Improve Throughput on Catalyst 8000V with Multi-TxQs in AWS

Contents

Introduction

This document describes how to enable and utilize Multi-TXQs on Catalyst 8000V deployed in AWS environments to improve throughput performance.

Background Information

The presence of multiple queues simplifies and accelerates the process of mapping incoming and outgoing packets to a particular vCPU. Utilizing Multi-TXQs on Catalyst 8000V allows for efficient core utilization across the available dataplane cores allocated resulting in higher throughput performance. This article provides a light overview of how Multi-TXQs work, how it is configured, show sample CLI configurations for both Autonomous and SD-WAN Catalyst 8000V deployments, and review troubleshooting commands to help find performance bottlenecks.

Catalyst 8000V Behavior When not Using Multi-TxQs

Until 17.18 software release, packets entering Catalyst 8000V are distributed to all vCPU (Packet Processing cores) regardless of flows. Once PP completes packet processing, the flow order is restored to be sent out on an interface.

Prior to placing the packet into a transmit queue (TxQ), the Catalyst 8000V creates one TxQ per interface. Therefore, if there is only one egress interface available, then multiple flows go into one TxQ.

The Catalyst 8000V is not able to take advantage of this Multi-TxQ process if there is only one interface available. This results in throughput performance bottlenecks and uneven load distribution across the available dataplane cores. If there is only one egress interface being used to transmit data out of the C8000V instance, then there is only one TxQ available to transmit network traffic and possibly cause packets to be dropped due to the single queue filling up quicker.

For reference, you can find the single TxQ architecture model for Catalyst 8000V deployed in AWS here on Figure 1.

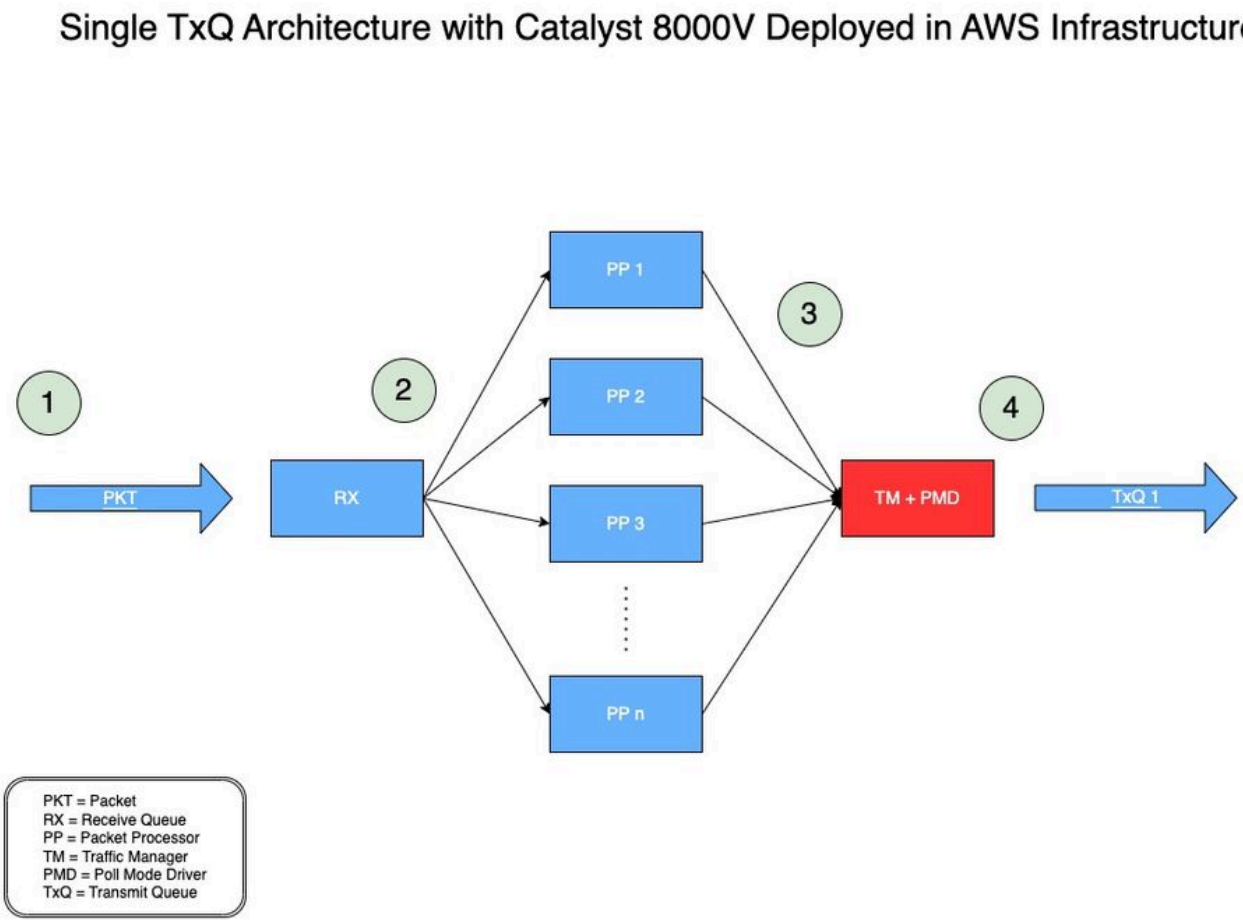


Figure 1: Single TxQ architecture model for Catalyst 8000V deployed in AWS.

1. A network packet (PKT) is traversing through a VPC and is received on the ingress interface of a C8000V.
2. The PKT is placed on a receive queue (RX) and is then forwarded to a Packet Processor (PP) engine decided by an algorithm.
3. After the Packet Processor (PP) processes the packet, it then sends the packet to Traffic Manager (TM).
4. At the end of TM processing, one core is responsible for placing the packet in the one TxQ available which is then forwarded to the egress interface of the Catalyst 8000V.

What are Multi-TXQs in AWS Infrastructure

AWS ENA provides multiple transmit queues (Multi-TxQ's) to reduce internal overhead and to increase scalability. The presence of multiple queues simplifies and accelerates the process of mapping incoming and outgoing packets to a particular vCPU. The AWS and DPDK network reference model is flow-based, where each vCPU processes a flow and transmits packets from that flow to an assigned transmit queue (TxQ). The RX/TX queue pair for each vCPU is valid based on the flow-based model.

Because the Catalyst 8000V is NOT flow based, the statement "RX/TX queue pair for each vCPU" does not apply to the Catalyst 8000V.

In this case, RX/TX queues are not per vCPU but per interface. RX/TX queues act as interfaces between application (Catalyst 8000V) and AWS infrastructure/hardware to send data/network traffics. AWS controls how fast and how many RX/TX queues are available per interface on a per instance basis.

The Catalyst 8000V must have multiple interfaces to create multiple TxQ's. To keep flow order with multiple flows going out an interface (once the Catalyst 8000V enables multiple TxQs following this process), the Catalyst 8000V hashes flows based on the 5-tuples to pick the appropriate TxQ. A user can create multiple interfaces on the Catalyst 8000V using the same physical NIC attached to the instance by using Loopback interfaces or secondary IP addresses.

In Figure 2, you can find how a packet is processed using the Multi-TxQ architecture with Catalyst 8000V in AWS.

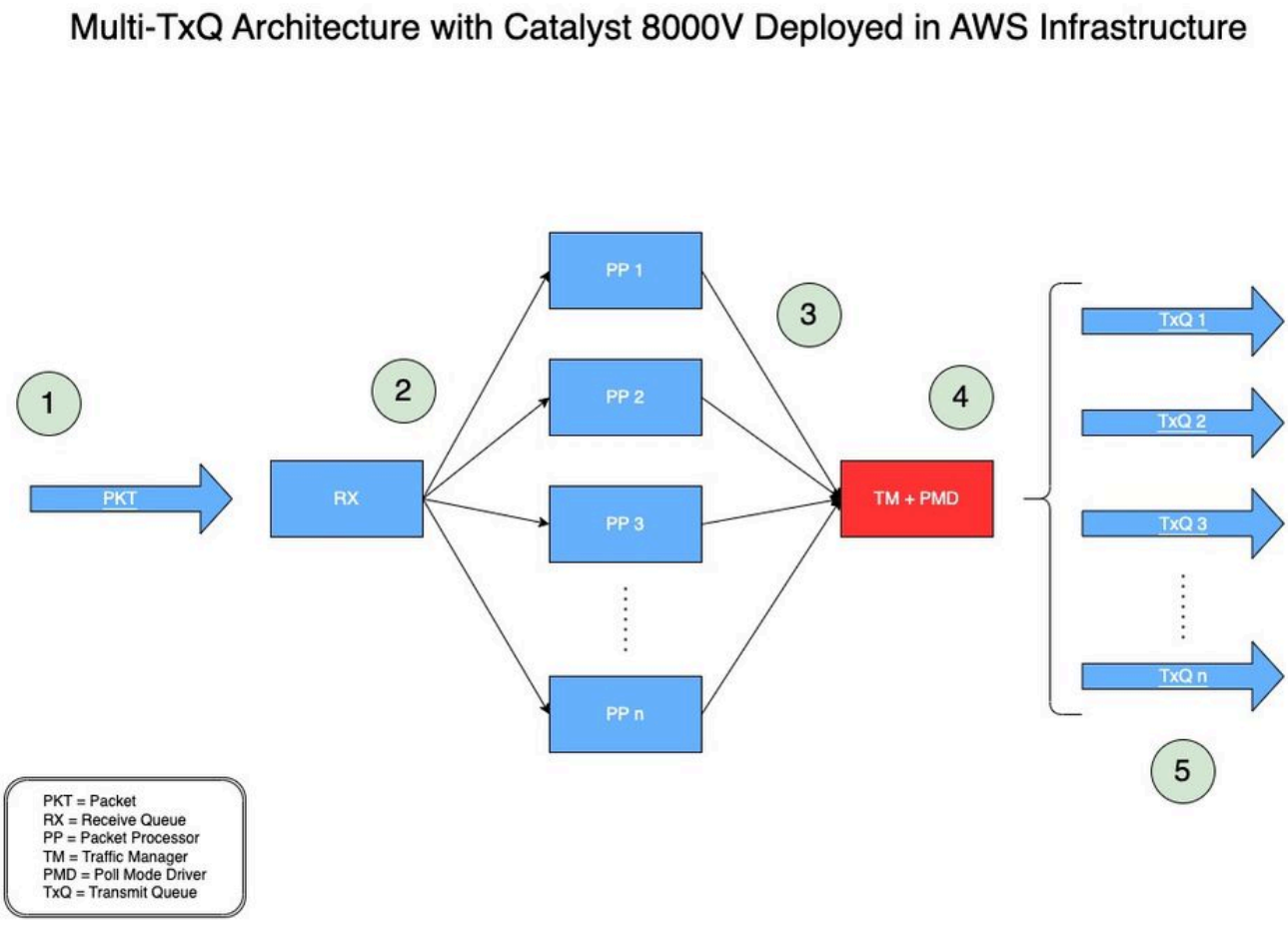


Figure 2: Multi-TxQ architecture model for Catalyst 8000V deployed in AWS.

1. A network packet (PKT) is traversing through a VPC and is received on the ingress interface of a C8000V.
2. The PKT is placed on a receive queue (RX) and is then forwarded to a Packet Processor (PP) engine decided by an algorithm.
3. After the Packet Processor (PP) processes the packet, it then sends the packet to Traffic Manager (TM).
4. At the end of TM processing, prior to placing the packet in a transmit queue (TxQ), the TM looks at the packet header and hashes the packet (explained in the next section). Another component, the Poll Mode Driver (PMD), is used to configure the number of TXQs supported by the instance. One core is dedicated for the TM + PMD function which do the hashing and sending of the packet to the assigned TxQ.
5. The TxQ is picked based on the five tuples hashed and modulo with the number of TxQ supported by the instance. Packet are placed to the selected TxQ and forwarded to the egress interface of the Catalyst 8000V.

How Traffic is Hashed into Multi-TxQs

At the end of TM processing as shown on Step 4 of Figure 2, prior to placing the packet in a TxQ, the TM looks at the packet header and extracts the 5 tuples (destination address, source address, protocol, destination port, and source port) and hashes the packet to a TxQ.

The TxQ is picked based on the five tuples hashed and modulo with the number of TxQ supported by the instance.

Catalyst 8000V Software Versions that Support Multi-TxQs

AWS EC2 instances of the same instance family type all support different number of TXQs, depending on instance size. The C8000V began supporting multiple TxQ’s starting from IOS® XE 17.7.

