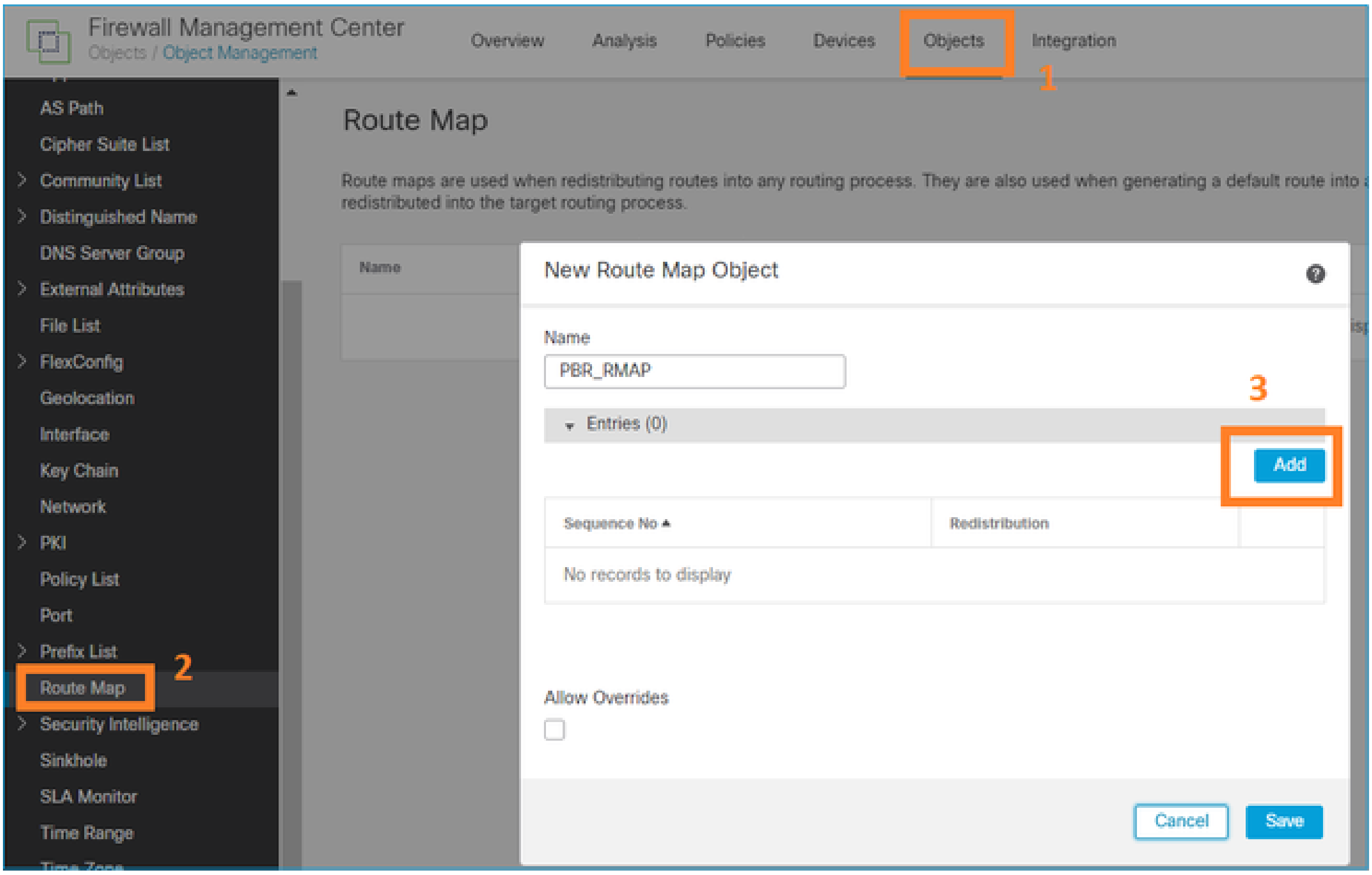
Name: ACL_PBR

Entries (1)

Sequence	Action	Source	Source Port	Destination	Destination Port	Application
1	Allow	192.168.2.0/24	Any	198.51.100.5	Any	Any

Step 2 – Define a Route-Map that matches the ACL and sets the Next Hop.

First, define the Match Clause:



Route Map

Route maps are used when redistributing routes into any routing process. They are also used when generating a default route into a
redistributed into the target routing process.

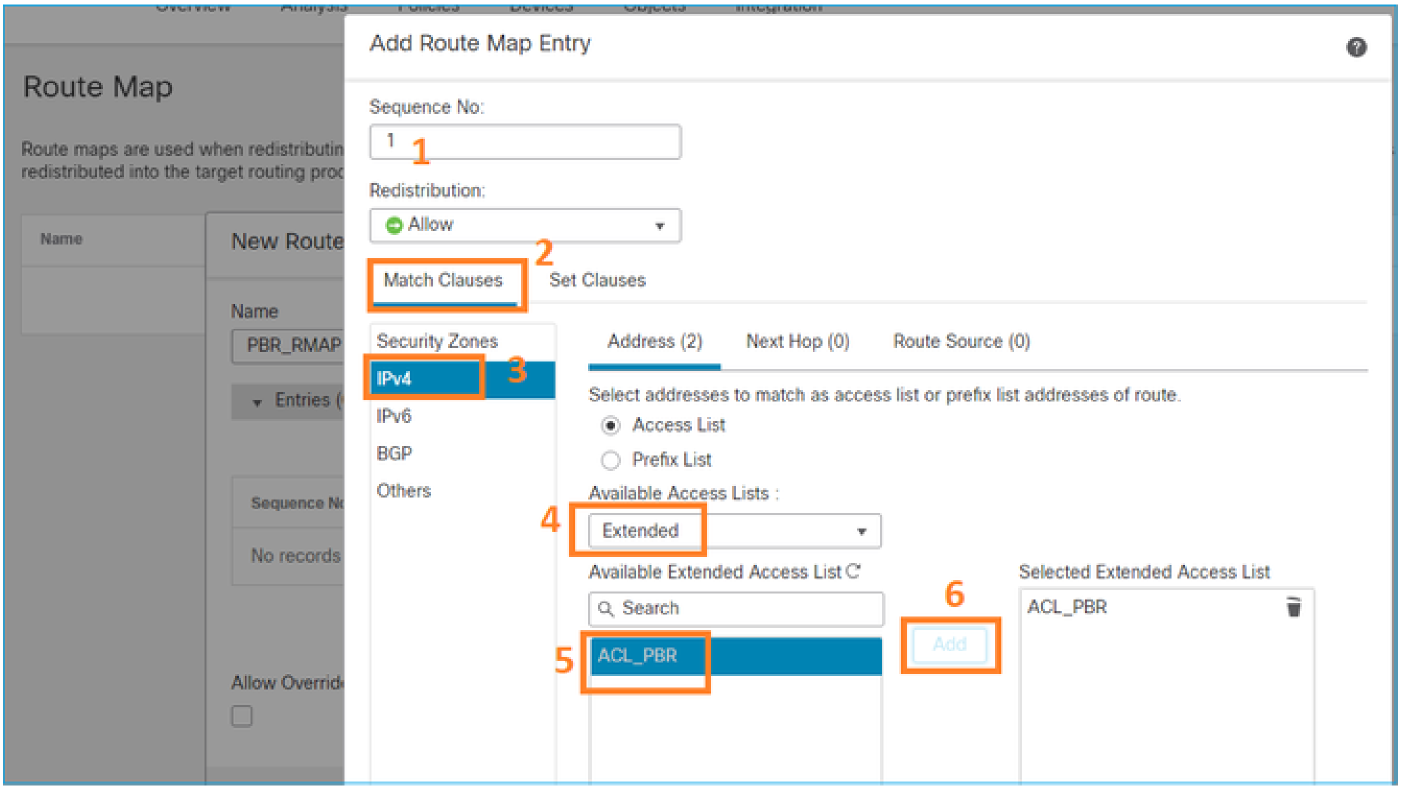
New Route Map Object

Name: PBR_RMAP

Entries (0)

Sequence No ▲	Redistribution
No records to display	

Allow Overrides
☐



Add Route Map Entry

Sequence No: 1

Redistribution: Allow

Match Clauses | Set Clauses

Security Zones
IPv4
IPv6
BGP
Others

Address (2) | Next Hop (0) | Route Source (0)

Select addresses to match as access list or prefix list addresses of route.

