Configuring VXLAN OAM

This chapter contains the following sections:

VXLAN OAM Overview

The VXLAN operations, administration, and maintenance (OAM) protocol is a protocol for installing, monitoring, and troubleshooting Ethernet networks to enhance management in VXLAN based overlay networks.

Cisco Nexus 3500 Series switches do not support VXLAN OAM on Cisco NX-OS Release 7.0(3)I7(2) and the previous releases.

Similar to ping, traceroute, or pathtrace utilities that allow quick determination of the problems in the IP networks, equivalent troubleshooting tools have been introduced to diagnose the problems in the VXLAN networks. The VXLAN OAM tools, for example, ping, pathtrace, and traceroute provide the reachability information to the hosts and the VTEPs in a VXLAN network. The OAM channel is used to identify the type of the VXLAN payload that is present in these OAM packets.

There are two types of payloads supported:

- Conventional ICMP packet to the destination to be tracked
- Special NVO3 draft Tissa OAM header that carries useful information

The ICMP channel helps to reach the traditional hosts or switches that do not support the new OAM packet formats. The NVO3 draft Tissa channels helps to reach the supported hosts or switches and carries the important diagnostic information. The VXLAN NVO3 draft Tissa OAM messages may be identified via the reserved OAM EtherType or by using a well-known reserved source MAC address in the OAM packets depending on the implementation on different platforms. This constitutes a signature for recognition of the VXLAN OAM packets. The VXLAN OAM tools are categorized as shown in table below.

Table 1: VXLAN OAM Tools

Category	Tools
Fault Verification	Loopback Message
Fault Isolation	Path Trace Message
Performance	Delay Measurement, Loss Measurement
Auxiliary	Address Binding Verification, IP End Station Locator, Error Notification, OAM Command Messages, and Diagnostic Payload Discovery for ECMP Coverage

Loopback (Ping) Message

The loopback message (The ping and the loopback messages are the same and they are used interchangeably in this guide) is used for the fault verification. The loopback message utility is used to detect various errors and the path failures. Consider the topology in the following example where there are three core (spine) switches labeled Spine 1, Spine 2, and Spine 3 and five leaf switches connected in a Clos topology. The path of an example loopback message initiated from Leaf 1 for Leaf 5 is displayed when it traverses via Spine 3. When the loopback message initiated by Leaf 1 reaches Spine 3, it forwards it as VXLAN encapsulated data packet based on the outer header. The packet is not sent to the software on Spine 3. On Leaf 3, based on the appropriate loopback message signature, the packet is sent to the software VXLAN OAM module, that in turn, generates a loopback response that is sent back to the originator Leaf 1.