Starting in IOS® XE 17.7, the C8000V supports multiple TxQ’s on the C5n.9xlarge which can have up to 8 TXQs.

Starting in IOS® XE 17.9, the C8000V supports the C5n.18xlarge instance size, which can have up to 12 TXQs (50% more than C5n.9xlarge).

Although Multi-TxQ is supported from IOS® XE 17.7, it is HIGHLY recommended to use IOS® XE 17.9 for both software lifecycle and higher throughput performance capabilities with 12 TxQ support.

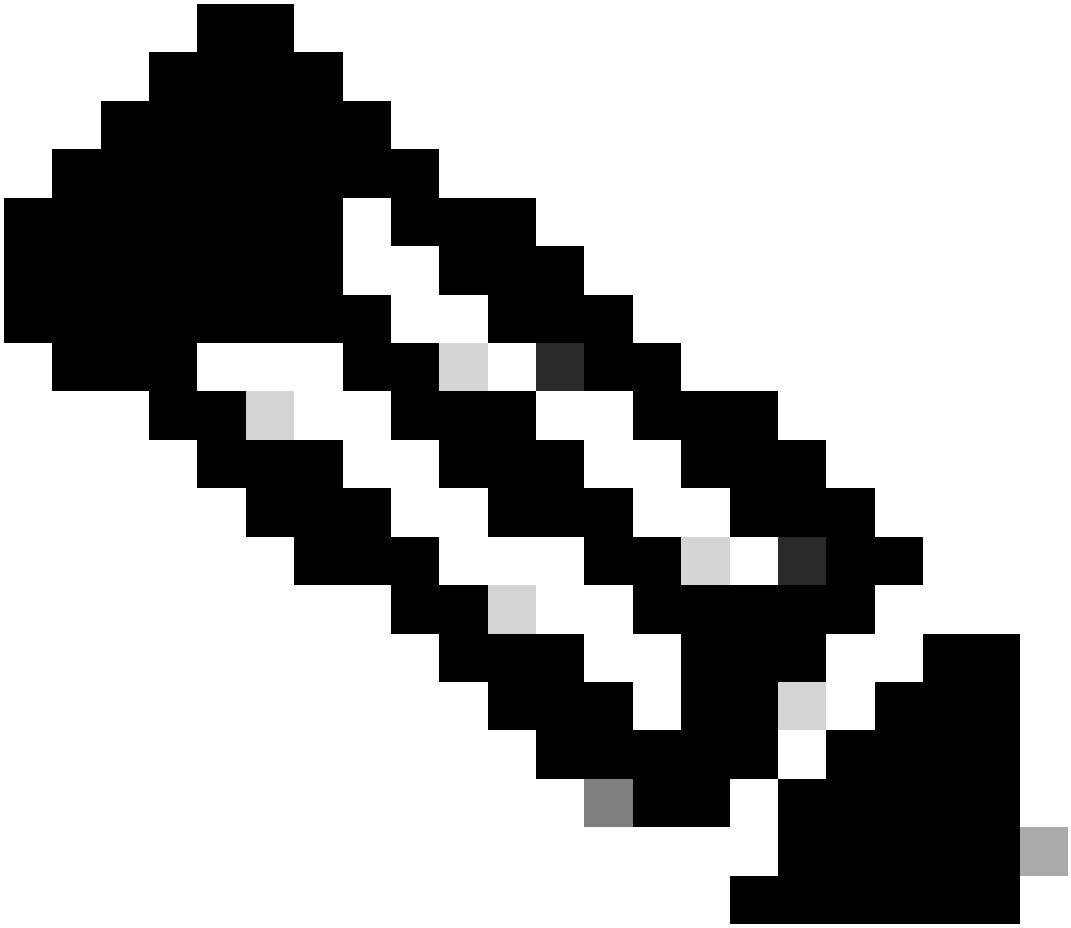
How to Engineer the IP Addressing Scheme to Compute the Hashing

To evenly hash traffic between all available TxQ’s, special IP addresses need to be used when the Catalyst 8000V is terminating IPsec/GRE tunnels.

There are public scripts available to generate these special IP addresses to be used to configure the Catalyst 8000V interfaces that are responsible for terminating these tunnels. This section provides instructions on how to download and use the scripts to engineer the required IP addresses for even Multi-TxQ hashing.

If the Catalyst 8000V is handling clear text traffic like TCP/UDP, then no special IP addressing scheme is required.

Original instructions can be found here: https://github.com/CiscoDevNet/python-c8000v-aws-multitx-queues/



> **Note**: For Catalyst 8000V running 17.18 or later, packets are being differently distributed. Thus, a different hashing algorithm needs to be used.

Prerequisites

- Must have Linux/MacOS, or Windows machine capable of running Python scripts.
- Verify Python version is 3.8.9 or higher; check Python version with 'python3 --version'
- Install PIP if not already installed. If not, run:
  - curl https://bootstrap.pypa.io/get-pip.py -o get-pip.py
  - python3 get-pip.py

You can check which Python version your machine is using with the command 'python3 --version'.

```
user@computer ~ % python3 --version
```

```
Python 3.9.6
```

Once Python version has been verified and is running, a version equal to or higher that 3.8.9, install the latest version of PIP.

```
user@computer ~ % curl https://bootstrap.pypa.io/get-pip.py -o get-pip.py

  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current

                                 Dload  Upload   Total   Spent    Left  Speed

100 2570k  100 2570k    0     0  6082k      0 --:--:-- --:--:-- --:--:-- 6135k
```

<#root>

```
user@computer ~ % python3 get-pip.py

Defaulting to user installation because normal site-packages is not writeable
Collecting pip
  Downloading pip-23.3.1-py3-none-any.whl.metadata (3.5 kB)
Downloading pip-23.3.1-py3-none-any.whl (2.1 MB)

   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 2.1/2.1 MB 7.4 MB/s eta 0:00:00

Installing collected packages: pip

  WARNING: The scripts pip, pip3 and pip3.9 are installed in '/Users/name/Library/Python/3.9/bin' which

  Consider adding this directory to PATH or, if you prefer to suppress this warning, use --no-warn-scri

Successfully installed pip-23.3.1


[

notice

]

 A new release of pip is available: 21.2.4 -> 23.3.1


[

notice

]

 To update, run: /Applications/Xcode.app/Contents/Developer/usr/bin/python3 -m pip install --upgrade pi
```

Create Virtual Environment

Once prerequisites have been installed, create the virtual environment and download the IP Address hashing script used to generate the unique IP address scheme for Multi-TxQ.

Summary of commands:

1. python3 -m venv c8kv-hash
2. cd c8kv-hash
3. source bin/activate
4. git clone https://github.com/CiscoDevNet/python-c8000v-aws-multitx-queues/
5. cd c8kv-aws-pmd-hash
6. python3 -m pip install --upgrade pip
7. pip install -r requirements.txt

Virtual environments in Python are used to create isolated workspaces that do not affect other projects or dependencies. Create the virtual environment 'c8kv-hash' using this command:

```
user@computer Desktop % python3 -m venv c8kv-hash
```

Navigate inside the virtual environment to the 'c8kv-hash' folder (created earlier).

```
user@computer Desktop % cd c8kv-hash
```

Activate the virtual environment.

```
user@computer c8kv-hash % source bin/activate
```

Clone the repository which has the Multi-TxQ hashing python script.

```
(c8kv-hash) user@computer c8kv-hash % git clone https://github.com/CiscoDevNet/python-c8000v-aws-multit

Cloning into 'c8kv-aws-pmd-hash'...
remote: Enumerating objects: 82, done.
remote: Counting objects: 100% (82/82), done.
remote: Compressing objects: 100% (59/59), done.
remote: Total 82 (delta 34), reused 57 (delta 19), pack-reused 0
Receiving objects: 100% (82/82), 13.01 KiB | 2.60 MiB/s, done.
Resolving deltas: 100% (34/34), done.
```

Once repository has been cloned, navigate to the 'c8kv-aws-pmd-hash' folder. Since this is located in the virtual environment created, install the latest version of PIP.

```
(c8kv-hash) user@computer c8kv-hash % cd c8kv-aws-pmd-hash
(c8kv-hash) user@computer c8kv-aws-pmd-hash % python3 -m pip install --upgrade pip

Requirement already satisfied: pip in /Users/name/Desktop/c8kv-hash/lib/python3.9/site-packages (21.2.4)
Collecting pip
```

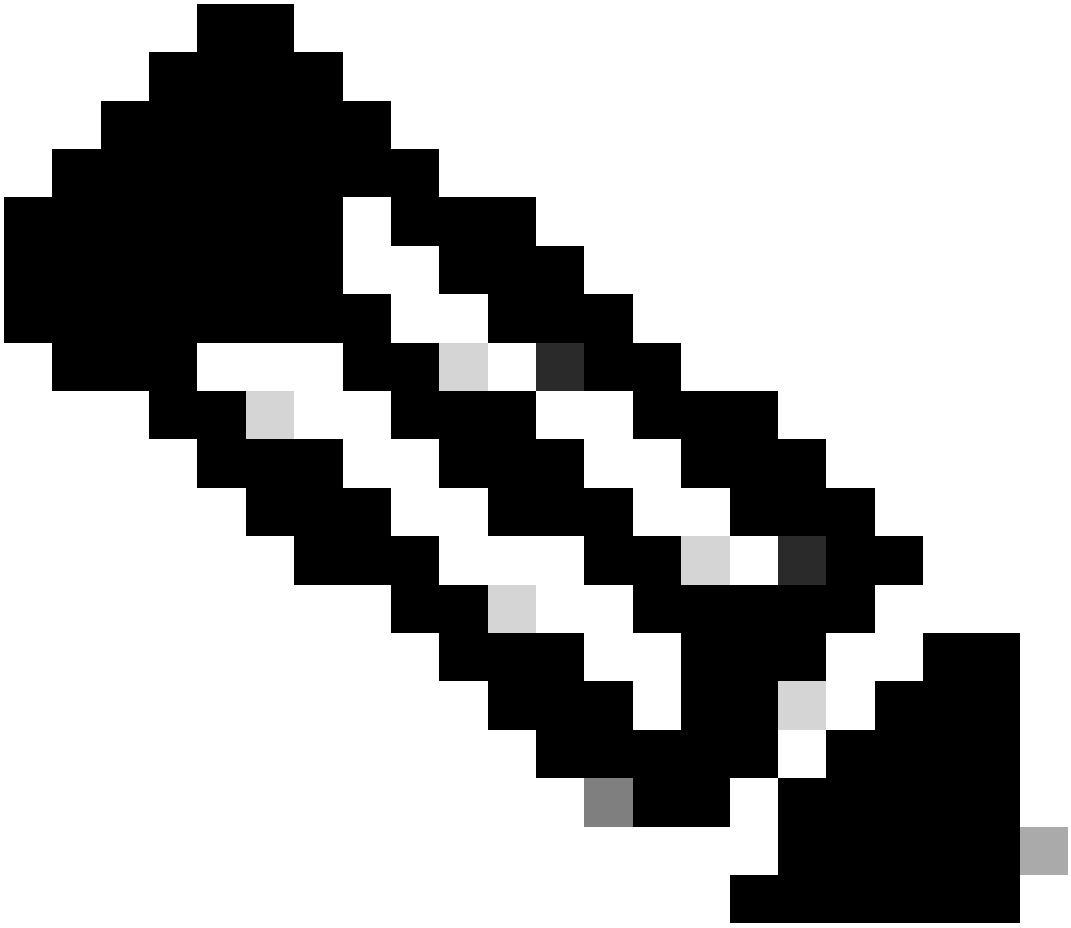
```
  Downloading pip-23.3.1-py3-none-any.whl (2.1 MB)
     |████████████████████████████████| 2.1 MB 2.7 MB/s
Installing collected packages: pip
  Attempting uninstall: pip
    Found existing installation: pip 21.2.4
    Uninstalling pip-21.2.4:
      Successfully uninstalled pip-21.2.4
Successfully installed pip-23.3.1
```

Once PIP has been upgraded, install the dependencies found in the requirements.txt file in the folder.

```
(c8kv-hash) user@computer c8kv-aws-pmd-hash % pip install -r requirements.txt
Collecting crc32c==2.3 (from -r requirements.txt (line 1))
  Downloading crc32c-2.3-cp39-cp39-macosx_11_0_arm64.whl (27 kB)
Installing collected packages: crc32c
Successfully installed crc32c-2.3
```

The virtual environment is now up to date and can be used to generate the IP address scheme for Multi-TxQ.