● Access List

○ Prefix List

Available Access Lists : Extended

Available Extended Access List

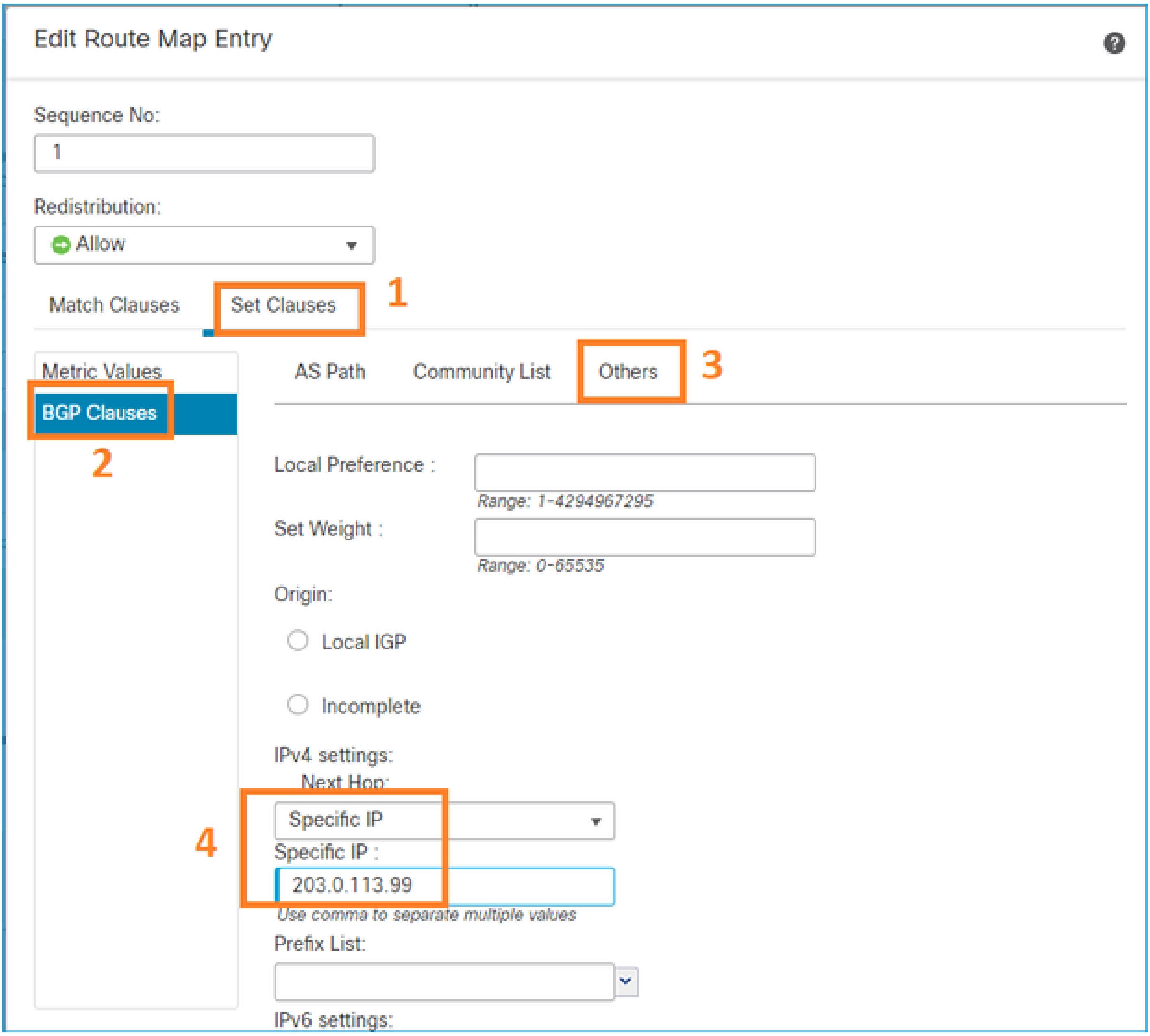
Search

ACL_PBR

Selected Extended Access List

ACL_PBR

Define the Set Clause:



Edit Route Map Entry

Sequence No: 1

Redistribution: Allow

Local Preference : (Range: 1-4294967295)

Set Weight : (Range: 0-65535)

Origin:

○ Local IGP

○ Incomplete

IPv4 settings:

Next Hop: Specific IP

Specific IP : 203.0.113.99

Use comma to separate multiple values

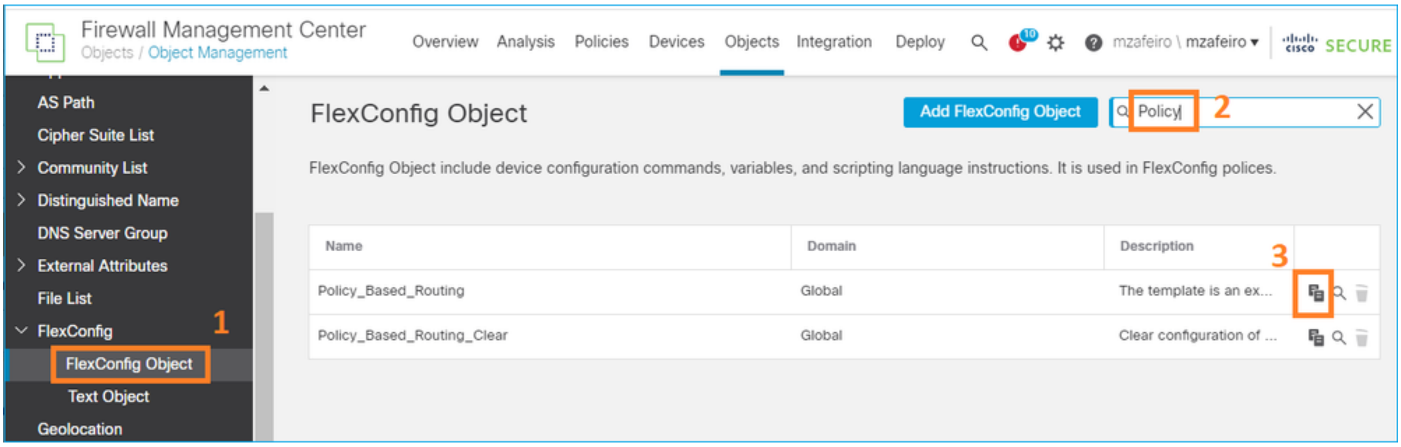
Prefix List:

IPv6 settings:

Add and Save.

Step 3. Configure the FlexConfig PBR Object.

First, copy (duplicate) the existing PBR object:

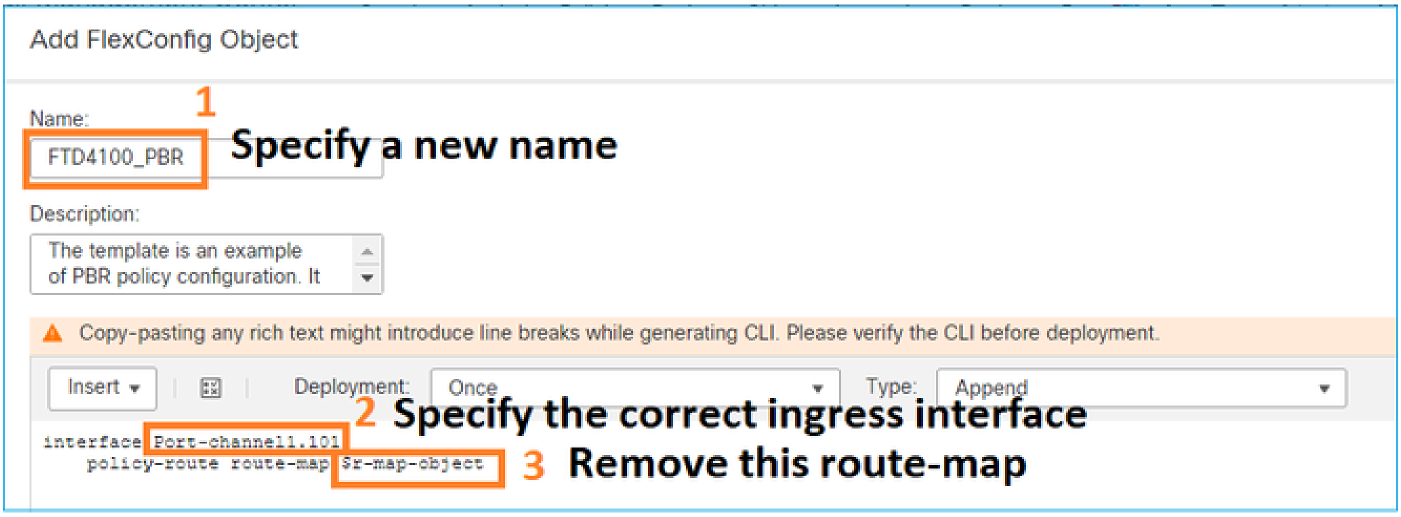


FlexConfig Object

FlexConfig Object include device configuration commands, variables, and scripting language instructions. It is used in FlexConfig polices.

Name	Domain	Description
Policy_Based_Routing	Global	The template is an ex...
Policy_Based_Routing_Clear	Global	Clear configuration of ...

Specify the Object name and remove the predefined route-map object:



Add FlexConfig Object

Name: FTD4100_PBR

1 Specify a new name

Description: The template is an example of PBR policy configuration. It

Copy-pasting any rich text might introduce line breaks while generating CLI. Please verify the CLI before deployment.

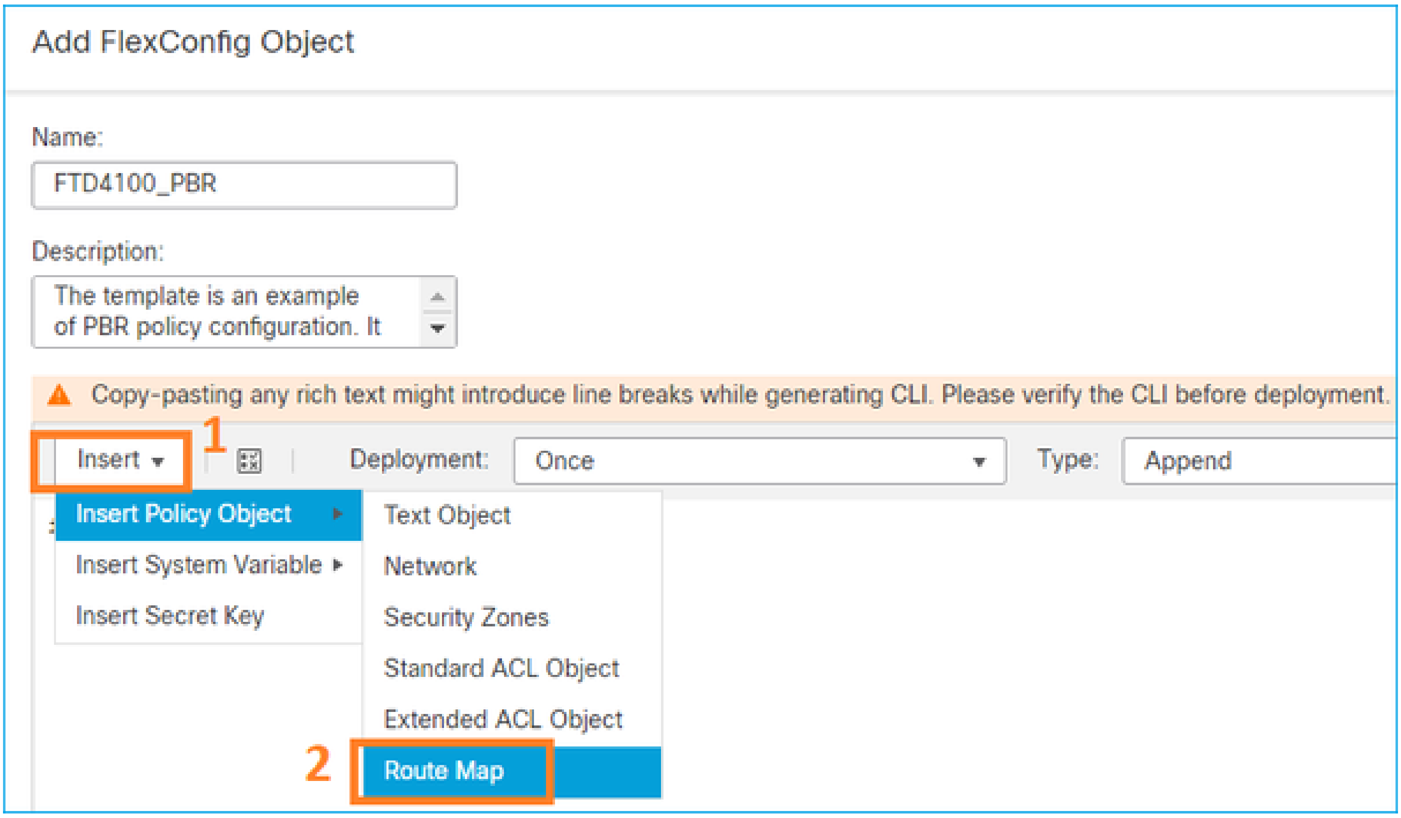
Insert ▾ | Deployment: Once ▾ | Type: Append ▾

```
interface Port-channel1.101
    policy-route route-map $r-map-object
```