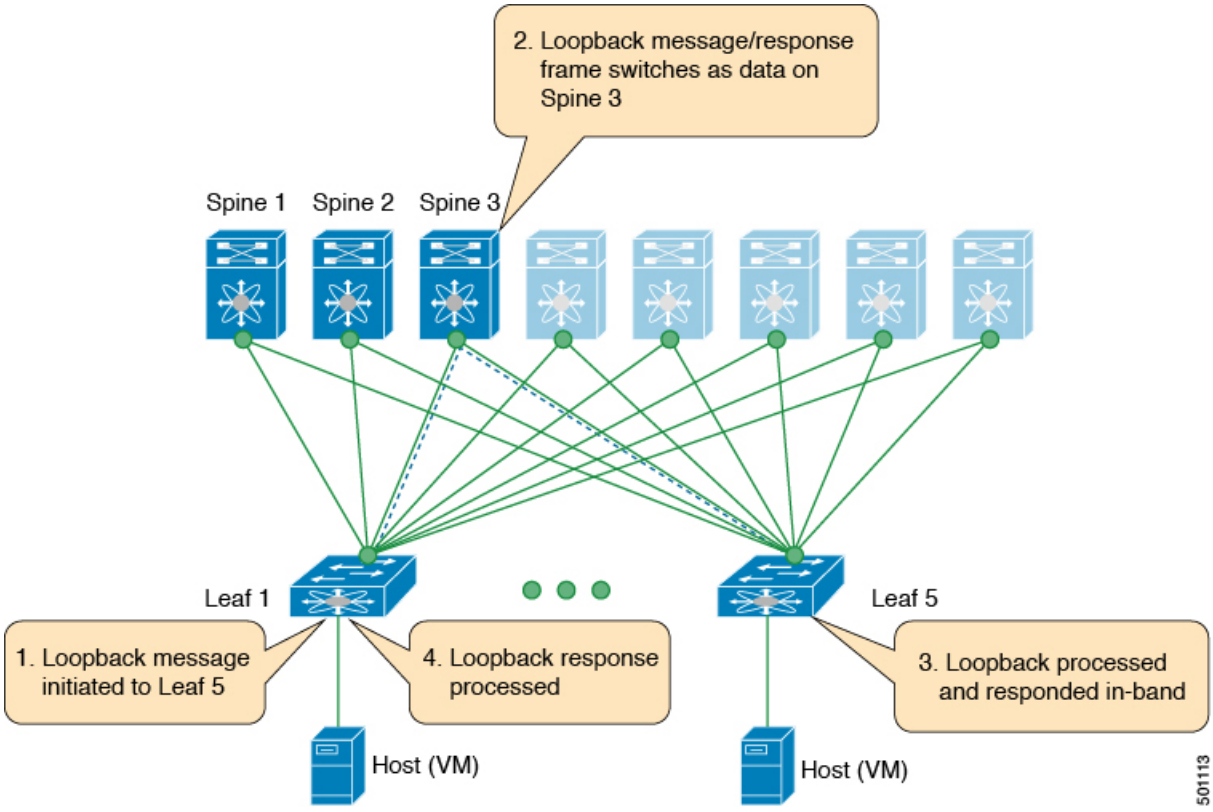
The loopback (ping) message can be destined to VM or to the (VTEP on) leaf switch. This ping message can use different OAM channels. If the ICMP channel is used, the loopback message can reach all the way to the VM if the VM's IP address is specified. If NVO3 draft Tissa channel is used, this loopback message is terminated on the leaf switch that is attached to the VM, as the VMs do not support the NVO3 draft Tissa headers in general. In that case, the leaf switch replies back to this message indicating the reachability of the VM. The ping message supports the following reachability options:

Ping

Check the network reachability (**Ping** command):

- From Leaf 1 (VTEP 1) to Leaf 2 (VTEP 2) (ICMP or NVO3 draft Tissa channel)
- From Leaf 1 (VTEP 1) to VM 2 (host attached to another VTEP) (ICMP or NVO3 draft Tissa channel)

Figure 1: Loopback Message



Traceroute or Pathtrace Message

The traceroute or pathtrace message is used for the fault isolation. In a VXLAN network, it may be desirable to find the list of switches that are traversed by a frame to reach the destination. When the loopback test from a source switch to a destination switch fails, the next step is to find out the offending switch in the path. The operation of the path trace message begins with the source switch transmitting a VXLAN OAM frame with a TTL value of 1. The next hop switch receives this frame, decrements the TTL, and on finding that the TTL is 0, it transmits a TTL expiry message to the sender switch. The sender switch records this message as an indication of success from the first hop switch. Then the source switch increases the TTL value by one in the next path trace message to find the second hop. At each new transmission, the sequence number in the message is incremented. Each intermediate switch along the path decrements the TTL value by 1 as is the case with regular VXLAN forwarding.

This process continues until a response is received from the destination switch, or the path trace process timeout occurs, or the hop count reaches a maximum configured value. The payload in the VXLAN OAM frames is referred to as the flow entropy. The flow entropy can be populated so as to choose a particular path among multiple ECMP paths between a source and destination switch. The TTL expiry message may also be generated by the intermediate switches for the actual data frames. The same payload of the original path trace request is preserved for the payload of the response.

The traceroute and pathtrace messages are similar, except that traceroute uses the ICMP channel, whereas pathtrace use the NVO3 draft Tissa channel. Pathtrace uses the NVO3 draft Tissa channel, carrying additional diagnostic information, for example, interface load and statistics of the hops taken by these messages. If an

intermediate device does not support the NVO3 draft Tissa channel, the pathtrace behaves as a simple traceroute and it provides only the hop information.