Calculate IP Address Scheme Using Python Hash Index Script for 17.7 and 17.8 releases (Deprecating)



Note: 7.7 AND 17.8 HASH SCRIPTS ARE TO BE DEPRECATED SOON. IT IS HIGHLY RECOMMENDED TO USE 17.9 HASH SCRIPT

Summary of commands:

- python3 c8kv_multitxq_hash.py --old_crc 1 --dest_network 192.168.1.0/24 --src_network 192.168.2.0/24 --unique_hash 1

'--old_crc 1' generates hash index based on 17.7 and 17.8 release with modulo 8 to match the supported PMD TXQ (do NOT modify)

'--dest_network' defines the destination network address subnet (modify based on your network IP address scheme)

'--src_network' defines the source network address subnet (modify based on your network IP address scheme)

'--unique_hash 1' generates one set (8 pairs for 8 TXQs) of uniquely hashed IP addresses. This can be modified.

<#root>

```
(c8kv-hash) user@computer c8kv-aws-pmd-hash % python3 c8kv_multitxq_hash.py --old_crc 1 --dest_network
```

```
Dest:            Src:             Prot  dstport  srcport          Hash: Rev-hash:

192.168.1.0      192.168.2.0      2     5
192.168.1.0      192.168.2.1      2     7
192.168.1.0      192.168.2.2      2     1
192.168.1.0      192.168.2.3      2     3
192.168.1.0      192.168.2.4      2     5
192.168.1.0      192.168.2.5      2     7
192.168.1.0      192.168.2.6      2     1
192.168.1.0      192.168.2.7      2     3
192.168.1.0      192.168.2.8      2     5
192.168.1.0      192.168.2.9      2     7
192.168.1.0      192.168.2.10     2     1
.
. ### trimmed output ###
.
192.168.1.255    192.168.2.247    5     2
192.168.1.255    192.168.2.248    5     4
192.168.1.255    192.168.2.249    5     6
192.168.1.255    192.168.2.250    5     0
192.168.1.255    192.168.2.251    5     2
192.168.1.255    192.168.2.252    5     4
192.168.1.255    192.168.2.253    5     6
192.168.1.255    192.168.2.254    5     0
192.168.1.255    192.168.2.255    5     2

Unique hash:

------ Tunnels set 0 ---------

192.168.1.37<===>192.168.2.37<===>0


192.168.1.129<===>192.168.2.129<===>1


192.168.1.36<===>192.168.2.36<===>2


192.168.1.128<===>192.168.2.128<===>3


192.168.1.39<===>192.168.2.39<===>4


192.168.1.131<===>192.168.2.131<===>5


192.168.1.38<===>192.168.2.38<===>6


192.168.1.130<===>192.168.2.130<===>7
```

Calculate IP Address Scheme Using Python Hash Index Script for 17.9 and Later Releases

Summary of commands:

- python3 c8kv_multitxq_hash.py --dest_network 192.168.1.0/24 --src_network 192.168.2.0/24 --prot udp --src_port 12346 --dst_port 12346 --unique_hash 1

Note that in IOS® XE release 17.9 and later, the script uses modulo 12 without the --old_crc option, matching the supported PMD TXQ.

'--dest_network' defines the destination network address subnet (modify based on your network IP address scheme)

'--src_network' defines the source network address subnet (modify based on your network IP address scheme)

'--prot udp' define the protocol used. The user can specify the protocol parameter as "gre" or "tcp" or "udp" or any decimal value (OPTIONAL)

'--src_port' defines the source port used (OPTIONAL)

'--dst_port' defines the destination port used (OPTIONAL)

'--unique_hash 1' generates one set (12 pairs for 12 TXQs) of uniquely hashed IP addresses. This can be modified.

<#root>

```
(c8kv-hash) user@computer c8kv-aws-pmd-hash % python3 c8kv_multitxq_hash.py --dest_network 192.168.1.0/

Dest:            Src:             Prot  dstport  srcport          Hash: Rev-hash:

192.168.1.0      192.168.2.0      17    12346    12346       ==>    4        4       <-- Unique Hash Va
192.168.1.0      192.168.2.1      17    12346    12346       ==>    4        4
192.168.1.0      192.168.2.2      17    12346    12346       ==>    8        8       <-- Unique Hash Va
192.168.1.0      192.168.2.3      17    12346    12346       ==>    0        0       <-- Unique Hash Va
192.168.1.0      192.168.2.4      17    12346    12346       ==>    0        0
192.168.1.0      192.168.2.5      17    12346    12346       ==>    0        0
192.168.1.0      192.168.2.6      17    12346    12346       ==>    4        4
192.168.1.0      192.168.2.7      17    12346    12346       ==>    0        0
192.168.1.0      192.168.2.8      17    12346    12346       ==>    9        9       <-- Unique Hash Va
192.168.1.0      192.168.2.9      17    12346    12346       ==>    9        9
192.168.1.0      192.168.2.10     17    12346    12346       ==>    9        9
192.168.1.0      192.168.2.11     17    12346    12346       ==>    1        1       <-- Unique Hash Va
192.168.1.0      192.168.2.12     17    12346    12346       ==>    1        1
.
. ### trimmed output ###
.
192.168.1.255    192.168.2.250    17    12346    12346       ==>    1        1
192.168.1.255    192.168.2.251    17    12346    12346       ==>    1        1
192.168.1.255    192.168.2.252    17    12346    12346       ==>    9        9
192.168.1.255    192.168.2.253    17    12346    12346       ==>    1        1
192.168.1.255    192.168.2.254    17    12346    12346       ==>    5        5       <-- Unique Hash Va
192.168.1.255    192.168.2.255    17    12346    12346       ==>    9        9

Unique hash:
```

```
------ Tunnels set 0 ---------

192.168.1.38 <===> 192.168.2.38<===>0

192.168.1.37 <===> 192.168.2.37<===>1

192.168.1.53 <===> 192.168.2.53<===>2

192.168.1.39 <===> 192.168.2.39<===>3

192.168.1.48 <===> 192.168.2.48<===>4

192.168.1.58 <===> 192.168.2.58<===>5

192.168.1.42 <===> 192.168.2.42<===>6

192.168.1.46 <===> 192.168.2.46<===>7

192.168.1.40 <===> 192.168.2.40<===>8

192.168.1.43 <===> 192.168.2.43<===>9

192.168.1.36 <===> 192.168.2.36<===>10

192.168.1.56 <===> 192.168.2.56<===>11
```

Sample Topology and CLI Configuration Using 8 TXQs with Loopback Interfaces

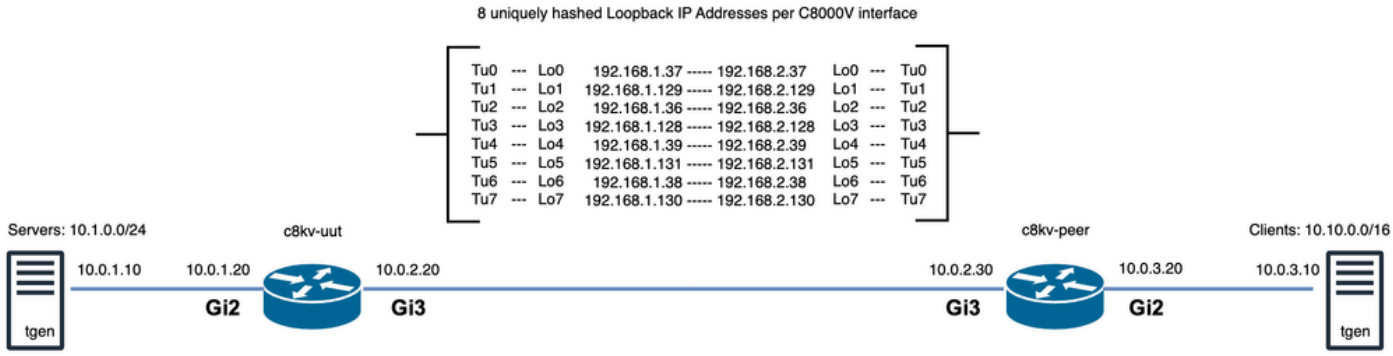


Figure 3: Sample topology that uses eight TxQs using Loopback interfaces.

This is a sample CLI configuration for 'c8kv-uut' (Figure 3) that creates eight IPsec tunnels with Loopback interfaces using the calculated hashed IP addresses (192.168.1.X) from the previous section.

A similar configuration would apply on the other router endpoint (c8kv-peer) with the remaining eight calculated hashed IP addresses (192.168.2.X).

```
ip cef load-sharing algorithm include-ports source destination 00ABC123

crypto keyring tunnel0
  local-address Loopback0
  pre-shared-key address 192.168.2.37 key cisco
crypto keyring tunnel1
  local-address Loopback1
  pre-shared-key address 192.168.2.129 key cisco
crypto keyring tunnel2
  local-address Loopback2
  pre-shared-key address 192.168.2.36 key cisco
crypto keyring tunnel3
  local-address Loopback3
  pre-shared-key address 192.168.2.128 key cisco
crypto keyring tunnel4
  local-address Loopback4
  pre-shared-key address 192.168.2.39 key cisco
crypto keyring tunnel5
  local-address Loopback5
  pre-shared-key address 192.168.2.131 key cisco
crypto keyring tunnel6
  local-address Loopback6
  pre-shared-key address 192.168.2.38 key cisco
crypto keyring tunnel7
  local-address Loopback7
  pre-shared-key address 192.168.2.130 key cisco

crypto isakmp policy 200
 encryption aes
 hash sha
 authentication pre-share
 group 16
 lifetime 28800

crypto isakmp profile isakmp-tunnel0
   keyring tunnel0
```

```
   match identity address 0.0.0.0
   local-address Loopback0
crypto isakmp profile isakmp-tunnel1
   keyring tunnel1
   match identity address 0.0.0.0
   local-address Loopback1
crypto isakmp profile isakmp-tunnel2
   keyring tunnel2
   match identity address 0.0.0.0
   local-address Loopback2
crypto isakmp profile isakmp-tunnel3
   keyring tunnel3
   match identity address 0.0.0.0
   local-address Loopback3
crypto isakmp profile isakmp-tunnel4
   keyring tunnel4
   match identity address 0.0.0.0
   local-address Loopback4
crypto isakmp profile isakmp-tunnel5
   keyring tunnel5
   match identity address 0.0.0.0
   local-address Loopback5
crypto isakmp profile isakmp-tunnel6
   keyring tunnel6
   match identity address 0.0.0.0
   local-address Loopback6
crypto isakmp profile isakmp-tunnel7
   keyring tunnel7
   match identity address 0.0.0.0
   local-address Loopback7

crypto ipsec transform-set ipsec-prop-vpn-tunnel esp-gcm 256
 mode tunnel
crypto ipsec df-bit clear

crypto ipsec profile ipsec-vpn-tunnel
 set transform-set ipsec-prop-vpn-tunnel
 set pfs group16

interface Loopback0
 ip address 192.168.1.37 255.255.255.255
!
interface Loopback1
 ip address 192.168.1.129 255.255.255.255
!
interface Loopback2
 ip address 192.168.1.36 255.255.255.255
!
interface Loopback3
 ip address 192.168.1.128 255.255.255.255
!
interface Loopback4
 ip address 192.168.1.39 255.255.255.255
!
interface Loopback5
 ip address 192.168.1.131 255.255.255.255
!
interface Loopback6
 ip address 192.168.1.38 255.255.255.255
!
interface Loopback7
 ip address 192.168.1.130 255.255.255.255
```

```
!

interface Tunnel0
 ip address 10.101.100.101 255.255.255.0
 load-interval 30
 tunnel source Loopback0
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.37
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel1
 ip address 10.101.101.101 255.255.255.0
 load-interval 30
 tunnel source Loopback1
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.129
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel2
 ip address 10.101.102.101 255.255.255.0
 load-interval 30
 tunnel source Loopback2
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.36
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel3
 ip address 10.101.103.101 255.255.255.0
 load-interval 30
 tunnel source Loopback3
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.128
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel4
 ip address 10.101.104.101 255.255.255.0
 load-interval 30
 tunnel source Loopback4
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.39
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel5
 ip address 10.101.105.101 255.255.255.0
 load-interval 30
 tunnel source Loopback5
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.131
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel6
 ip address 10.101.106.101 255.255.255.0
 load-interval 30
 tunnel source Loopback6
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.38
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel7
 ip address 10.101.107.101 255.255.255.0
 load-interval 30
 tunnel source Loopback7
```

```
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.130
 tunnel protection ipsec profile ipsec-vpn-tunnel
!


interface GigabitEthernet2
 mtu 9216
 ip address dhcp
 load-interval 30
 speed 25000
 no negotiation auto
 no mop enabled
 no mop sysid
!
interface GigabitEthernet3
 mtu 9216
 ip address dhcp
 load-interval 30
 speed 25000
 no negotiation auto
 no mop enabled
 no mop sysid
!

 !  ### IP route from servers to c8kv-uut

ip route 10.1.0.0 255.255.0.0 GigabitEthernet2 10.0.1.10

!  ### IP routes from c8kv-uut to clients on c8kv-peer side, routes are evenly distributed to all 8 TXQ

ip route 10.10.0.0 255.255.0.0 Tunnel0
ip route 10.10.0.0 255.255.0.0 Tunnel1
ip route 10.10.0.0 255.255.0.0 Tunnel2
ip route 10.10.0.0 255.255.0.0 Tunnel3
ip route 10.10.0.0 255.255.0.0 Tunnel4
ip route 10.10.0.0 255.255.0.0 Tunnel5
ip route 10.10.0.0 255.255.0.0 Tunnel6
ip route 10.10.0.0 255.255.0.0 Tunnel7

 !  ### IP route from c8kv-uut Loopback int tunnel endpoint to c8kv-peer Loopback int tunnel endpoints

ip route 192.168.2.0 255.255.255.0 GigabitEthernet3 10.0.2.30
```