2 Specify the correct ingress interface

3 Remove this route-map

Specify the new route-map:



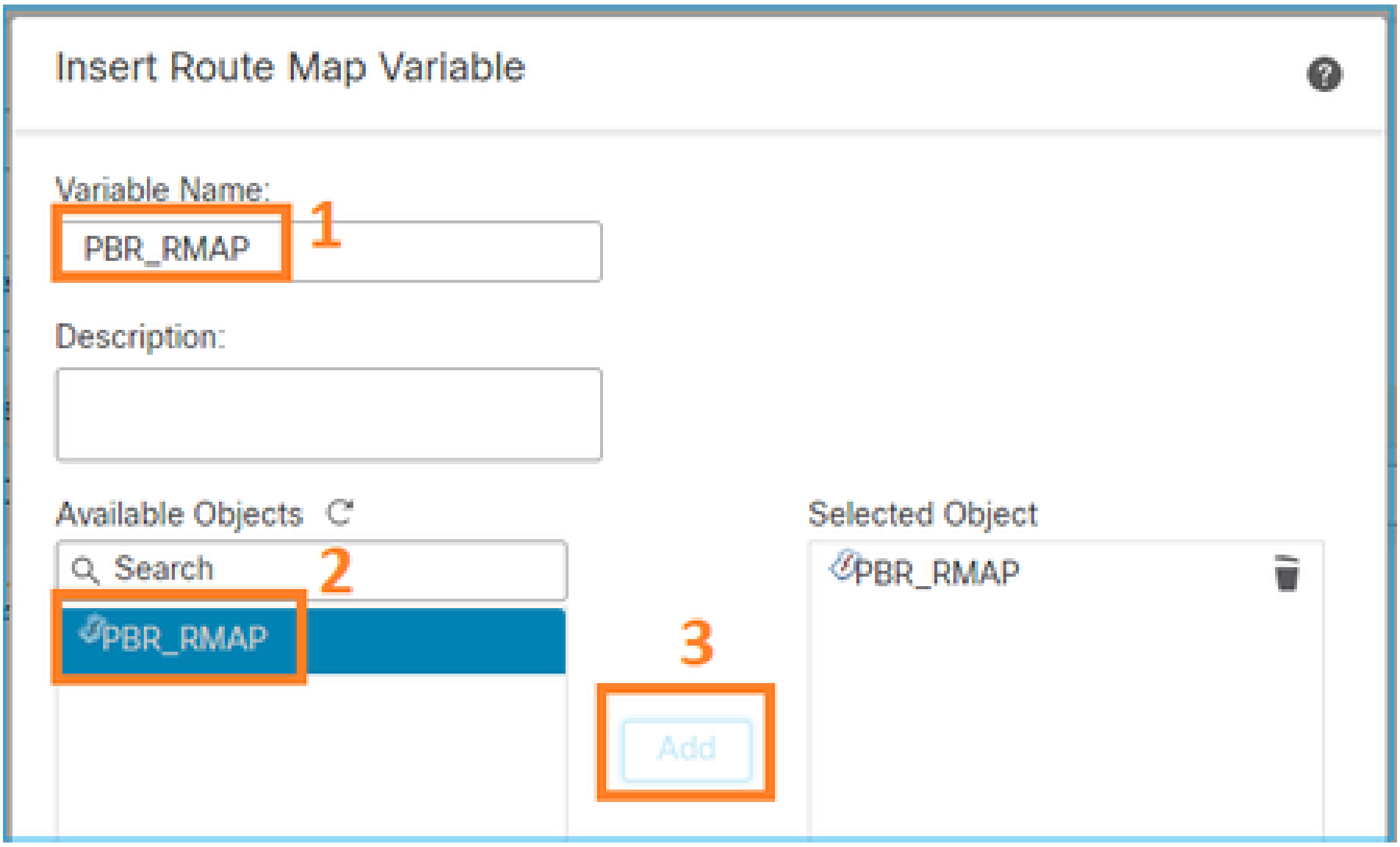
Add FlexConfig Object

Name: FTD4100_PBR

Description: The template is an example of PBR policy configuration. It

Copy-pasting any rich text might introduce line breaks while generating CLI. Please verify the CLI before deployment.

Insert ▾ | Deployment: Once ▾ | Type: Append


Insert Route Map Variable

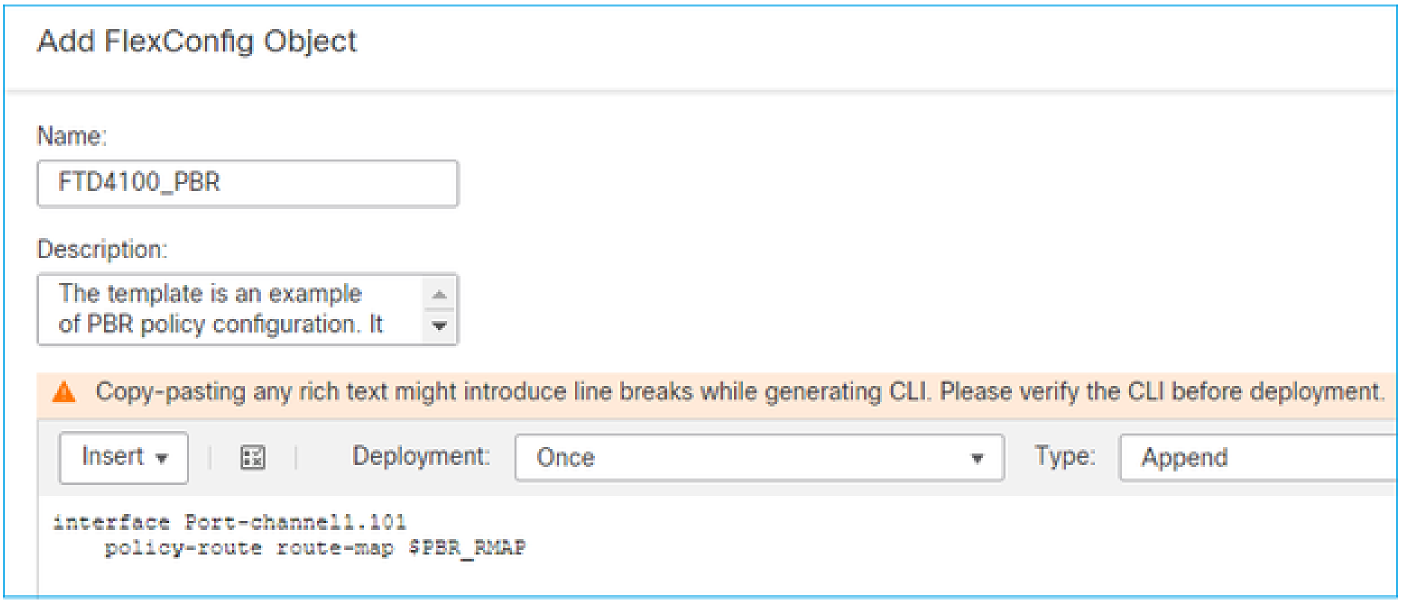
Variable Name: PBR_RMAP

Description:

Available Objects

Selected Object: PBR_RMAP

This is the end result:


Add FlexConfig Object

Name: FTD4100_PBR

Description: The template is an example of PBR policy configuration. It

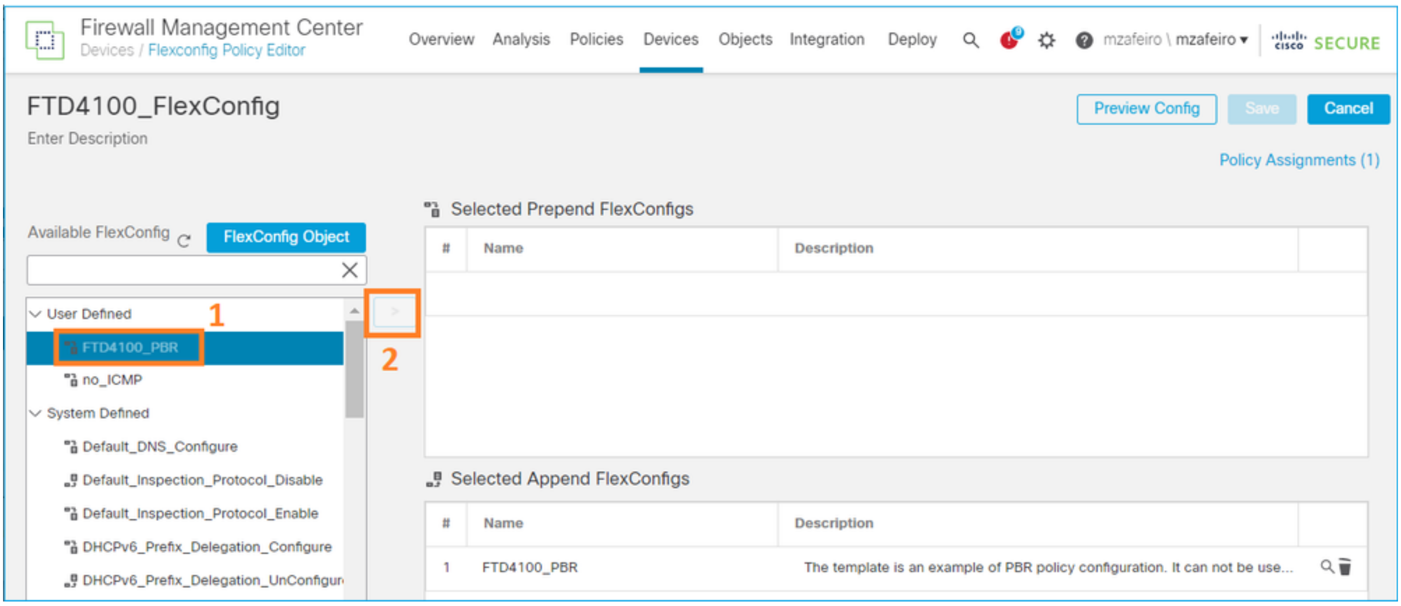
Copy-pasting any rich text might introduce line breaks while generating CLI. Please verify the CLI before deployment.