Traceroute

Trace the path that is traversed by the packet in the VXLAN overlay using **Traceroute** command:

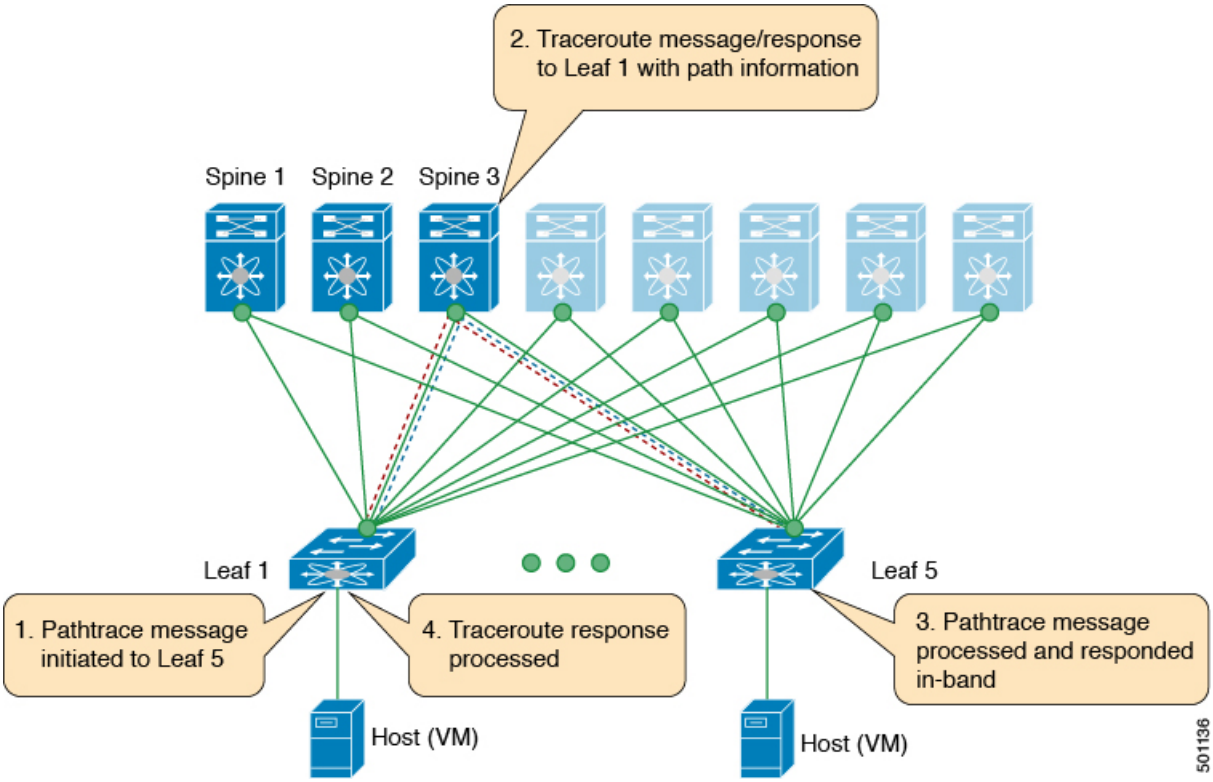
- Traceroute uses the ICMP packets (channel-1), encapsulated in the VXLAN encapsulation to reach the host

Pathtrace

Trace the path that is traversed by the packet in the VXLAN overlay using the NVO3 draft Tissa channel with **Pathtrace** command:

- Pathtrace uses special control packets like NVO3 draft Tissa or TISSA (channel-2) to provide additional information regarding the path (for example, ingress interface and egress interface). These packets terminate at VTEP and they does not reach the host. Therefore, only the VTEP responds.

Figure 2: Traceroute Message



Configuring VXLAN OAM

Before you begin

As a prerequisite, ensure that the VXLAN configuration is complete.