Sample Topology and CLI Configuration Using 12 TXQs with Loopback Interfaces

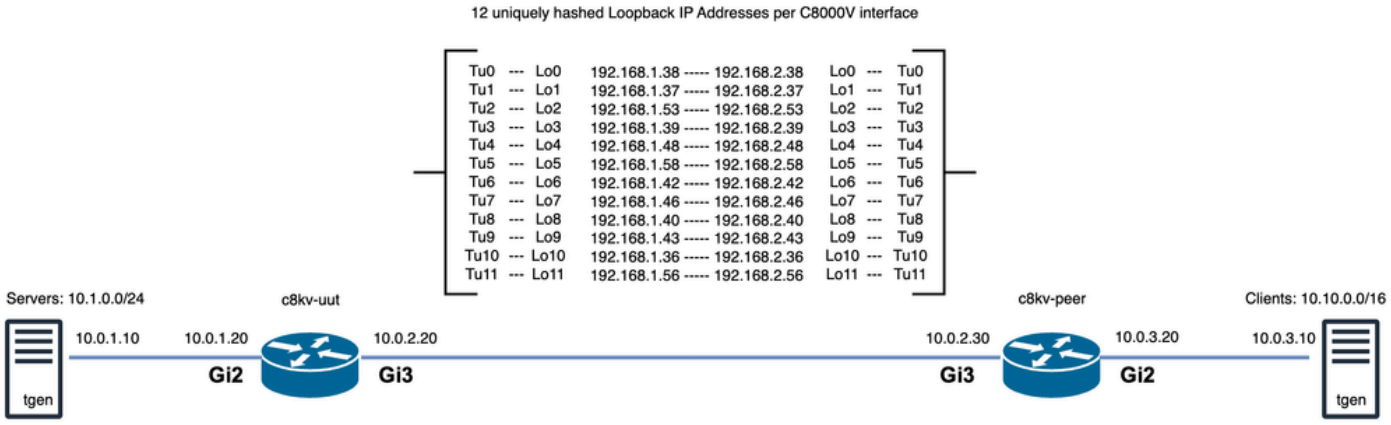


Figure 4. Sample topology that uses twelve TxQs using Loopback interfaces.

This is a sample CLI configuration for 'c8kv-uut' (Figure 4) that creates twelve IPsec tunnels with Loopback interfaces using the calculated hashed IP addresses (192.168.1.X) from the previous section.

A similar configuration would apply on the other router endpoint (c8kv-peer) with the remaining eight calculated hashed IP addresses (192.168.2.X).

```
ip cef load-sharing algorithm include-ports source destination 00ABC123

crypto keyring tunnel0
  local-address Loopback0
  pre-shared-key address 192.168.2.38 key cisco
crypto keyring tunnel1
  local-address Loopback1
  pre-shared-key address 192.168.2.37 key cisco
crypto keyring tunnel2
  local-address Loopback2
  pre-shared-key address 192.168.2.53 key cisco
crypto keyring tunnel3
  local-address Loopback3
  pre-shared-key address 192.168.2.39 key cisco
crypto keyring tunnel4
  local-address Loopback4
  pre-shared-key address 192.168.2.48 key cisco
crypto keyring tunnel5
  local-address Loopback5
  pre-shared-key address 192.168.2.58 key cisco
crypto keyring tunnel6
  local-address Loopback6
  pre-shared-key address 192.168.2.42 key cisco
crypto keyring tunnel7
  local-address Loopback7
  pre-shared-key address 192.168.2.46 key cisco
crypto keyring tunnel8
  local-address Loopback8
  pre-shared-key address 192.168.2.40 key cisco
crypto keyring tunnel9
  local-address Loopback9
  pre-shared-key address 192.168.2.43 key cisco
crypto keyring tunnel10
  local-address Loopback10
  pre-shared-key address 192.168.2.36 key cisco
```

```
crypto keyring tunnel11
  local-address Loopback11
  pre-shared-key address 192.168.2.56 key cisco


crypto isakmp policy 200
 encryption aes
 hash sha
 authentication pre-share
 group 16
 lifetime 28800
crypto isakmp profile isakmp-tunnel0
   keyring tunnel0
   match identity address 0.0.0.0
   local-address Loopback0
crypto isakmp profile isakmp-tunnel1
   keyring tunnel1
   match identity address 0.0.0.0
   local-address Loopback1
crypto isakmp profile isakmp-tunnel2
   keyring tunnel2
   match identity address 0.0.0.0
   local-address Loopback2
crypto isakmp profile isakmp-tunnel3
   keyring tunnel3
   match identity address 0.0.0.0
   local-address Loopback3
crypto isakmp profile isakmp-tunnel4
   keyring tunnel4
   match identity address 0.0.0.0
   local-address Loopback4
crypto isakmp profile isakmp-tunnel5
   keyring tunnel5
   match identity address 0.0.0.0
   local-address Loopback5
crypto isakmp profile isakmp-tunnel6
   keyring tunnel6
   match identity address 0.0.0.0
   local-address Loopback6
crypto isakmp profile isakmp-tunnel7
   keyring tunnel7
   match identity address 0.0.0.0
   local-address Loopback7
crypto isakmp profile isakmp-tunnel8
   keyring tunnel8
   match identity address 0.0.0.0
   local-address Loopback8
crypto isakmp profile isakmp-tunnel9
   keyring tunnel9
   match identity address 0.0.0.0
   local-address Loopback9
crypto isakmp profile isakmp-tunnel10
   keyring tunnel10
   match identity address 0.0.0.0
   local-address Loopback10
crypto isakmp profile isakmp-tunnel11
   keyring tunnel11
   match identity address 0.0.0.0
   local-address Loopback11

crypto ipsec transform-set ipsec-prop-vpn-tunnel esp-gcm 256
 mode tunnel
```

```
crypto ipsec df-bit clear

crypto ipsec profile ipsec-vpn-tunnel
 set transform-set ipsec-prop-vpn-tunnel
 set pfs group16

interface Loopback0
 ip address 192.168.1.38 255.255.255.255
!
interface Loopback1
 ip address 192.168.1.37 255.255.255.255
!
interface Loopback2
 ip address 192.168.1.53 255.255.255.255
!
interface Loopback3
 ip address 192.168.1.39 255.255.255.255
!
interface Loopback4
 ip address 192.168.1.48 255.255.255.255
!
interface Loopback5
 ip address 192.168.1.58 255.255.255.255
!
interface Loopback6
 ip address 192.168.1.42 255.255.255.255
!
interface Loopback7
 ip address 192.168.1.46 255.255.255.255
!
interface Loopback8
 ip address 192.168.1.40 255.255.255.255
!
interface Loopback9
 ip address 192.168.1.43 255.255.255.255
!
interface Loopback10
 ip address 192.168.1.36 255.255.255.255
!
interface Loopback11
 ip address 192.168.1.56 255.255.255.255

interface Tunnel0
 ip address 10.101.100.101 255.255.255.0
 load-interval 30
 tunnel source Loopback0
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.38
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel1
 ip address 10.101.101.101 255.255.255.0
 load-interval 30
 tunnel source Loopback1
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.37
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel2
 ip address 10.101.102.101 255.255.255.0
 load-interval 30
 tunnel source Loopback2
```

```
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.53
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel3
 ip address 10.101.103.101 255.255.255.0
 load-interval 30
 tunnel source Loopback3
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.39
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel4
 ip address 10.101.104.101 255.255.255.0
 load-interval 30
 tunnel source Loopback4
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.48
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel5
 ip address 10.101.105.101 255.255.255.0
 load-interval 30
 tunnel source Loopback5
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.58
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel6
 ip address 10.101.106.101 255.255.255.0
 load-interval 30
 tunnel source Loopback6
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.42
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel7
 ip address 10.101.107.101 255.255.255.0
 load-interval 30
 tunnel source Loopback7
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.46
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel8
 ip address 10.101.108.101 255.255.255.0
 load-interval 30
 tunnel source Loopback8
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.40
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel9
 ip address 10.101.109.101 255.255.255.0
 load-interval 30
 tunnel source Loopback9
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.43
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel10
 ip address 10.101.110.101 255.255.255.0
```

```
 load-interval 30
 tunnel source Loopback10
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.36
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel11
 ip address 10.101.111.101 255.255.255.0
 load-interval 30
 tunnel source Loopback11
 tunnel mode ipsec ipv4
 tunnel destination 192.168.2.56
 tunnel protection ipsec profile ipsec-vpn-tunnel


interface GigabitEthernet2
 mtu 9216
 ip address dhcp
 load-interval 30
 speed 25000
 no negotiation auto
 no mop enabled
 no mop sysid
!
interface GigabitEthernet3
 mtu 9216
 ip address dhcp
 load-interval 30
 speed 25000
 no negotiation auto
 no mop enabled
 no mop sysid
!

  !  ### IP route from c8kv-uut to local servers

ip route 10.1.0.0 255.255.0.0 GigabitEthernet2 10.0.1.10

!  ### IP routes from c8kv-uut to clients on c8kv-peer side, routes are evenly distributed to all 12 TX

ip route 10.10.0.0 255.255.0.0 Tunnel0
ip route 10.10.0.0 255.255.0.0 Tunnel1
ip route 10.10.0.0 255.255.0.0 Tunnel2
ip route 10.10.0.0 255.255.0.0 Tunnel3
ip route 10.10.0.0 255.255.0.0 Tunnel4
ip route 10.10.0.0 255.255.0.0 Tunnel5
ip route 10.10.0.0 255.255.0.0 Tunnel6
ip route 10.10.0.0 255.255.0.0 Tunnel7
ip route 10.10.0.0 255.255.0.0 Tunnel8
ip route 10.10.0.0 255.255.0.0 Tunnel9
ip route 10.10.0.0 255.255.0.0 Tunnel10
ip route 10.10.0.0 255.255.0.0 Tunnel11

 !  ### IP route from c8kv-uut Loopback int tunnel endpoint to c8kv-peer Loopback int tunnel endpoints

ip route 192.168.2.0 255.255.255.0 GigabitEthernet3 10.0.2.30
```