Deployment: Once

Type: Append

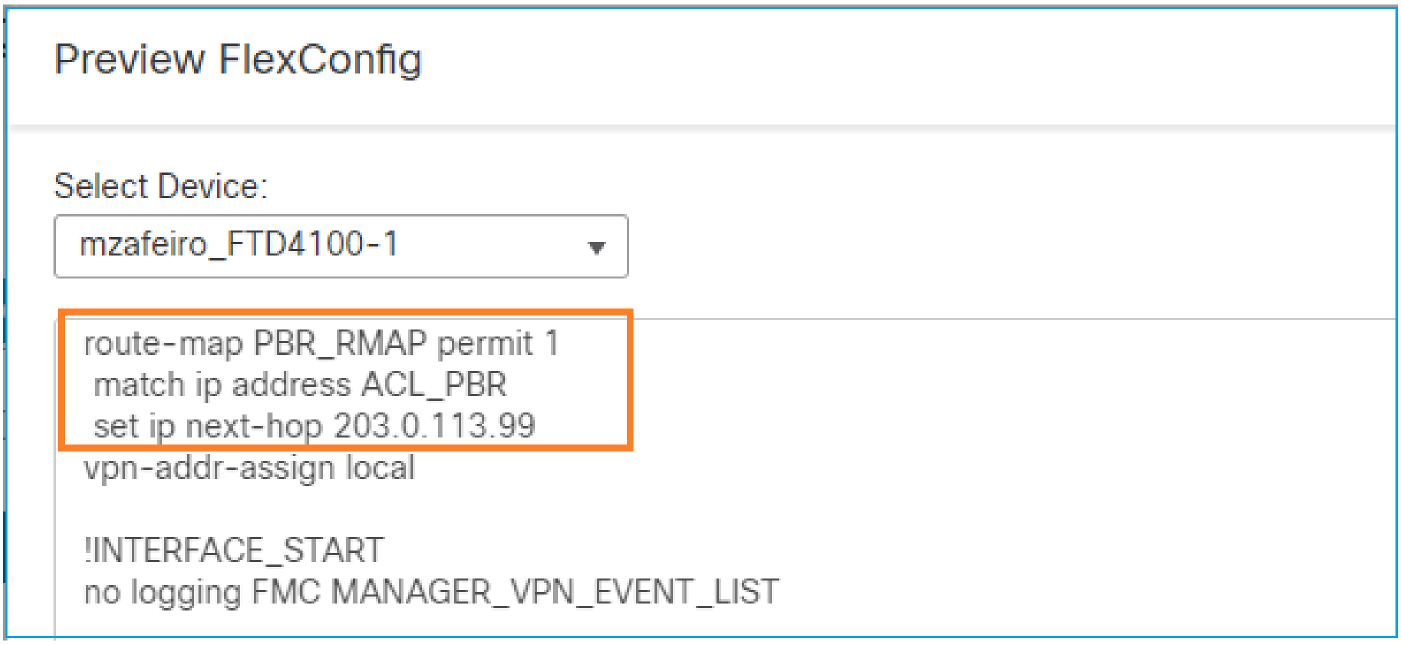
```
interface Port-channel1.101
    policy-route route-map $PBR_RMAP
```

Step 4. Add the PBR Object to the FTD FlexConfig policy.

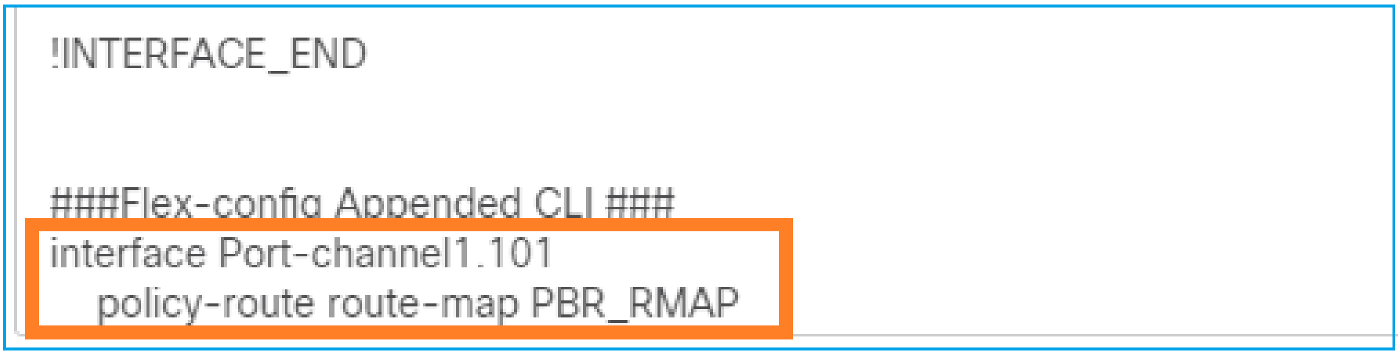


#	Name	Description
1	FTD4100_PBR	The template is an example of PBR policy configuration. It can not be use...

Save and select **Preview Config**:



```
route-map PBR_RMAP permit 1
 match ip address ACL_PBR
 set ip next-hop 203.0.113.99
vpn-addr-assign local

!INTERFACE_START
no logging FMC MANAGER_VPN_EVENT_LIST
```



```
!INTERFACE_END


###Flex-config Appended CLI ###
interface Port-channel1.101
   policy-route route-map PBR_RMAP
```

Finally, Deploy the policy.

Note: PBR cannot be configured using FlexConfig and FMC UI for the same ingress interface.

For PBR SLA configuration, check this document: Configure PBR with IP SLAs for DUAL ISP on FTD

Managed by FMC

PBR Verification

Ingress interface verification:

```
firepower# show run interface Po1.101
!
interface Port-channel1.101
vlan 101
nameif INSIDE
cts manual
propagate sgt preserve-untag
policy static sgt disabled trusted
security-level 0
ip address 192.168.0.1 255.255.255.0
policy-route route-map FMC_GENERATED_PBR_1649228271478
ospf authentication null
```

Route-map verification:

```
firepower# show run route-map
!
route-map FMC_GENERATED_PBR_1649228271478 permit 5
 match ip address ACL_PBR
 set ip next-hop 203.0.113.99
```

```
firepower# show route-map
route-map FMC_GENERATED_PBR_1649228271478, permit, sequence 5
Match clauses:
ip address (access-lists): ACL_PBR

Set clauses:
adaptive-interface cost OUTSIDE1 (0)
```

Policy-route verification:

```
firepower# show policy-route
Interface Route map
Port-channel1.101 FMC_GENERATED_PBR_1649228271478
```

Packet-Tracer before and after the change:

Without PBR	With PBR

```
firepower# packet-tracer input INSIDE tcp 192.168.2.100 1111 198.51.100.5 23


....



Phase: 3
Type: INPUT-ROUTE-LOOKUP
Subtype: Resolve Egress Interface
Result: ALLOW
Elapsed time: 11596 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)

...




Phase: 13
Type: INPUT-ROUTE-LOOKUP-FROM-OUTPUT-ROUTE-LOOKUP
Subtype: Resolve Preferred Egress interface
Result: ALLOW
Elapsed time: 6244 ns
Config:
Additional Information:
Found next-hop 192.0.2.99 using egress ifc OUTSIDE2(vrfid:0)


Phase: 14
Type: ADJACENCY-LOOKUP
Subtype: Resolve Nexthop IP address to MAC
Result: ALLOW
Elapsed time: 2230 ns
Config:
Additional Information:
Found adjacency entry for Next-hop 192.0.2.99 on interface OUTSIDE2
Adjacency :Active
MAC address 4c4e.35fc.fcd8 hits 0 reference 1


Result:
input-interface: INSIDE(vrfid:0)
input-status: up
input-line-status: up
output-interface: OUTSIDE2(vrfid:0)
output-status: up
output-line-status: up
Action: allow
Time Taken: 272058 ns
```

```
firepower# packet-tracer in

...
Phase: 3
Type: SUBOPTIMAL-LOOKUP
Subtype: suboptimal next-ho
Result: ALLOW
Elapsed time: 39694 ns
Config:
Additional Information:
Input route lookup returned

Phase: 4
Type: ECMP load balancing
Subtype:
Result: ALLOW
Elapsed time: 2230 ns
Config:
Additional Information:
ECMP load balancing
Found next-hop 203.0.113.9

Phase: 5
Type: PBR-LOOKUP
Subtype: policy-route
Result: ALLOW
Elapsed time: 446 ns
Config:
route-map FMC_GENERATED_PBR
match ip address ACL_PBR
set adaptive-interface cost
Additional Information:
Matched route-map FMC_GENER
Found next-hop 203.0.113.9

...

Phase: 15
Type: ADJACENCY-LOOKUP
Subtype: Resolve Nexthop IP
Result: ALLOW
Elapsed time: 5352 ns
Config:
Additional Information:
Found adjacency entry for N
Adjacency :Active
MAC address 4c4e.35fc.fcd8

Result:
input-interface: INSIDE(vr
input-status: up
input-line-status: up
output-interface: OUTSIDE1
output-status: up
output-line-status: up
Action: allow
Time Taken: 825100 ns
```