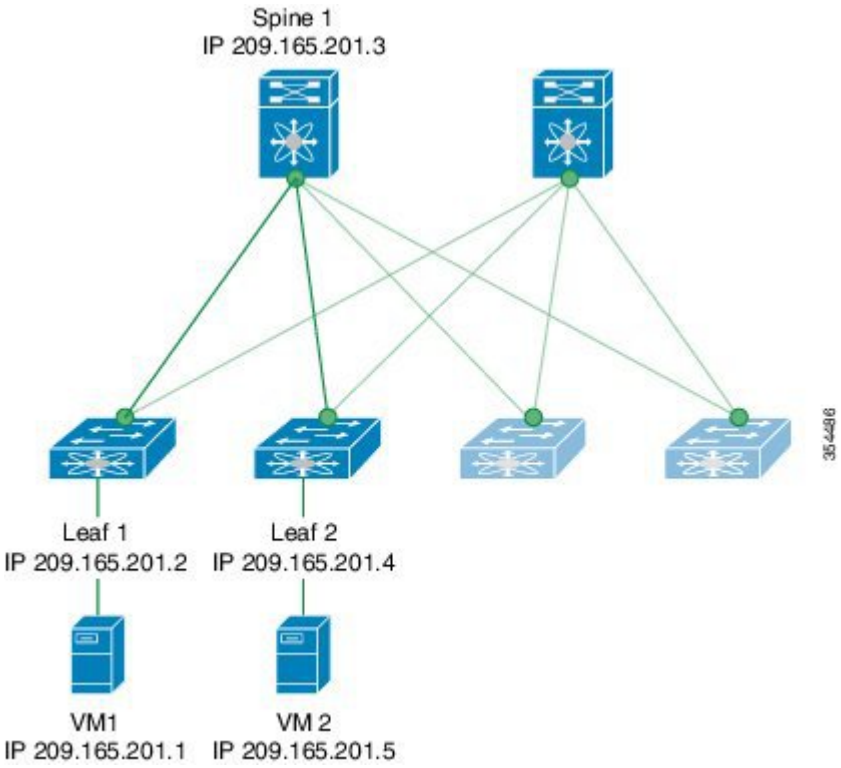
Procedure

	Command or Action	Purpose
Step 1	switch(config)# **feature ngoam**	Enters the NGOAM feature.
Step 2	switch(config)# **hardware access-list tcam region arp-ether 256 double-wide**	For Cisco Nexus 3000 Series switches with Network Forwarding Engine (NFE), configure the TCAM region for ARP-ETHER using this command. This step is essential to program the ACL rule in the hardware and it is a pre-requisite before installing the ACL rule. **Note** Configuring the TCAM region requires the node to be rebooted.
Step 3	switch(config)# **ngoam install acl**	Installs NGOAM Access Control List (ACL).
Step 4	(Optional) **#bcm-shell module 1 "fp show group 62"**	For Cisco Nexus 3000 Series switches with Network Forwarding Engine (NFE), complete this verification step. After entering the command, perform a lookup for entry/eid with data=0x8902 under EtherType.
Step 5	(Optional) **# show system internal access-list tcam ingress start-idx <hardware index> count 1**	

Example

See the following examples of the configuration topology.

Figure 3: VXLAN Network



VXLAN OAM provides the visibility of the host at the switch level, that allows a leaf to ping the host using the **ping nve** command.

The following example displays how to ping from Leaf 1 to VM2 via Spine 1.

```
switch# ping nve ip 209.165.201.5 vrf vni-31000 source 1.1.1.1 verbose

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
'D' - Destination Unreachable, 'X' - unknown return code,
'm' - malformed request(parameter problem),
'c' - Corrupted Data/Test, '#' - Duplicate response


Sender handle: 34
! sport 40673 size 39,Reply from 209.165.201.5,time = 3 ms
! sport 40673 size 39,Reply from 209.165.201.5,time = 1 ms
! sport 40673 size 39,Reply from 209.165.201.5,time = 1 ms
! sport 40673 size 39,Reply from 209.165.201.5,time = 1 ms
! sport 40673 size 39,Reply from 209.165.201.5,time = 1 ms
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/4/18 ms
Total time elapsed 49 ms
```

Note The source ip-address 1.1.1.1 used in the above example is a loopback interface that is configured on Leaf 1 in the same VRF as the destination ip-address. For example, the VRF in this example is vni-31000.