Sample Topology and CLI Configuration Using 12 TXQs with

Secondary IP Addresses

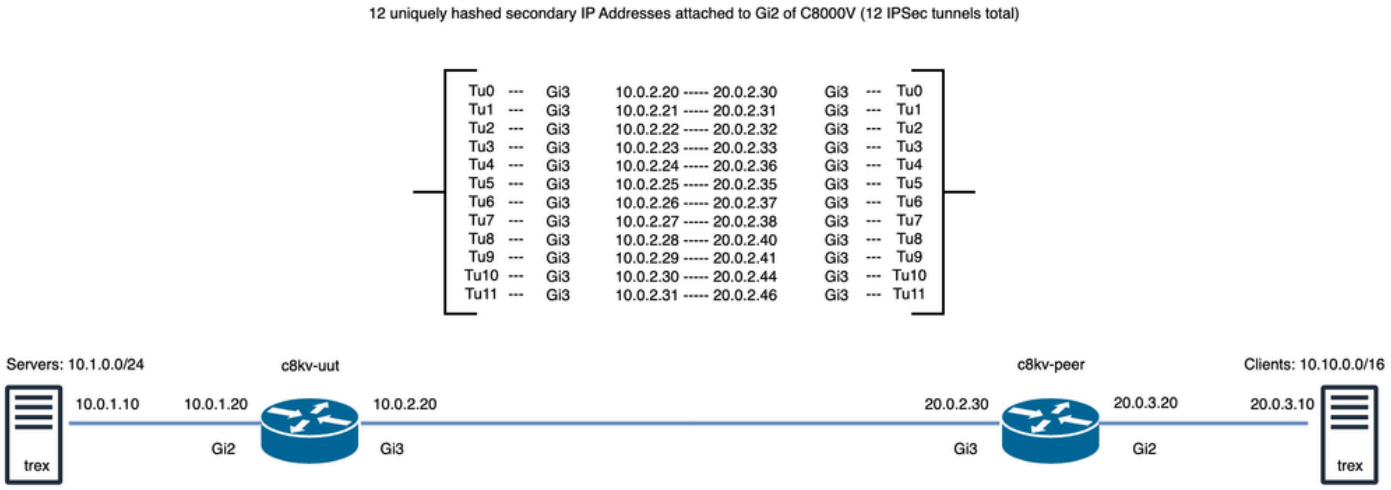
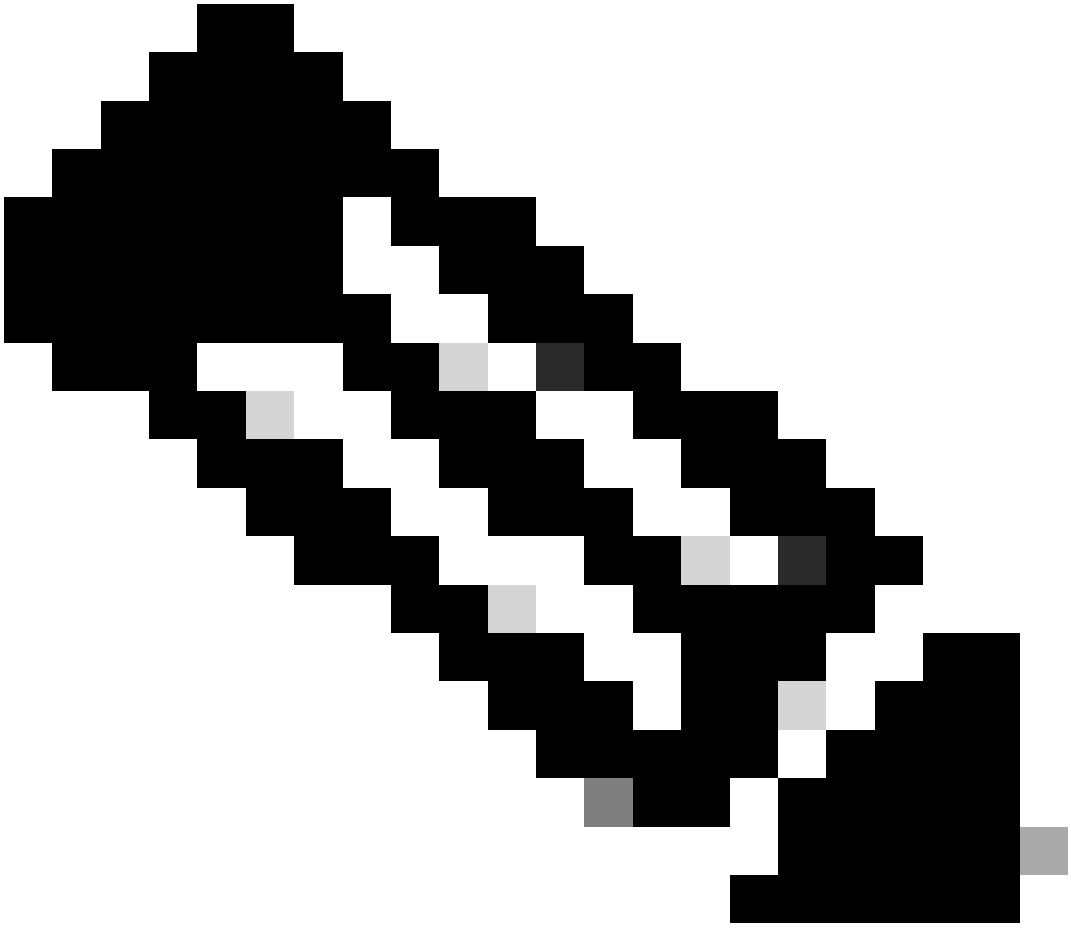


Figure 5. Sample topology that uses twelve TxQs using secondary IP addresses.

If Loopback addresses cannot be used in the AWS environment, then secondary IP addresses attached to the ENI can be used instead.

This is a sample CLI configuration for 'c8kv-uut' (Figure 5) that creates twelve IPsec tunnels with the source being 1 primary IP address + 11 secondary IP addresses attached to the GigabitEthernet3 interface using calculated hashed IP addresses (10.0.2.X). A similar configuration would apply on the other router endpoint (c8kv-peer) with the remaining twelve calculated hashed IP addresses (20.0.2.X).



Note: In this example we are using a second C8000V as the tunnel endpoint but other cloud networking endpoints such TGW or DX can be used as well.

```
ip cef load-sharing algorithm include-ports source destination 00ABC123

crypto keyring tunnel0
  local-address 10.0.2.20
  pre-shared-key address 20.0.2.30 key cisco
crypto keyring tunnel1
  local-address 10.0.2.21
  pre-shared-key address 20.0.2.31 key cisco
crypto keyring tunnel2
  local-address 10.0.2.22
  pre-shared-key address 20.0.2.32 key cisco
crypto keyring tunnel3
  local-address 10.0.2.23
  pre-shared-key address 20.0.2.33 key cisco
crypto keyring tunnel4
  local-address 10.0.2.24
  pre-shared-key address 20.0.2.36 key cisco
crypto keyring tunnel5
```

```
  local-address 10.0.2.25
  pre-shared-key address 20.0.2.35 key cisco
crypto keyring tunnel6
  local-address 10.0.2.26
  pre-shared-key address 20.0.2.37 key cisco
crypto keyring tunnel7
  local-address 10.0.2.27
  pre-shared-key address 20.0.2.38 key cisco
crypto keyring tunnel8
  local-address 10.0.2.28
  pre-shared-key address 20.0.2.40 key cisco
crypto keyring tunnel9
  local-address 10.0.2.29
  pre-shared-key address 20.0.2.41 key cisco
crypto keyring tunnel10
  local-address 10.0.2.30
  pre-shared-key address 20.0.2.44 key cisco
crypto keyring tunnel11
  local-address 10.0.2.31
  pre-shared-key address 20.0.2.46 key cisco


crypto isakmp policy 200
 encryption aes
 hash sha
 authentication pre-share
 group 16
 lifetime 28800
crypto isakmp profile isakmp-tunnel0
   keyring tunnel0
   match identity address 20.0.2.30 255.255.255.255
   local-address 10.0.2.20
crypto isakmp profile isakmp-tunnel1
   keyring tunnel1
   match identity address 20.0.2.31 255.255.255.255
   local-address 10.0.2.21
crypto isakmp profile isakmp-tunnel2
   keyring tunnel2
   match identity address 20.0.2.32 255.255.255.255
   local-address 10.0.2.22
crypto isakmp profile isakmp-tunnel3
   keyring tunnel3
   match identity address 20.0.2.33 255.255.255.255
   local-address 10.0.2.23
crypto isakmp profile isakmp-tunnel4
   keyring tunnel4
   match identity address 20.0.2.36 255.255.255.255
   local-address 10.0.2.24
crypto isakmp profile isakmp-tunnel5
   keyring tunnel5
   match identity address 20.0.2.35 255.255.255.255
   local-address 10.0.2.25
crypto isakmp profile isakmp-tunnel6
   keyring tunnel6
   match identity address 20.0.2.37 255.255.255.255
   local-address 10.0.2.26
crypto isakmp profile isakmp-tunnel7
   keyring tunnel7
   match identity address 20.0.2.38 255.255.255.255
   local-address 10.0.2.27
crypto isakmp profile isakmp-tunnel8
   keyring tunnel8
```

```
   match identity address 20.0.2.40 255.255.255.255
   local-address 10.0.2.28
crypto isakmp profile isakmp-tunnel9
   keyring tunnel9
   match identity address 20.0.2.41 255.255.255.255
   local-address 10.0.2.29
crypto isakmp profile isakmp-tunnel10
   keyring tunnel10
   match identity address 20.0.2.44 255.255.255.255
   local-address 10.0.2.30
crypto isakmp profile isakmp-tunnel11
   keyring tunnel11
   match identity address 20.0.2.46 255.255.255.255
   local-address 10.0.2.31


crypto ipsec transform-set ipsec-prop-vpn-tunnel esp-gcm 256
 mode tunnel
crypto ipsec df-bit clear

crypto ipsec profile ipsec-vpn-tunnel
 set transform-set ipsec-prop-vpn-tunnel
 set pfs group16

interface Tunnel0
 ip address 10.101.100.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.20
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.30
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel1
 ip address 10.101.101.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.21
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.31
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel2
 ip address 10.101.102.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.22
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.32
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel3
 ip address 10.101.103.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.23
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.33
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel4
 ip address 10.101.104.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.24
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.36
```

```
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel5
 ip address 10.101.105.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.25
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.35
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel6
 ip address 10.101.106.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.26
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.37
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel7
 ip address 10.101.107.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.27
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.38
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel8
 ip address 10.101.108.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.28
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.40
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel9
 ip address 10.101.109.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.29
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.41
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel10
 ip address 10.101.110.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.30
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.44
 tunnel protection ipsec profile ipsec-vpn-tunnel
!
interface Tunnel11
 ip address 10.101.111.101 255.255.255.0
 load-interval 30
 tunnel source 10.0.2.31
 tunnel mode ipsec ipv4
 tunnel destination 20.0.2.46
 tunnel protection ipsec profile ipsec-vpn-tunnel
!


interface GigabitEthernet2
 mtu 9216
```

```
 ip address dhcp
 load-interval 30
 speed 25000
 no negotiation auto
 no mop enabled
 no mop sysid
!
interface GigabitEthernet3
 mtu 9216
 ip address 10.0.2.20 255.255.255.0
 ip address 10.0.2.21 255.255.255.0 secondary
 ip address 10.0.2.22 255.255.255.0 secondary
 ip address 10.0.2.23 255.255.255.0 secondary
 ip address 10.0.2.24 255.255.255.0 secondary
 ip address 10.0.2.25 255.255.255.0 secondary
 ip address 10.0.2.26 255.255.255.0 secondary
 ip address 10.0.2.27 255.255.255.0 secondary
 ip address 10.0.2.28 255.255.255.0 secondary
 ip address 10.0.2.29 255.255.255.0 secondary
 ip address 10.0.2.30 255.255.255.0 secondary
 ip address 10.0.2.31 255.255.255.0 secondary
 load-interval 30
 speed 25000
 no negotiation auto
 no mop enabled
 no mop sysid
!

  !  ### IP route from c8kv-uut to local servers

ip route 10.1.0.0 255.255.255.0 GigabitEthernet2 10.0.1.10

!  ### IP routes from c8kv-uut to clients on c8kv-peer side, routes are evenly distributed to all 12 TX

ip route 10.10.0.0 255.255.0.0 Tunnel0
ip route 10.10.0.0 255.255.0.0 Tunnel1
ip route 10.10.0.0 255.255.0.0 Tunnel2
ip route 10.10.0.0 255.255.0.0 Tunnel3
ip route 10.10.0.0 255.255.0.0 Tunnel4
ip route 10.10.0.0 255.255.0.0 Tunnel5
ip route 10.10.0.0 255.255.0.0 Tunnel6
ip route 10.10.0.0 255.255.0.0 Tunnel7
ip route 10.10.0.0 255.255.0.0 Tunnel8
ip route 10.10.0.0 255.255.0.0 Tunnel9
ip route 10.10.0.0 255.255.0.0 Tunnel10
ip route 10.10.0.0 255.255.0.0 Tunnel11


!  ### IP route from c8kv-uut Gi3 int tunnel endpoint to c8kv-peer Gi3

int tunnel endpoints (secondary IP addresses on c8kv-peer side)

ip route 20.0.2.30 255.255.255.255 10.0.2.1
ip route 20.0.2.31 255.255.255.255 10.0.2.1
ip route 20.0.2.32 255.255.255.255 10.0.2.1
ip route 20.0.2.33 255.255.255.255 10.0.2.1
ip route 20.0.2.36 255.255.255.255 10.0.2.1
ip route 20.0.2.35 255.255.255.255 10.0.2.1
ip route 20.0.2.37 255.255.255.255 10.0.2.1
ip route 20.0.2.38 255.255.255.255 10.0.2.1
ip route 20.0.2.40 255.255.255.255 10.0.2.1
ip route 20.0.2.41 255.255.255.255 10.0.2.1
```

```
ip route 20.0.2.44 255.255.255.255 10.0.2.1
ip route 20.0.2.46 255.255.255.255 10.0.2.1
```

Typical Catalyst 8000V Deployment in AWS

Autonomous Mode

Please see the previous sample CLI configurations and topologies. CLI configuration can be copied and modified based on network addressing scheme and hashed IP addresses generated.