Test with Real Traffic

Configure packet capture with a trace:

```
firepower# capture CAPI trace interface INSIDE match ip host 192.168.2.1 host 198.51.100.5
firepower# capture CAPO1 trace interface OUTSIDE1 match ip host 192.168.2.1 host 198.51.100.5
firepower# capture CAPO2 trace interface OUTSIDE2 match ip host 192.168.2.1 host 198.51.100.5
```

```
Router1# telnet 198.51.100.5 /vrf VRF-101 /source-interface lo2
Trying 198.51.100.5 ... Open
```

The capture shows:

```
firepower# show capture
capture CAPI type raw-data trace interface INSIDE [Capturing - 4389 bytes]
match ip host 192.168.2.1 host 198.51.100.5
capture CAPO1 type raw-data trace interface OUTSIDE1 [Capturing - 4389 bytes]
match ip host 192.168.2.1 host 198.51.100.5
capture CAPO2 type raw-data trace interface OUTSIDE2 [Capturing - 0 bytes]
match ip host 192.168.2.1 host 198.51.100.5
```

Trace of the TCP SYN packet:

```
firepower# show capture CAPI packet-number 1 trace

44 packets captured

1: 13:26:38.485585 802.1Q vlan#101 P0 192.168.2.1.49032 > 198.51.100.5.23: S 571152066:571152066(0) win
...

Phase: 3
Type: SUBOPTIMAL-LOOKUP
Subtype: suboptimal next-hop
Result: ALLOW
Elapsed time: 13826 ns
Config:
Additional Information:
Input route lookup returned ifc OUTSIDE2 is not same as existing ifc OUTSIDE1

Phase: 4
Type: ECMP load balancing
Subtype:
Result: ALLOW
Elapsed time: 1784 ns
Config:
Additional Information:
ECMP load balancing
Found next-hop 203.0.113.99 using egress ifc OUTSIDE1(vrfid:0)

Phase: 5
Type: PBR-LOOKUP
```

```
Subtype: policy-route
Result: ALLOW
Elapsed time: 446 ns
Config:
route-map FMC_GENERATED_PBR_1649228271478 permit 5
match ip address ACL_PBR
set adaptive-interface cost OUTSIDE1
Additional Information:
Matched route-map FMC_GENERATED_PBR_1649228271478, sequence 5, permit
Found next-hop 203.0.113.99 using egress ifc OUTSIDE1

...

Phase: 15
Type: ADJACENCY-LOOKUP
Subtype: Resolve Nexthop IP address to MAC
Result: ALLOW
Elapsed time: 4906 ns
Config:
Additional Information:
Found adjacency entry for Next-hop 203.0.113.99 on interface OUTSIDE1
Adjacency :Active
MAC address 4c4e.35fc.fcd8 hits 348 reference 2

...

Result:
input-interface: INSIDE(vrfid:0)
input-status: up
input-line-status: up
output-interface: OUTSIDE1(vrfid:0)
output-status: up
output-line-status: up
Action: allow
Time Taken: 222106 ns
```

The ASP PBR table shows the policy hit counts:

```
firepower# show asp table classify domain pbr

Input Table
in id=0x1505f26d3420, priority=2147483642, domain=pbr, deny=false
hits=7, user_data=0x1505f26e7590, cs_id=0x0, use_real_addr, flags=0x0, protocol=0
src ip/id=192.168.2.0, mask=255.255.255.0, port=0, tag=any
dst ip/id=198.51.100.5, mask=255.255.255.255, port=0, tag=any, dscp=0x0, nsg_id=none
input_ifc=INSIDE(vrfid:0), output_ifc=any

Output Table:

L2 - Output Table:

L2 - Input Table:

Last clearing of hits counters: Never
```

Note: The packet-tracer also increases the hit counter.

PBR Debug

Warning: In a production environment, the debug can produce a lot of messages.

Enable this debug:

```
firepower# debug policy-route
debug policy-route enabled at level 1
```

Send real traffic:

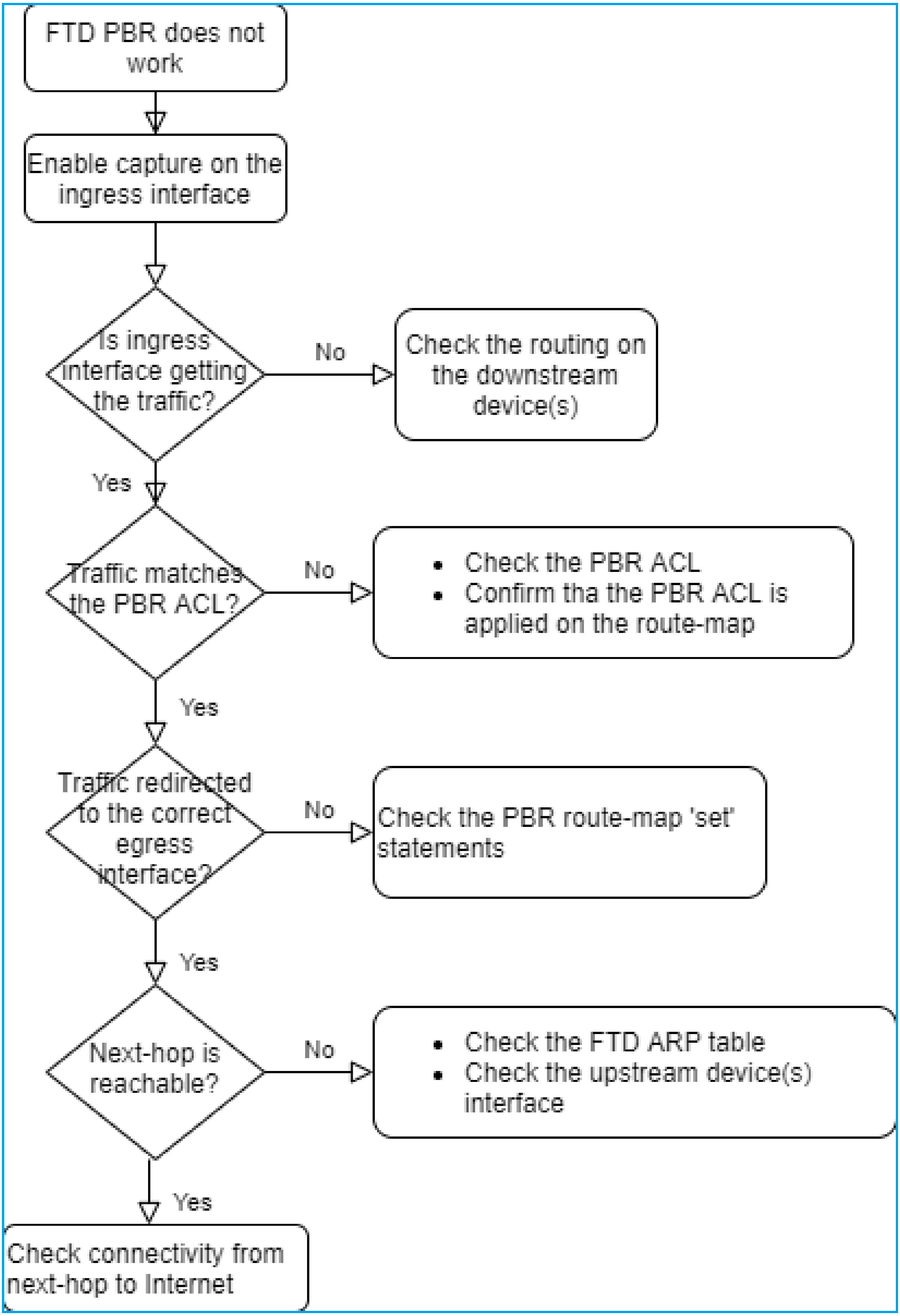
```
Router1# telnet 198.51.100.5 /vrf VRF-101 /source-interface lo2
Trying 198.51.100.5 ... Open
```

The debug shows:

```
firepower#

pbr: policy based route lookup called for 192.168.2.1/37256 to 198.51.100.5/23 proto 6 sub_proto 0 rece
pbr: First matching rule from ACL(2)
pbr: route map FMC_GENERATED_PBR_1649228271478, sequence 5, permit; proceed with policy routing
pbr: policy based routing applied; egress_ifc = OUTSIDE1 : next_hop = 203.0.113.99
```

Note: Packet-tracer also generates a debug output.

This flowchart can be used to troubleshoot PBR:


FTD PBR does not work
Enable capture on the ingress interface
Is ingress interface getting the traffic?
No
Check the routing on the downstream device(s)
Yes
Traffic matches the PBR ACL?
No
Check the PBR ACL
Confirm tha the PBR ACL is applied on the route-map
Yes
Traffic redirected to the correct egress interface?
No
Check the PBR route-map 'set' statements
Yes
Next-hop is reachable?
No
Check the FTD ARP table
Check the upstream device(s) interface
Yes
Check connectivity from next-hop to Internet