The following example displays how to traceroute from Leaf 1 to VM 2 via Spine 1.

```
switch# traceroute nve ip 209.165.201.5 vrf vni-31000 source 1.1.1.1 verbose


Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
'D' - Destination Unreachable, 'X' - unknown return code,
'm' - malformed request(parameter problem),
'c' - Corrupted Data/Test, '#' - Duplicate response


Traceroute request to peer ip 209.165.201.4 source ip 209.165.201.2
Sender handle: 36
  1 !Reply from 209.165.201.3,time = 1 ms
  2 !Reply from 209.165.201.4,time = 2 ms
  3 !Reply from 209.165.201.5,time = 1 ms
```

The following example displays how to pathtrace from Leaf 2 to Leaf 1.

```
switch# pathtrace nve ip 209.165.201.4 vni 31000 verbose

Path trace Request to peer ip 209.165.201.4 source ip 209.165.201.2

Sender handle: 42
TTL            Code        Reply
          IngressI/f               EgressI/f               State
=====================================================================
1     !Reply from 209.165.201.3,  Eth5/5/1      Eth5/5/2     UP/UP
2     !Reply from 209.165.201.4,  Eth1/3                    Unknown         UP/DOWN
```

The following example displays how to MAC ping from Leaf 2 to Leaf 1 using NVO3 draft Tissa channel:

```
switch# ping nve mac 0050.569a.7418 2901 ethernet 1/51 profile 4 verbose

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
'D' - Destination Unreachable, 'X' - unknown return code,
'm' - malformed request(parameter problem),
'c' - Corrupted Data/Test, '#' - Duplicate response

Sender handle: 408
!!!!Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/5 ms
Total time elapsed 104 ms

switch# show run ngoam
feature ngoam
ngoam profile 4
oam-channel 2
ngoam install acl
```

The following example displays how to pathtrace based on a payload from Leaf 2 to Leaf 1:

```
switch# pathtrace nve ip unknown vrf vni-31000 payload mac-addr 0050.569a.d927 0050.569a.a4fa
ip 209.165.201.5 209.165.201.1 port 15334 12769 proto 17 payload-end

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
'D' - Destination Unreachable, 'X' - unknown return code,
'm' - malformed request(parameter problem),
```

```
'c' - Corrupted Data/Test, '#' - Duplicate response

Path trace Request to peer ip 209.165.201.4 source ip 209.165.201.2
Sender handle: 46
TTL Code Reply IngressI/f EgressI/f State
=====================================================================
1 !Reply from 209.165.201.3, Eth5/5/1 Eth5/5/2 UP/UP
2 !Reply from 209.165.201.4, Eth1/3 Unknown UP/DOWN
```

Configuring NGOAM Profile

Complete the following steps to configure NGOAM profile.

Procedure

	Command or Action	Purpose
Step 1	switch(config)#**[no] feature ngoam**	Enables or disables NGOAM feature
Step 2	switch(config)#**[no] ngoam profile <profile-id>**	Configures OAM profile. The range for the profile-id is <1 – 1023>. This command does not have a default value. Enters the config-ngoam-profile submode to configure NGOAM specific commands. **Note** All profiles have default values and the **show run all** CLI command displays them. The default values are not visible through the **show run** CLI command.

Step 3	switch(config-ng-oam-profile)# **?**
	Example:
	`switch(config-ng-oam-profile)# ?`
	`  description  Configure description of the profile`
	`  dot1q  Encapsulation dot1q/bd`
	`  flow  Configure ngoam flow`
	`  hop  Configure ngoam hop count`
	`  interface  Configure ngoam egress interface`
	`  no  Negate a command or set its defaults`
	`  oam-channel  Oam-channel used`
	`  payload  Configure ngoam payload`
	`  sport  Configure ngoam Udp source port range`
		Displays the options for configuring NGOAM profile.