For successful tunnel creation, be sure to create IP routes both on the C8000V and routing tables on AWS VPC.

SD-WAN Mode

This is an example topology and SD-WAN configuration that creates TLOCs using Loopback interfaces on C8000Vs located in an AWS VPC.

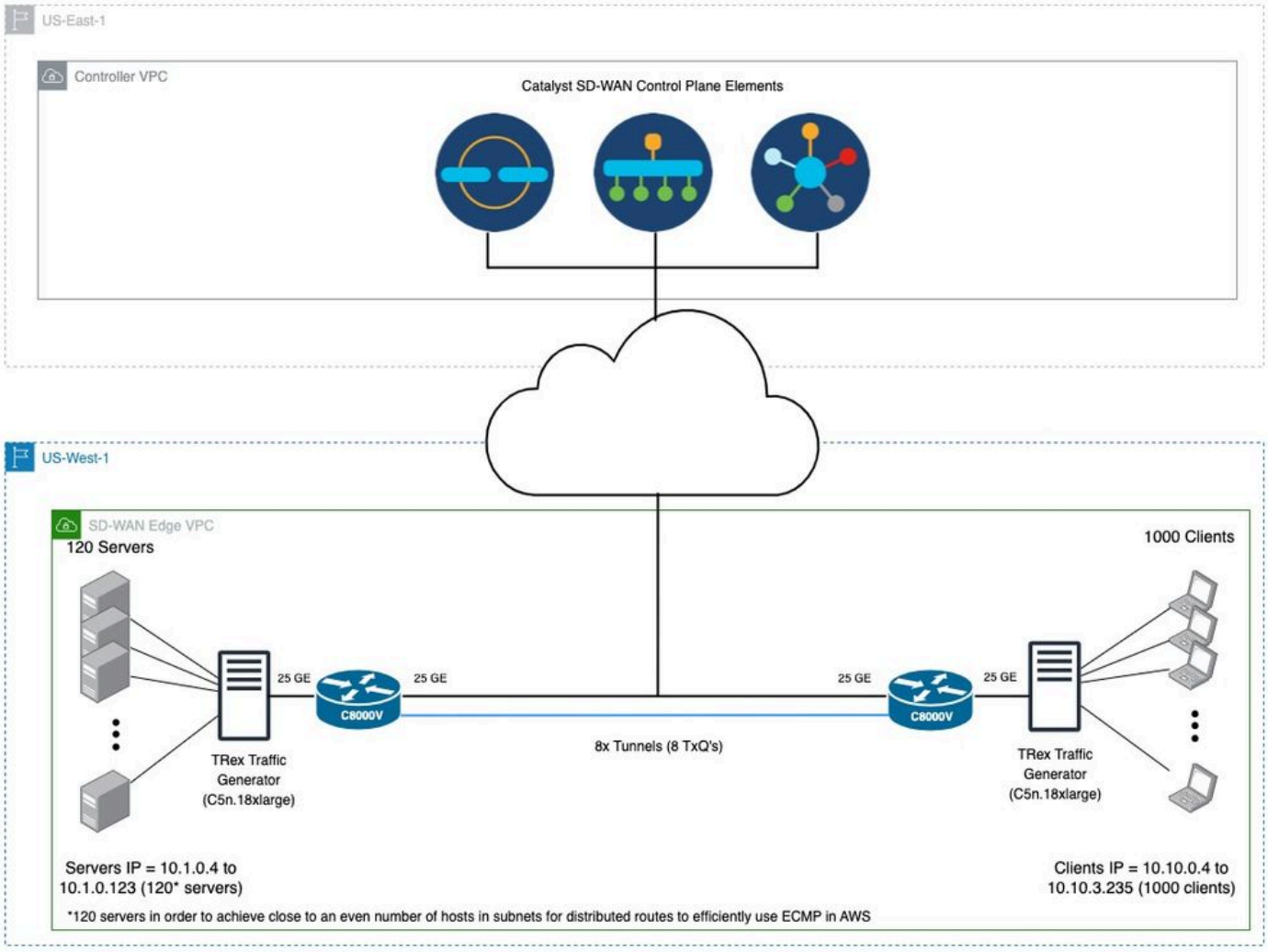
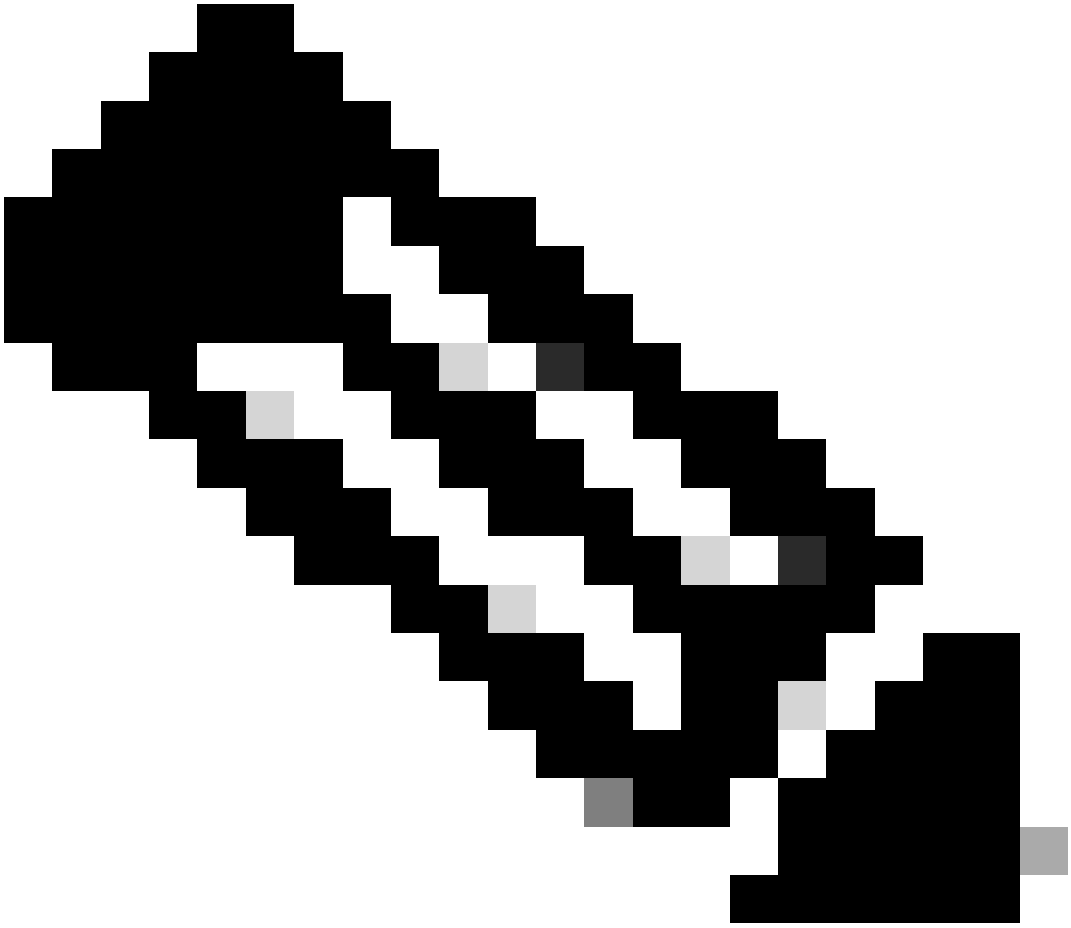


Figure 6. Sample SD-WAN topology that uses TLOCs with Loopback interfaces on C8000Vs located in an AWS VPC.



Note: In Figure 6, the black-colored connection represents Control (VPN0) connection between SD-WAN control plane elements and SD-WAN edge devices. Blue-colored connections represent tunnels between the two SD-WAN edge devices using TLOCs.