Summary of PBR commands

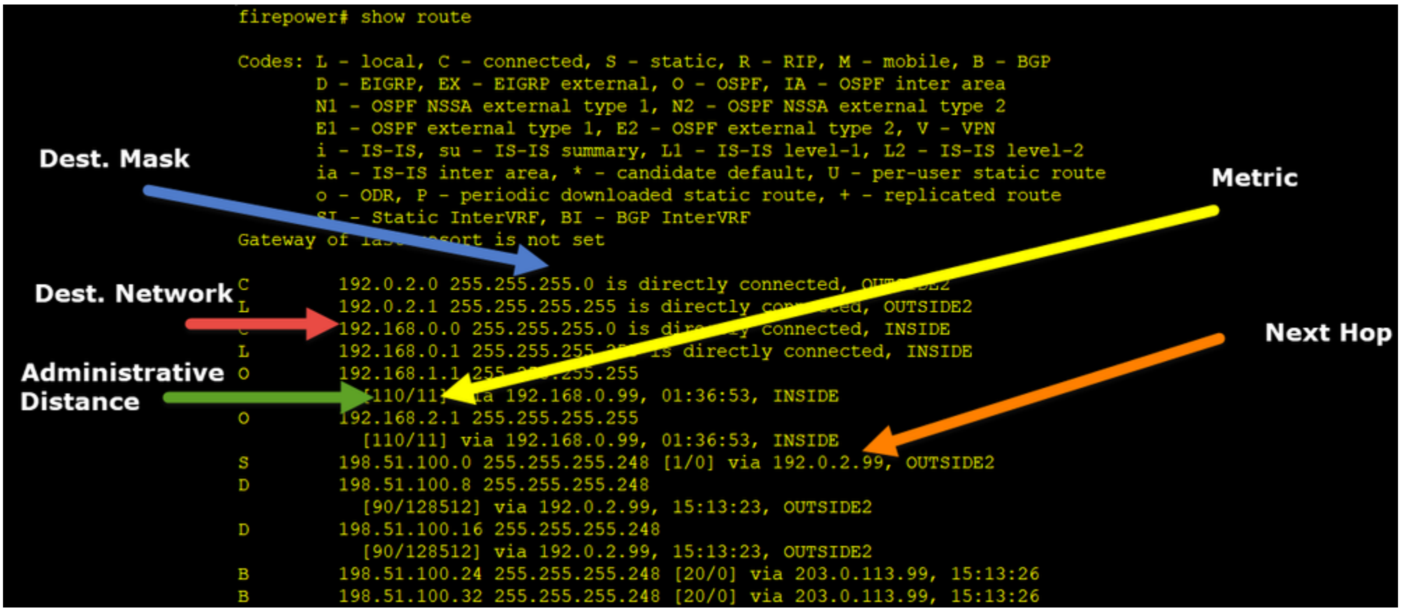
```
show asp drop
```

Case 4 – Forwarding Based on Global Routing Lookup

After the connection lookup, NAT lookup, and PBR, the last item that is checked to determine the egress interface is the Global Routing table.

Routing Table Verification

Let us examine an FTD routing table output:



```
firepower# show route

Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, V - VPN
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, + - replicated route
       SI - Static InterVRF, BI - BGP InterVRF
Gateway of last resort is not set

C        192.0.2.0 255.255.255.0 is directly connected, OUTSIDE2
L        192.0.2.1 255.255.255.255 is directly connected, OUTSIDE2
C        192.168.0.0 255.255.255.0 is directly connected, INSIDE
L        192.168.0.1 255.255.255.255 is directly connected, INSIDE
O        192.168.1.1 255.255.255.255
           [110/11] via 192.168.0.99, 01:36:53, INSIDE
O        192.168.2.1 255.255.255.255
           [110/11] via 192.168.0.99, 01:36:53, INSIDE
S        198.51.100.0 255.255.255.248 [1/0] via 192.0.2.99, OUTSIDE2
D        198.51.100.8 255.255.255.248
           [90/128512] via 192.0.2.99, 15:13:23, OUTSIDE2
D        198.51.100.16 255.255.255.248
           [90/128512] via 192.0.2.99, 15:13:23, OUTSIDE2
B        198.51.100.24 255.255.255.248 [20/0] via 203.0.113.99, 15:13:26
B        198.51.100.32 255.255.255.248 [20/0] via 203.0.113.99, 15:13:26
```

The main goal of the routing process is to find the next hop. The route selection is in this order:

1. Longest match wins
2. Lowest AD (between different routing protocol sources)
3. Lowest Metric (in case routes are learned from the same source - routing protocol)

How the routing table is populated:

- IGP (R, D, EX, O, IA, N1, N2, E1, E2, i, su, L1, L2, ia, o)

- BGP (B)

- BGP InterVRF (BI)

- Static (S)

- Static InterVRF (SI)

- Connected (C)

- local IPs (L)

- VPN (V)

- Redistribution

- Default

To view the routing table summary use this command:

```
<#root>

firepower#

show route summary



IP routing table maximum-paths is 8
Route Source   Networks Subnets Replicates Overhead Memory (bytes)
connected      0        8       0          704      2368
static         0        1       0          88       296
ospf 1         0        2       0          176      600
Intra-area: 2 Inter-area: 0 External-1: 0 External-2: 0
NSSA External-1: 0 NSSA External-2: 0
bgp 65000      0        2       0          176      592
External: 2 Internal: 0 Local: 0
eigrp 1        0        2       0          216      592
internal       7                                    3112

Total          7        15      0          1360     7560
```

You can track the routing table updates with this command:

```
<#root>

firepower#

debug ip routing


IP routing debugging is on
```

For example, this is what the debug shows when OSPF route 192.168.1.0/24 is removed from the global routing table:

```
<#root>

firepower#

RT: ip_route_delete 192.168.1.0 255.255.255.0 via 192.0.2.99, INSIDE


ha_cluster_synced 0 routetype 0
RT: del 192.168.1.0 via 192.0.2.99, ospf metric [110/11]NP-route: Delete-Output 192.168.1.0/24 hop_coun
RT: delete network route to 192.168.1.0 255.255.255.0NP-route: Delete-Output 192.168.1.0/24 hop_count:1
NP-route: Delete-Input 192.168.1.0/24 hop_count:1 Distance:110 Flags:0X0 , via 0.0.0.0, INSIDE
```

When it is added back:

<#root>

```
firepower#
```

```
RT: NP-route: Add-Output 192.168.1.0/24 hop_count:1 , via 192.0.2.99, INSIDE
```

```
NP-route: Add-Input 192.168.1.0/24 hop_count:1 Distance:110 Flags:0X0 , via 192.0.2.99, INSIDE
```

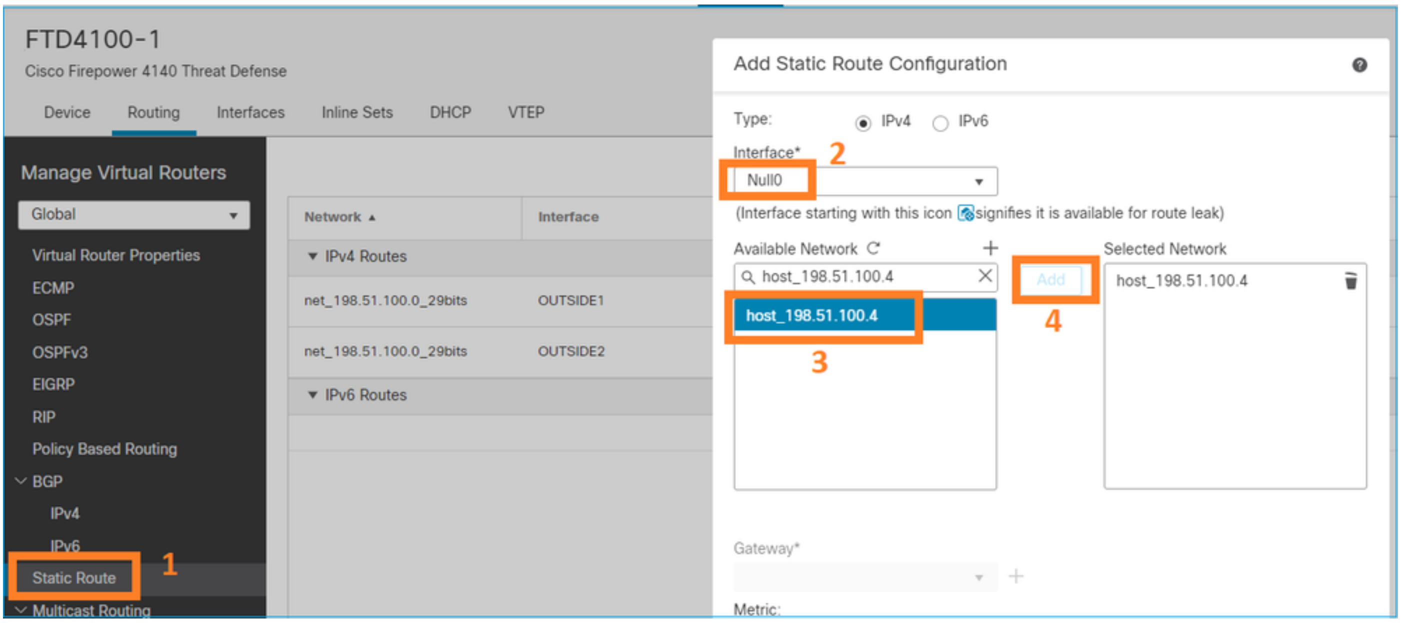
Null0 Interface

Null0 interface can be used to drop unwanted traffic. This drop has less performance impact than the drop in the traffic with an Access Control Policy (ACL) rule.

Requirement

Configure a Null0 route for 198.51.100.4/32 host.

Solution



FTD4100-1
Cisco Firepower 4140 Threat Defense

Add Static Route Configuration

Type: ● IPv4 ○ IPv6

Interface*: Null0

(Interface starting with this icon signifies it is available for route leak)

Available Network: host_198.51.100.4

Selected Network: host_198.51.100.4

Network ▲	Interface
▼ IPv4 Routes	
net_198.51.100.0_29bits	OUTSIDE1
net_198.51.100.0_29bits	OUTSIDE2
▼ IPv6 Routes	

Save and **Deploy**.

Verification:

<#root>

```
firepower#
```

```
show run route
```

```
route OUTSIDE2 198.51.100.0 255.255.255.248 192.0.2.99 1
route OUTSIDE1 198.51.100.0 255.255.255.248 203.0.113.99 200

route Null0 198.51.100.4 255.255.255.255 1
```

<#root>

```
firepower#

show route | include 198.51.100.4


S 198.51.100.4 255.255.255.255 [1/0] is directly connected, Null0
```

Try to access the remote host:

<#root>

```
Router1#

ping vrf VRF-101 198.51.100.4


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 198.51.100.4, timeout is 2 seconds:

.....


Success rate is 0 percent (0/5)
```

The FTD logs show:

<#root>

```
firepower#

show log | include 198.51.100.4


Apr 12 2022 12:35:28:

%FTD-6-110002: Failed to locate egress interface for ICMP from INSIDE:192.168.0.99/0 to 198.51.100.4/0
```

ASP drops show:

<#root>

```
firepower#

show asp drop
```

```
Frame drop:

No route to host (no-route)                1920
```

Equal Cost Multi-Path (ECMP)

Traffic Zones

- ECMP Traffic Zone allows a user to group interfaces together (referred to as an ECMP Zone).
- This allows ECMP routing as well as load-balancing of traffic across multiple interfaces.
- When interfaces are associated with ECMP Traffic Zone, the user is able to create Equal-Cost Static Routes across the interfaces. Equal-Cost Static Routes are routes to the same destination network with the same metric value.