Example

See the following examples for configuring an NGOAM profile and for configuring NGOAM flow.

```
switch(config)#
ngoam profile 1
oam-channel 1
flow forward
payload pad 0x2
sport 12345, 54321

switch(config-ngoam-profile)#flow {forward }
Enters config-ngoam-profile-flow submode to configure forward flow entropy specific
information
```

NGOAM Authentication

NGOAM provides the interface statistics in the pathtrace response. Beginning with Cisco NX-OS Release 7.0(3)I6(1), NGOAM authenticates the pathtrace requests to provide the statistics by using the HMAC MD5 authentication mechanism.

NGOAM authentication validates the pathtrace requests before providing the interface statistics. NGOAM authentication takes effect only for the pathtrace requests with **req-stats** option. All the other commands are not affected with the authentication configuration. If NGOAM authentication key is configured on the requesting node, NGOAM runs the MD5 algorithm using this key to generate the 16-bit MD5 digest. This digest is encoded as type-length-value (TLV) in the pathtrace request messages.

When the pathtrace request is received, NGOAM checks for the **req-stats** option and the local NGOAM authentication key. If the local NGOAM authentication key is present, it runs MD5 using the local key on the request to generate the MD5 digest. If both digests match, it includes the interface statistics. If both digests do not match, it sends only the interface names. If an NGOAM request comes with the MD5 digest but no local authentication key is configured, it ignores the digest and sends all the interface statistics. To secure an entire network, configure the authentication key on all nodes.

To configure the NGOAM authentication key, use the **ngoam authentication-key** <*key*> CLI command. Use the **show running-config ngoam** CLI command to display the authentication key.

```
switch# show running-config ngoam
!Time: Tue Mar 28 18:21:50 2017
version 7.0(3)I6(1)
feature ngoam
ngoam profile 1
  oam-channel 2
ngoam profile 3
ngoam install acl
ngoam authentication-key 987601ABCDEF
```

In the following example, the same authentication key is configured on the requesting switch and the responding switch.

```
switch# pathtrace nve ip 12.0.22.1 profile 1 vni 31000 req-stats ver
Path trace Request to peer ip 12.0.22.1 source ip 11.0.22.1
Hop   Code   ReplyIP   IngressI/f  EgressI/f   State
```

```
================================================
  1 !Reply from 55.55.55.2, Eth5/7/1  Eth5/7/2  UP / UP
  Input Stats: PktRate:0 ByteRate:0 Load:0 Bytes:339573434 unicast:14657 mcast:307581
bcast:67 discards:0 errors:3 unknown:0 bandwidth:42949672970000000
Output Stats: PktRate:0 ByteRate:0 load:0 bytes:237399176 unicast:2929 mcast:535710
bcast:10408 discards:0 errors:0 bandwidth:42949672970000000
  2 !Reply from 12.0.22.1, Eth1/7  Unknown  UP / DOWN
  Input Stats: PktRate:0 ByteRate:0 Load:0 Bytes:4213416 unicast:275 mcast:4366 bcast:3
discards:0 errors:0 unknown:0 bandwidth:42949672970000000
switch# conf t
switch(config)# no ngoam authentication-key 123456789
switch(config)# end
```

In the following example, an authentication key is not configured on the requesting switch. Therefore, the responding switch does not send any interface statistics. The intermediate node does not have any authentication key configured and it always replies with the interface statistics.

```
switch# pathtrace nve ip 12.0.22.1 profile 1 vni 31000 req-stats ver
Path trace Request to peer ip 12.0.22.1 source ip 11.0.22.1
Sender handle: 10
Hop   Code   ReplyIP   IngressI/f  EgressI/f   State
================================================
  1 !Reply from 55.55.55.2, Eth5/7/1  Eth5/7/2  UP / UP
  Input Stats: PktRate:0 ByteRate:0 Load:0 Bytes:339580108 unicast:14658 mcast:307587
bcast:67 discards:0 errors:3 unknown:0 bandwidth:42949672970000000
Output Stats: PktRate:0 ByteRate:0 load:0 bytes:237405790 unicast:2929 mcast:535716
bcast:10408 discards:0 errors:0 bandwidth:42949672970000000
  2 !Reply from 12.0.22.1, Eth1/17  Unknown  UP / DOWN
```