You can find a sample SD-WAN CLI configuration for Figure 6 (here).

```
csr_uut#show sdwan run
system
system-ip             29.173.249.161
site-id               5172
admin-tech-on-failure
sp-organization-name  SP_ORG_NAME
organization-name     ORG_NAME
upgrade-confirm       15
vbond X.X.X.X
!
memory free low-watermark processor 68484
service timestamps debug datetime msec
service timestamps log datetime msec
no service tcp-small-servers
```

```
no service udp-small-servers
platform console virtual
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname csr_uut
username ec2-user privilege 15 secret 5 $1$4P16$..ag88eFsOMLIemjNcWSt0
vrf definition 11
address-family ipv4
exit-address-family
!
address-family ipv6
exit-address-family
!
!
vrf definition Mgmt-intf
address-family ipv4
exit-address-family
!
address-family ipv6
exit-address-family
!
!
no ip finger
no ip rcmd rcp-enable
no ip rcmd rsh-enable
no ip dhcp use class
ip route 0.0.0.0 0.0.0.0 X.X.X.X
ip route 0.0.0.0 0.0.0.0 X.X.X.X
ip route 0.0.0.0 0.0.0.0 X.X.X.X
ip route vrf 11 10.1.0.0 255.255.0.0 X.X.X.X
ip route vrf Mgmt-intf 0.0.0.0 0.0.0.0 X.X.X.X
no ip source-route
ip ssh pubkey-chain
username ec2-user
key-hash ssh-rsa 353158c28c7649710b3c933da02e384b ec2-user
!
!
!
no ip http server
ip http secure-server
ip nat settings central-policy
ip nat settings gatekeeper-size 1024
ipv6 unicast-routing
class-map match-any class0
match dscp 1
!
class-map match-any class1
match dscp 2
!
class-map match-any class2
match dscp 3
!
class-map match-any class3
match dscp 4
!
class-map match-any class4
match dscp 5
!
class-map match-any class5
match dscp 6
!
class-map match-any class6
```

```
match dscp 7
!
class-map match-any class7
match dscp 8
!
policy-map qos_map1
class class0
priority percent 20
!
class class1
bandwidth percent 18
random-detect
!
class class2
bandwidth percent 15
random-detect
!
class class3
bandwidth percent 12
random-detect
!
class class4
bandwidth percent 10
random-detect
!
class class5
bandwidth percent 10
random-detect
!
class class6
bandwidth percent 10
random-detect
!
class class7
bandwidth percent 5
random-detect
!
!
interface GigabitEthernet1
no shutdown
ip address dhcp
no mop enabled
no mop sysid
negotiation auto
exit
interface GigabitEthernet2
no shutdown
ip address dhcp
load-interval 30
speed 10000
no negotiation auto
service-policy output qos_map1
exit
interface GigabitEthernet3
shutdown
ip address dhcp
load-interval 30
speed 10000
no negotiation auto
exit
interface GigabitEthernet4
no shutdown
```

```
vrf forwarding 11
ip address X.X.X.X 255.255.255.0
load-interval 30
speed 10000
no negotiation auto
exit
interface Loopback1
no shutdown
ip address 192.168.1.21 255.255.255.255
exit
interface Loopback2
no shutdown
ip address 192.168.1.129 255.255.255.255
exit
interface Loopback3
no shutdown
ip address 192.168.1.20 255.255.255.255
exit
interface Loopback4
no shutdown
ip address 192.168.1.128 255.255.255.255
exit
interface Loopback5
no shutdown
ip address 192.168.1.23 255.255.255.255
exit
interface Loopback6
no shutdown
ip address 192.168.1.131 255.255.255.255
exit
interface Loopback7
no shutdown
ip address 192.168.1.22 255.255.255.255
exit
interface Loopback8
no shutdown
ip address 192.168.1.130 255.255.255.255
exit
interface Tunnel1
no shutdown
ip unnumbered GigabitEthernet1
tunnel source GigabitEthernet1
tunnel mode sdwan
exit
interface Tunnel14095001
no shutdown
ip unnumbered Loopback1
no ip redirects
ipv6 unnumbered Loopback1
no ipv6 redirects
tunnel source Loopback1
tunnel mode sdwan
exit
interface Tunnel14095002
no shutdown
ip unnumbered Loopback2
no ip redirects
ipv6 unnumbered Loopback2
no ipv6 redirects
tunnel source Loopback2
tunnel mode sdwan
exit
```

```
interface Tunnel14095003
no shutdown
ip unnumbered Loopback3
no ip redirects
ipv6 unnumbered Loopback3
no ipv6 redirects
tunnel source Loopback3
tunnel mode sdwan
exit
interface Tunnel14095004
no shutdown
ip unnumbered Loopback4
no ip redirects
ipv6 unnumbered Loopback4
no ipv6 redirects
tunnel source Loopback4
tunnel mode sdwan
exit
interface Tunnel14095005
no shutdown
ip unnumbered Loopback5
no ip redirects
ipv6 unnumbered Loopback5
no ipv6 redirects
tunnel source Loopback5
tunnel mode sdwan
exit
interface Tunnel14095006
no shutdown
ip unnumbered Loopback6
no ip redirects
ipv6 unnumbered Loopback6
no ipv6 redirects
tunnel source Loopback6
tunnel mode sdwan
exit
interface Tunnel14095007
no shutdown
ip unnumbered Loopback7
no ip redirects
ipv6 unnumbered Loopback7
no ipv6 redirects
tunnel source Loopback7
tunnel mode sdwan
exit
interface Tunnel14095008
no shutdown
ip unnumbered Loopback8
no ip redirects
ipv6 unnumbered Loopback8
no ipv6 redirects
tunnel source Loopback8
tunnel mode sdwan
exit
no logging console
aaa authentication enable default enable
aaa authentication login default local
aaa authorization console
aaa authorization exec default local none
login on-success log
license smart transport smart
license smart url https://smartreceiver.cisco.com/licservice/license
```

```
line aux 0
!
line con 0
stopbits 1
!
line vty 0 4
transport input ssh
!
line vty 5 80
transport input ssh
!
sdwan
interface GigabitEthernet1
tunnel-interface
encapsulation ipsec
color private1 restrict
allow-service all
no allow-service bgp
allow-service dhcp
allow-service dns
allow-service icmp
no allow-service sshd
no allow-service netconf
no allow-service ntp
no allow-service ospf
no allow-service stun
allow-service https
no allow-service snmp
no allow-service bfd
exit
exit
interface GigabitEthernet2
exit
interface GigabitEthernet3
exit
interface Loopback1
tunnel-interface
encapsulation ipsec preference 150 weight 1
no border
color private2 restrict
no last-resort-circuit
no low-bandwidth-link
max-control-connections       0
no vbond-as-stun-server
vmanage-connection-preference 0
port-hop
carrier                       default
nat-refresh-interval          5
hello-interval                1000
hello-tolerance               12
bind                          GigabitEthernet2
no allow-service all
no allow-service bgp
allow-service dhcp
allow-service dns
allow-service icmp
no allow-service sshd
no allow-service netconf
no allow-service ntp
no allow-service ospf
no allow-service stun
allow-service https
```

```
no allow-service snmp
no allow-service bfd
exit
exit
interface Loopback2
tunnel-interface
encapsulation ipsec preference 150 weight 1
no border
color private3 restrict
no last-resort-circuit
no low-bandwidth-link
max-control-connections       0
no vbond-as-stun-server
vmanage-connection-preference 0
port-hop
carrier                       default
nat-refresh-interval          5
hello-interval                1000
hello-tolerance               12
bind                          GigabitEthernet2
no allow-service all
no allow-service bgp
allow-service dhcp
allow-service dns
allow-service icmp
no allow-service sshd
no allow-service netconf
no allow-service ntp
no allow-service ospf
no allow-service stun
allow-service https
no allow-service snmp
no allow-service bfd
exit
exit
interface Loopback3
tunnel-interface
encapsulation ipsec preference 150 weight 1
no border
color private4 restrict
no last-resort-circuit
no low-bandwidth-link
max-control-connections       0
no vbond-as-stun-server
vmanage-connection-preference 0
port-hop
carrier                       default
nat-refresh-interval          5
hello-interval                1000
hello-tolerance               12
bind                          GigabitEthernet2
allow-service all
no allow-service bgp
allow-service dhcp
allow-service dns
allow-service icmp
no allow-service sshd
no allow-service netconf
no allow-service ntp
no allow-service ospf
no allow-service stun
allow-service https
```

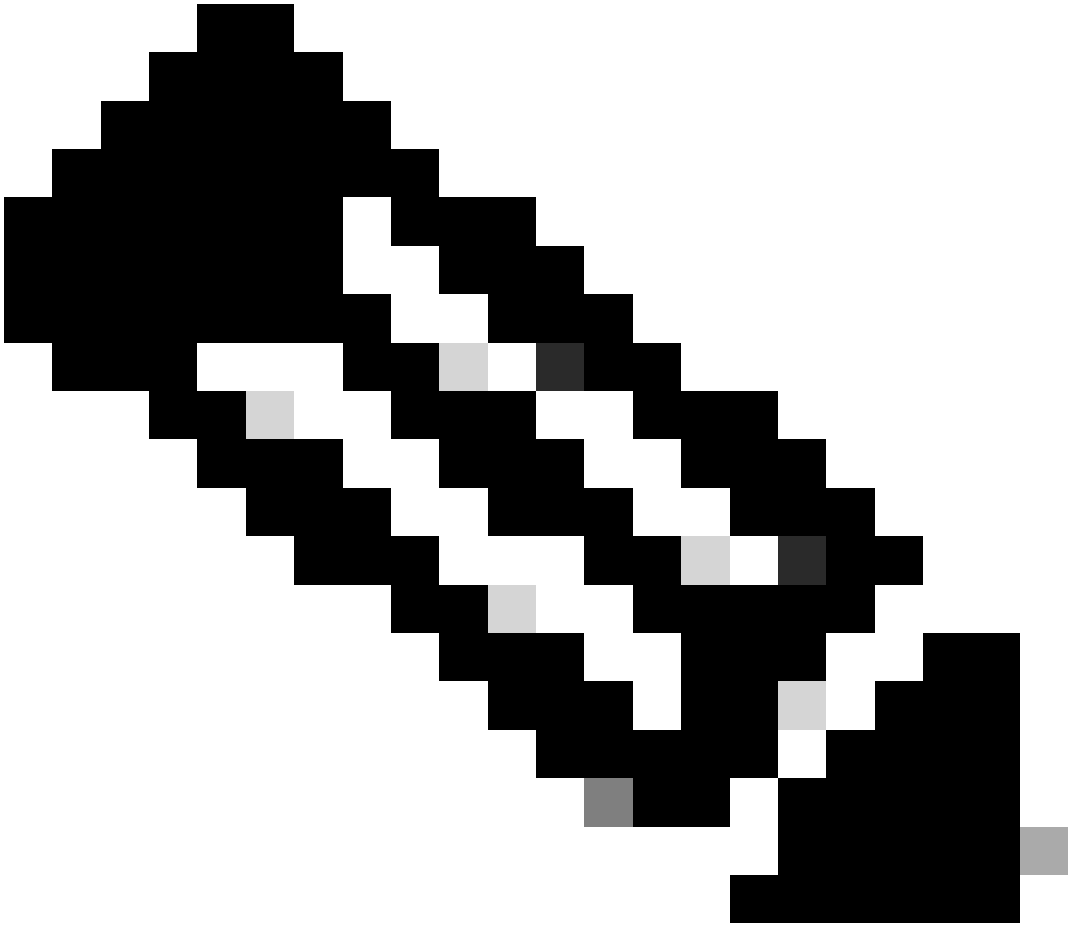
```
no allow-service snmp
no allow-service bfd
exit
exit
interface Loopback4
tunnel-interface
encapsulation ipsec preference 150 weight 1
no border
color private5 restrict
no last-resort-circuit
no low-bandwidth-link
max-control-connections       0
no vbond-as-stun-server
vmanage-connection-preference 0
port-hop
carrier                       default
nat-refresh-interval          5
hello-interval                1000
hello-tolerance               12
bind                          GigabitEthernet2
no allow-service all
no allow-service bgp
allow-service dhcp
allow-service dns
allow-service icmp
no allow-service sshd
no allow-service netconf
no allow-service ntp
no allow-service ospf
no allow-service stun
allow-service https
no allow-service snmp
no allow-service bfd
exit
exit
interface Loopback5
tunnel-interface
encapsulation ipsec preference 150 weight 1
no border
color private6 restrict
no last-resort-circuit
no low-bandwidth-link
max-control-connections       0
no vbond-as-stun-server
vmanage-connection-preference 0
port-hop
carrier                       default
nat-refresh-interval          5
hello-interval                1000
hello-tolerance               12
bind                          GigabitEthernet2
no allow-service all
no allow-service bgp
allow-service dhcp
allow-service dns
allow-service icmp
no allow-service sshd
no allow-service netconf
no allow-service ntp
no allow-service ospf
no allow-service stun
allow-service https
```

```
no allow-service snmp
no allow-service bfd
exit
exit
interface Loopback6
tunnel-interface
encapsulation ipsec preference 150 weight 1
no border
color red restrict
no last-resort-circuit
no low-bandwidth-link
max-control-connections       0
no vbond-as-stun-server
vmanage-connection-preference 0
port-hop
carrier                       default
nat-refresh-interval          5
hello-interval                1000
hello-tolerance               12
bind                          GigabitEthernet2
no allow-service all
no allow-service bgp
allow-service dhcp
allow-service dns
allow-service icmp
no allow-service sshd
no allow-service netconf
no allow-service ntp
no allow-service ospf
no allow-service stun
allow-service https
no allow-service snmp
no allow-service bfd
exit
exit
interface Loopback7
tunnel-interface
encapsulation ipsec preference 150 weight 1
no border
color blue restrict
no last-resort-circuit
no low-bandwidth-link
max-control-connections       0
no vbond-as-stun-server
vmanage-connection-preference 0
port-hop
carrier                       default
nat-refresh-interval          5
hello-interval                1000
hello-tolerance               12
bind                          GigabitEthernet2
no allow-service all
no allow-service bgp
allow-service dhcp
allow-service dns
allow-service icmp
no allow-service sshd
no allow-service netconf
no allow-service ntp
no allow-service ospf
no allow-service stun
allow-service https
```

```
no allow-service snmp
no allow-service bfd
exit
exit
interface Loopback8
tunnel-interface
encapsulation ipsec preference 150 weight 1
no border
color green restrict
no last-resort-circuit
no low-bandwidth-link
max-control-connections       0
no vbond-as-stun-server
vmanage-connection-preference 0
port-hop
carrier                       default
nat-refresh-interval          5
hello-interval                1000
hello-tolerance               12
bind                          GigabitEthernet2
no allow-service all
no allow-service bgp
allow-service dhcp
allow-service dns
allow-service icmp
no allow-service sshd
no allow-service netconf
no allow-service ntp
no allow-service ospf
no allow-service stun
allow-service https
no allow-service snmp
no allow-service bfd
exit
exit
appqoe
no tcpopt enable
no dreopt enable
no httpopt enable
!
omp
no shutdown
send-path-limit  16
ecmp-limit       16
graceful-restart
no as-dot-notation
timers
graceful-restart-timer 43200
exit
address-family ipv4
advertise connected
advertise static
!
address-family ipv6
advertise connected
advertise static
!
!
!
security
ipsec
replay-window  8192
```

```
integrity-type ip-udp-esp esp
!
!
sslproxy
no enable
rsa-key-modulus      2048
certificate-lifetime 730
eckey-type           P256
ca-tp-label          PROXY-SIGNING-CA
settings expired-certificate  drop
settings untrusted-certificate drop
settings unknown-status       drop
settings certificate-revocation-check none
settings unsupported-protocol-versions drop
settings unsupported-cipher-suites drop
settings failure-mode         close
settings minimum-tls-ver      TLSv1
dual-side optimization enable
!
policy
app-visibility
flow-visibility
!
```

Throughput Performance Troubleshooting in AWS



Note: Conducting performance tests in public cloud environments introduce new variables that might affect throughput performance. Here are a few to consider while performing these kinds of tests:

- Underlying resource usage by the peers at the time of running the tests
- Not using dedicated hosts (use of dedicated hosts increases cloud cost by 16x)
- Cloud runs in different regions, the performance might vary
- In some instances, the numbers are similar irrespective of feature profile; this is possibly due to AWS throttling on interface per instance size
- AWS throttles packets per second rate on EC2 instances which can cause packet drop as well
- AWS does not disclose the throttling rate but drops due to the pps throttling can be observed via the 'pps_allowance_exceeded' counter

Helpful CLI Troubleshooting Commands

When conducting throughput performance tests, thse troubleshooting commands can be used to pinpoint bottlenecks or reasons for performance degradation.