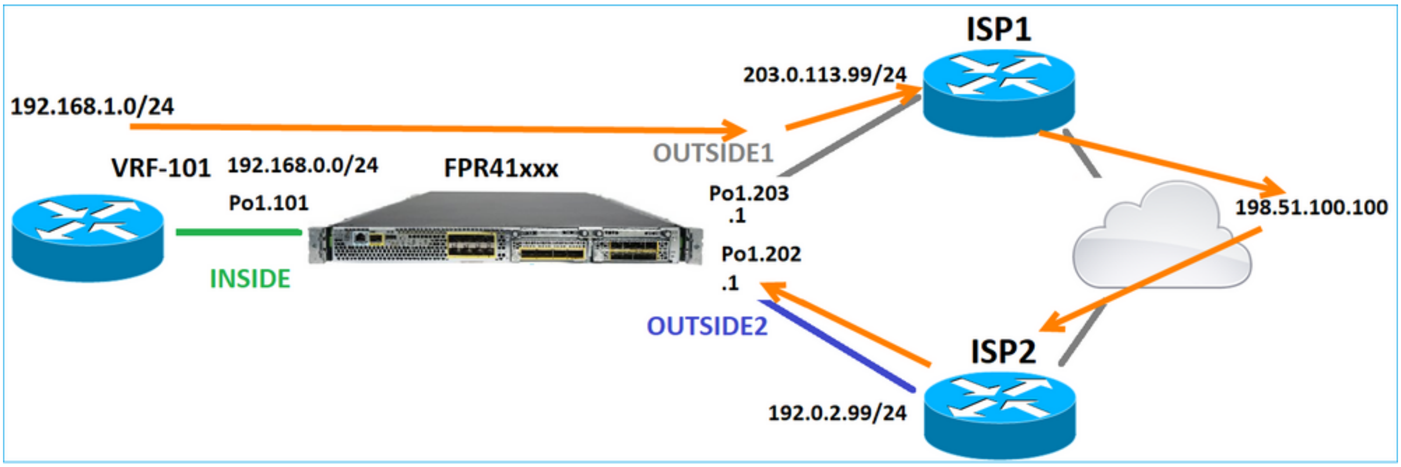
Before version 7.1, Firepower Threat Defense supported ECMP routing through FlexConfig policies. As from the 7.1 release, you can group interfaces into traffic zones and configure ECMP routing in Firepower Management Center.

EMCP is documented in: ECMP

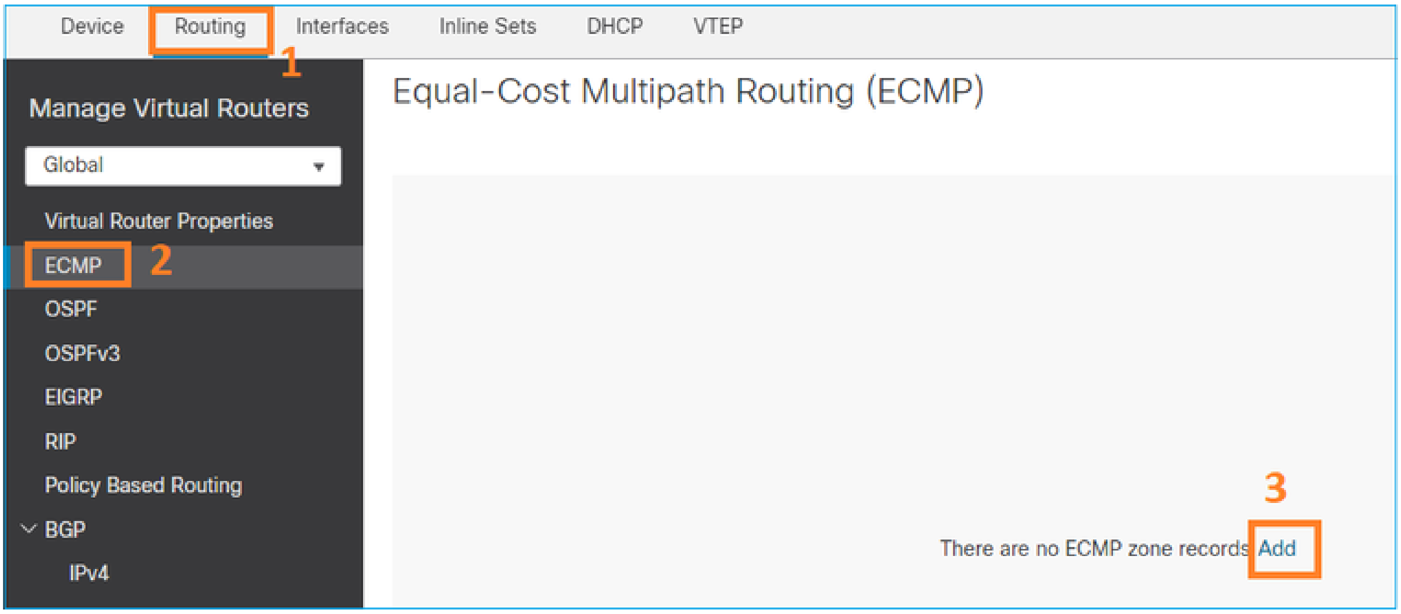
In this example, there is asymmetric routing, and return traffic is dropped:

<#root>

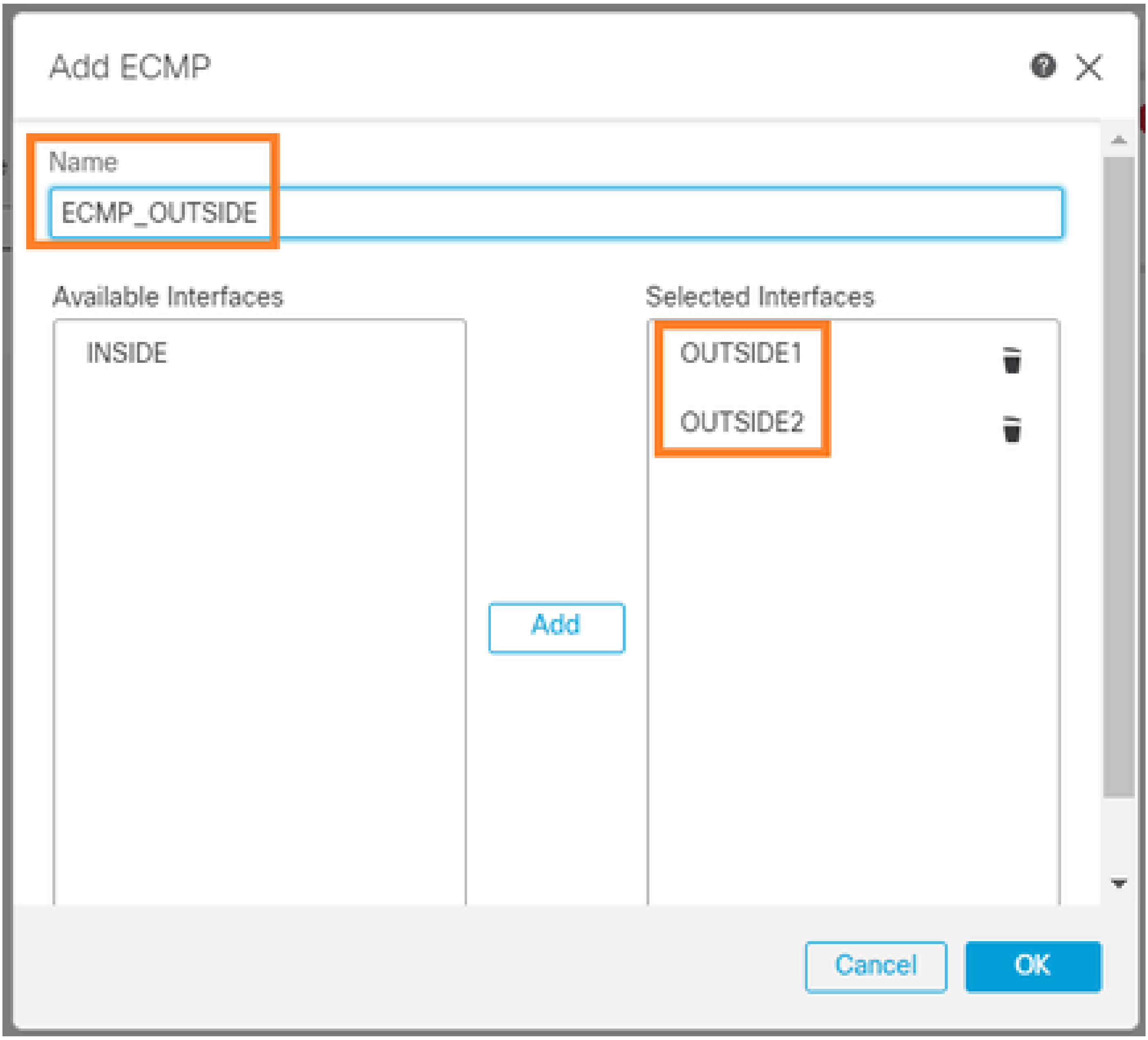
```
firepower#

show log


Apr 13 2022 07:20:48: %FTD-6-302013:

B

uilt inbound TCP connection 4046 for INSIDE:192.168.1.1/23943 (192.168.1.1/23943) to OUTSIDE1:198.51.100


Apr 13 2022 07:20:48: %FTD-6-106015:

Deny TCP (no connection) from 198.51.100.100/23 to 192.168.1.1/23943 flags SYN ACK on interface OUTSIDE2
```



Configure ECMP from the FMC UI:



Add the 2 interfaces in the ECMP group:

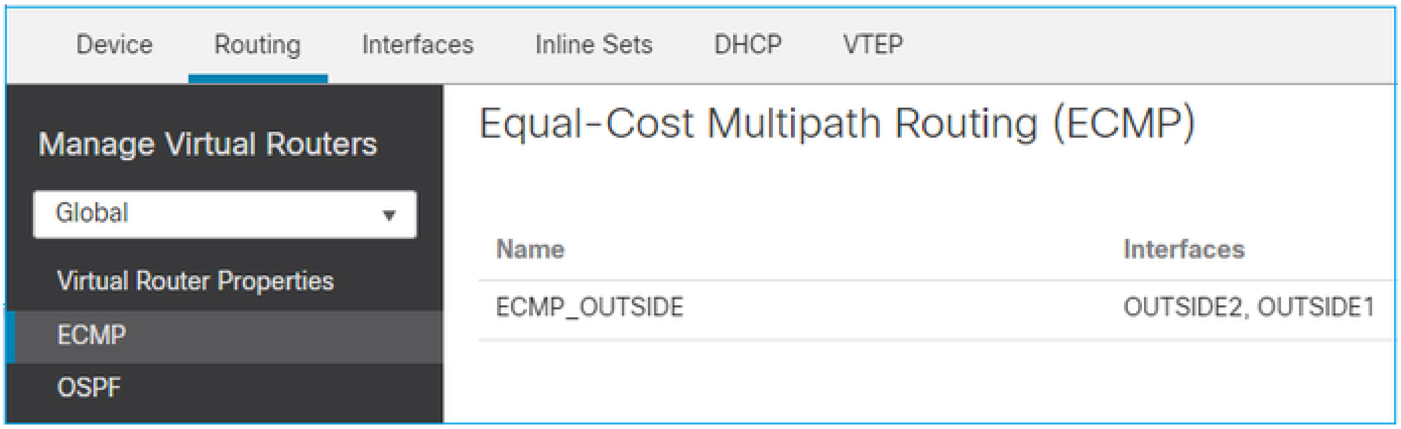


Name: ECMP_OUTSIDE

Available Interfaces: INSIDE

Selected Interfaces: OUTSIDE1, OUTSIDE2

The result:



Equal-Cost Multipath Routing (ECMP)

Name	Interfaces
ECMP_OUTSIDE	OUTSIDE2, OUTSIDE1

Save and **Deploy.**

ECMP zone verification:

<#root>

```
firepower#

show run zone


zone ECMP_OUTSIDE ecmp


firepower#

show zone


Zone: ECMP_OUTSIDE ecmp


Security-level: 0


Zone member(s): 2


OUTSIDE1 Port-channel1.203


OUTSIDE2 Port-channel1.202
```

Interface verification:

<#root>

```
firepower#

show run int po1.202


!
interface Port-channel1.202
vlan 202
nameif OUTSIDE2
cts manual
propagate sgt preserve-untag
policy static sgt disabled trusted
security-level 0

zone-member ECMP_OUTSIDE


ip address 192.0.2.1 255.255.255.0

firepower#

show run int po1.203


!
interface Port-channel1.203
```

```
vlan 203
nameif OUTSIDE1
cts manual
propagate sgt preserve-untag
policy static sgt disabled trusted
security-level 0

zone-member ECMP_OUTSIDE


ip address 203.0.113.1 255.255.255.0
```

Now, the return traffic is allowed, and the connection is UP:

<#root>

```
Router1#

telnet 198.51.100.100 /vrf VRF-101 /source-interface lo1


Trying 198.51.100.100 ... Open
```

Capture on ISP1 interface shows the egress traffic:

<#root>

```
firepower#

show capture CAP1


5 packets captured

1: 10:03:52.620115 802.1Q vlan#203 P0 192.168.1.1.56199 > 198.51.100.100.23: S 1782458734:1782458734(0)
2: 10:03:52.621992 802.1Q vlan#203 P0 192.168.1.1.56199 > 198.51.100.100.23: . ack 2000807246 win 4128
3: 10:03:52.622114 802.1Q vlan#203 P0 192.168.1.1.56199 > 198.51.100.100.23: . ack 2000807246 win 4128
4: 10:03:52.622465 802.1Q vlan#203 P0 192.168.1.1.56199 > 198.51.100.100.23: P 1782458735:1782458753(18
5: 10:03:52.622556 802.1Q vlan#203 P0 192.168.1.1.56199 > 198.51.100.100.23: . ack 2000807246 win 4128
```

Capture on ISP2 interface shows the return traffic:

<#root>

```
firepower#

show capture CAP2


6 packets captured

1: 10:03:52.621305 802.1Q vlan#202 P0 198.51.100.100.23 > 192.168.1.1.56199:
```

```
S

 2000807245:2000807245(0)

ack

 1782458735 win 64240 <mss 1460>
3: 10:03:52.623808 802.1Q vlan#202 P0 198.51.100.100.23 > 192.168.1.1.56199: . ack 1782458753 win 64222
```

FTD Management Plane

The FTD has 2 Management Planes:

- Management0 interface – Provides access to the Firepower subsystem
- LINA diagnostic interface – Provide access to FTD LINA subsystem

To configure and verify the Management0 interface, use the configure network and show network commands respectively.

On the other hand, the LINA interfaces provide access to the LINA itself. The FTD interface entries in the FTD RIB can be seen as Local routes:

<#root>

```
firepower#

show route | include L


Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
L 192.0.2.1 255.255.255.255 is directly connected, OUTSIDE2
L 192.168.0.1 255.255.255.255 is directly connected, INSIDE
L 203.0.113.1 255.255.255.255 is directly connected, OUTSIDE1
```

Similarly, they can be seen as identity entries in the ASP routing table:

<#root>

```
firepower#

show asp table routing | include identity


in 169.254.1.1 255.255.255.255 identity
in

192.0.2.1 255.255.255.255 identity


in

203.0.113.1 255.255.255.255 identity


in
```

```
192.168.0.1 255.255.255.255 identity


in ff02::1 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
in ff02::1:ff01:3 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
in ff02::1:ff00:1 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
in fe80::200:ff:fe01:3 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
in fd00:0:0:1::1 ffff:ffff:ffff:ffff:ffff:ffff:ffff:ffff identity
out 0.0.0.0 0.0.0.0 via 0.0.0.0, identity
out :: :: via 0.0.0.0, identity
```

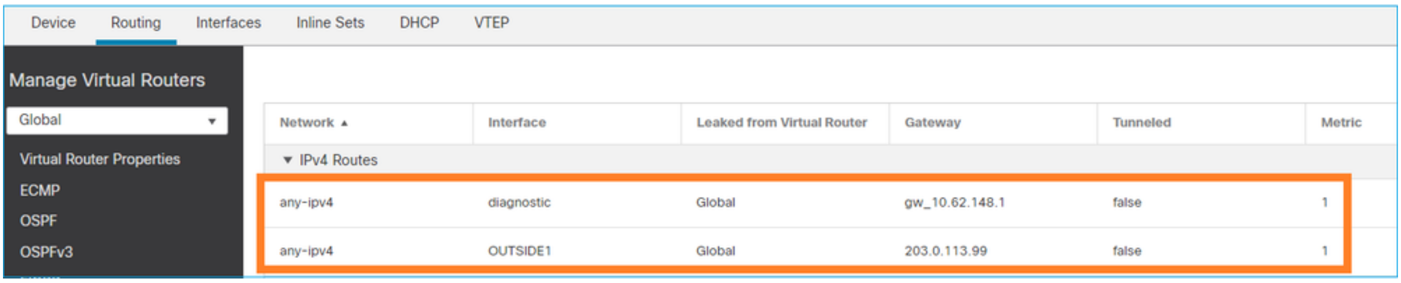
Main Point

When a packet arrives on FTD, and the destination IP matches one of the identity IPs, the FTD knows that it has to consume the packet.

FTD LINA Diagnostic Interface Routing

FTD (like an ASA that runs post-9.5 code) maintains a VRF-like routing table for any interface that is configured as management-only. An example of such an interface is the diagnostic interface.

While FMC does not allow you (without ECMP) to configure 2 default routes on 2 different interfaces with the same metric, you can configure 1 default route on an FTD data interface and another default route on the diagnostic interface:



Network ▲	Interface	Leaked from Virtual Router	Gateway	Tunneled	Metric
any-ipv4	diagnostic	Global	gw_10.62.148.1	false	1
any-ipv4	OUTSIDE1	Global	203.0.113.99	false	1

The data plane traffic uses the global table default gateway, while the management plane traffic uses the diagnostic default GW:

<#root>

```
firepower#

show route management-only



Routing Table: mgmt-only


Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2, V - VPN
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, + - replicated route
SI - Static InterVRF, BI - BGP InterVRF
```

```
Gateway of last resort is 10.62.148.1 to network 0.0.0.0



S* 0.0.0.0 0.0.0.0 [1/0] via 10.62.148.1, diagnostic
```

The global routing table gateway:

<#root>

```
firepower#

show route | include S\*|Gateway


Gateway of last resort is 203.0.113.99 to network 0.0.0.0


S* 0.0.0.0 0.0.0.0 [1/0] via 203.0.113.99, OUTSIDE1
```

When you send traffic from the FTD (from-the-box traffic), the egress interface is selected based on:

1. Global routing table
2. Management-only routing table

You can overwrite the egress interface selection if you manually specify the egress interface.

Try to ping the diagnostic interface gateway. If you do not specify the source interface, the ping fails because FTD first uses the global routing table which, in this case, it contains a default route. If there is no route in the global table, the FTD does a route lookup on the management-only routing table:

<#root>

```
firepower#

ping 10.62.148.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.62.148.1, timeout is 2 seconds:

?????


Success rate is 0 percent (0/5)
firepower#

show capture CAP1 | include 10.62.148.1


1: 10:31:22.970607 802.1Q vlan#203 P0

203.0.113.1 > 10.62.148.1 icmp: echo request


2: 10:31:22.971431 802.1Q vlan#203 P0
```

```
10.1.1.2 > 203.0.113.1 icmp: host 10.62.148.1 unreachable
```

<#root>

```
firepower#

ping diagnostic 10.62.148.1


Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.62.148.1, timeout is 2 seconds:

!!!!!


Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

The same applies if you try to copy a file from LINA CLI with the copy command.

Bidirectional Forwarding Detection (BFD)

BFD support was added on classic ASA version 9.6 and only for BGP protocol: Bidirectional Forwarding Detection Routing

On FTD:

- BGP IPv4 and BGP IPv6 protocols are supported (software 6.4).
- OSPFv2, OSPFv3, and EIGRP protocols are not supported.
- BFD for Static Routes is not supported.

Virtual Routers (VRF)

VRF support was added in the 6.6 release. For more details check this document: Configuration Examples for Virtual Routers.

Related Information

- FTD Static and Default Routes