“show platform hardware qfp active statistics drop" - allows us to understand if there are any drops on the c8kv. We need to ensure there are no significant tail drops or any relevant counters incrementing.

"show platform hardware qfp active statistics drop clear" - This command clears the counters.

"show platform hardware qfp active datapath infrastructure sw-cio" - This command gives us detailed information on the percentage of Packet Processor (PP), Traffic Manager (TM) being utilized during the performance runs. This allows us to determine if there is enough processing capability or not from the c8kv.

"show platform hardware qfp active datapath util summary" - This command gives us the complete information of the input/output that the c8kv is transmitting/receiving from all the ports.

Ensure to check the input/output rate and see if there is any drop. Also, ensure to check the processing load percentage. If it reaches 100%; it means the c8kv has reached its capacity.

"show plat hardware qfp active infrastructure bqs interface GigabitEthernetX" - This command allows us to check the interface level statistics in terms of the queue number, bandwidth, taildrops.

"show controller" - This command gives us much granular information on the rx/tx good packets, missed packets.

This command can be used in a scenario where we dont see any tail drops but the Traffic generator still shows us drop.

This can be happen in a scenario where data utilization is reaching already 100% and likewise the PP at 100%.

If the rx_missed_errors counters keep incrementing, it implies that the CSR is backpressuring the cloud infrastructure as it is unable to process any more traffic.

"show platform hardware qfp active datapath infrastructure sw-hqf" - can be used to check for any congestion happening due to the backpressure from AWS.

"show plat hardware qfp active datapath infrastructure sw-nic" - Determines how the traffic is load balanced across multiple-queues. Post 17.7, we have 8 Multi-TXQs.

Also, it can determine if there is any one particular queue which is taking all the traffic or is being load balanced properly.

"show controllers | in errors|exceeded|Giga" - Shows the packet drops due to pps throttling done from AWS side, which can be observed via pps_allowance_exceeded counter.

Sample CLI Output

Sample output where Tail drops counter keep incrementing- Issue the command multiple times to see if the counters are incrementing thus allowing us to confirm it is indeed tail drops.

<#root>

```
csr_uut#show platform hardware qfp active statistics drop
Last clearing of QFP drops statistics : never
-----------------------------------------------------------------------
Global Drop Stats Packets Octets
-----------------------------------------------------------------------
```

```
Disabled 30 3693
IpFragErr 192 290976
Ipv4NoRoute 43 3626
Ipv6NoRoute 4 224
SdwanImplicitAclDrop 31 3899
```

TailDrop 19099700 22213834441

```
UnconfiguredIpv6Fia 3816 419760
```

Sample output shown here - Issue the command every 30 seconds to get the real-time data

<#root>

```
csr_uut#show platform hardware qfp active datapath infrastructure sw-cio
Credits Usage:

ID Port Wght Global WRKR0 WRKR1 WRKR2 WRKR3 WRKR4 WRKR5 WRKR6 WRKR7 WRKR8 WRKR9 WRKR10 WRKR11 WRKR12 WR
1 rcl0 16: 455 0 4 1 2 3 2 2 4 4 4 4 0 4 23 512
1 rcl0 32: 496 0 0 0 0 0 0 0 0 0 0 0 0 0 16 512
2 ipc 1: 468 4 2 4 3 0 1 1 4 0 2 0 4 0 18 511
3 vxe_punti 4: 481 0 0 0 0 0 0 0 0 0 0 0 0 0 31 512
4 Gi1 4: 446 0 0 1 1 0 2 3 0 3 2 0 1 1 52 512
5 Gi2 4: 440 4 4 4 3 2 1 1 3 2 4 4 3 2 59 504
6 Gi3 4: 428 1 1 1 0 4 4 1 0 4 4 0 0 2 43 494
7 Gi4 4: 427 1 1 0 1 4 2 0 4 3 4 1 1 7 56 512

Core Utilization over preceding 12819.5863 seconds
-----------------------------------------------
ID: 0 1 2 3 4 5 6 7 8 9 10 11 12 13
```

% PP

```
: 6.11 6.23 6.09 6.09 6.04 6.05 6.06 6.07 6.05 6.03 6.04 6.06 0.00 0.00
% RX: 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 2.23
```

% TM:

```
0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 4.79 0.00
% IDLE: 93.89 93.77 93.91 93.91 93.96 93.95 93.94 93.93 93.95 93.97 93.96 93.94 95.21 97.77
```

Sample output shown here - Ensure to check the input/output rate and see if there is any drop. Also, ensure to check the processing load percentage. If it reaches 100%; it means the node has reached its capacity.

<#root>

```
csr_uut#show platform hardware qfp active datapath util summary
CPP 0: 5 secs 1 min 5 min 60 min
```

Input: Total (pps)

```
900215 980887 903176 75623
(bps) 10276623992 11197595912 10310265440 863067008
```

Output: Total (pps)

```
900216 937459 865930 72522
```

```
(bps) 10276642720 10712432752 9894215928 828417104
```

Processing: Load (pct)

```
56 58 54 4
```

Sample output shown here for interface level statistics :

<#root>

```
csr_uut#sh plat hardware qfp active infrastructure bqs interface GigabitEthernet2
Interface: GigabitEthernet2, QFP interface: 7
Queue: QID: 111 (0x6f)
bandwidth (cfg) : 0 , bandwidth (hw) : 1050000000
shape (cfg) : 0 , shape (hw) : 0
prio level (cfg) : 0 , prio level (hw) : n/a
limit (pkts ) : 1043
Statistics:
depth (pkts ) : 0
```

tail drops (bytes): 0 , (packets) : 0

```
total enqs (bytes): 459322360227 , (packets) : 374613901
licensed throughput oversubscription drops:
(bytes): 0 , (packets) : 0
Schedule: (SID:0x8a)
Schedule FCID : n/a
bandwidth (cfg) : 10500000000 , bandwidth (hw) : 10500000000
shape (cfg) : 10500000000 , shape (hw) : 10500000000
Schedule: (SID:0x87)
Schedule FCID : n/a
bandwidth (cfg) : 200000000000 , bandwidth (hw) : 200000000000
shape (cfg) : 200000000000 , shape (hw) : 200000000000
Schedule: (SID:0x86)
Schedule FCID : n/a
bandwidth (cfg) : 500000000000 , bandwidth (hw) : 500000000000
shape (cfg) : 500000000000 , shape (hw) : 500000000000
```

```
csr_uut#sh plat hardware qfp active infrastructure bqs interface GigabitEthernet3 | inc tail
tail drops (bytes): 55815791988 , (packets) : 43177643
```

Sample output for the RX/TX good packets, missed packets statistics

<#root>

```
c8kv-aws-1#show controller
GigabitEthernet1 - Gi1 is mapped to UIO on VXE
rx_good_packets 346
tx_good_packets 243
rx_good_bytes 26440
tx_good_bytes 31813
rx_missed_errors 0
rx_errors 0
tx_errors 0
```

```
rx_mbuf_allocation_errors 0
rx_q0packets 0
rx_q0bytes 0
rx_q0errors 0
tx_q0packets 0
tx_q0bytes 0
GigabitEthernet2 - Gi2 is mapped to UIO on VXE
rx_good_packets 96019317
tx_good_packets 85808651
rx_good_bytes 12483293931
tx_good_bytes 11174853219
rx_missed_errors 522036


rx_errors 0
tx_errors 0
rx_mbuf_allocation_errors 0
rx_q0packets 0
rx_q0bytes 0
rx_q0errors 0
tx_q0packets 0
tx_q0bytes 0
GigabitEthernet3 - Gi3 is mapped to UIO on VXE
rx_good_packets 171596935
tx_good_packets 191911304
rx_good_bytes 11668588022
tx_good_bytes 13049984257
rx_missed_errors 21356065


rx_errors 0
tx_errors 0
rx_mbuf_allocation_errors 0
rx_q0packets 0
rx_q0bytes 0
rx_q0errors 0
tx_q0packets 0
tx_q0bytes 0
GigabitEthernet4 - Gi4 is mapped to UIO on VXE
rx_good_packets 95922932
tx_good_packets 85831238
rx_good_bytes 12470124252
tx_good_bytes 11158486786
rx_missed_errors 520328


rx_errors 46
tx_errors 0
rx_mbuf_allocation_errors 0
rx_q0packets 0
rx_q0bytes 0
rx_q0errors 0
tx_q0packets 0
tx_q0bytes 0
```

Sample output to check for any congestion happening due to the backpressure from AWS:

<#root>

```
csr_uut#show platform hardware qfp active datapath infrastructure sw-hqf
Name : Pri1 Pri2 None / Inflight pkts
GigabitEthernet4 : XON XON XOFF / 43732

HQF[0] IPC: send 514809 fc 0 congested_cnt 0
HQF[0] recycle: send hi 0 send lo 228030112
fc hi 0 fc lo 0
cong hi 0 cong lo 0
HQF[0] pkt: send hi 433634 send lo 2996661158
fc/full hi 0 fc/full lo 34567275
```

cong hi 0 cong lo 4572971630********Congestion counters keep incrementing**

```
HQF[0] aggr send stats 3225639713 aggr send lo state 3225206079
aggr send hi stats 433634
max_tx_burst_sz_hi 0 max_tx_burst_sz_lo 0
HQF[0] gather: failed_to_alloc_b4q 0
HQF[0] ticks 662109543, max ticks accumulated 348
HQF[0] mpsc stats: count: 0
enq 3225683472 enq_spin 0 enq_post 0 enq_flush 0
sig_cnt:0 enq_cancel 0
deq 3225683472 deq_wait 0 deq_fail 0 deq_cancel 0
deq_wait_timeout
```

Sample output for how the traffic is load balanced across multiple-queues:

```
um-csr-uut#sh plat hardware qfp active datapath infrastructure sw-nic
pmd b1c5a400 device Gi1
RX: pkts 50258 bytes 4477620 return 0 badlen 0
pkts/burst 1 cycl/pkt 579 ext_cycl/pkt 996
Total ring read 786244055, empty 786197491
TX: pkts 57860 bytes 6546349
pri-0: pkts 7139 bytes 709042
pkts/send 1
pri-1: pkts 3868 bytes 451352
pkts/send 1
pri-2: pkts 1875 bytes 219403
pkts/send 1
pri-3: pkts 2417 bytes 242527
pkts/send 1
pri-4: pkts 8301 bytes 984022
pkts/send 1
pri-5: pkts 10268 bytes 1114859
pkts/send 1
pri-6: pkts 1740 bytes 175353
pkts/send 1
pri-7: pkts 22252 bytes 2649791
pkts/send 1
Total: pkts/send 1 cycl/pkt 1091
send 56756 sendnow 0
forced 56756 poll 0 thd_poll 0
blocked 0 retries 0 mbuf alloc err 0
TX Queue 0: full 0 current index 0 hiwater 0
TX Queue 1: full 0 current index 0 hiwater 0
TX Queue 2: full 0 current index 0 hiwater 0
TX Queue 3: full 0 current index 0 hiwater 0
TX Queue 4: full 0 current index 0 hiwater 0
```

```
TX Queue 5: full 0 current index 0 hiwater 0
TX Queue 6: full 0 current index 0 hiwater 0
TX Queue 7: full 0 current index 0 hiwater 0
pmd b1990b00 device Gi2
RX: pkts 1254741010 bytes 511773562848 return 0 badlen 0
pkts/burst 16 cycl/pkt 792 ext_cycl/pkt 1342
Total ring read 1012256968, empty 937570790
TX: pkts 1385120320 bytes 564465308380
pri-0: pkts 168172786 bytes 68650796972
pkts/send 1
pri-1: pkts 177653235 bytes 72542203822
pkts/send 1
pri-2: pkts 22541430O bytes 91947701824
pkts/send 1
pri-3: pkts 136817435 bytes 55908224442
pkts/send 1
pri-4: pkts 256461818 bytes 104687120554
pkts/send 1
pri-5: pkts 176043289 bytes 71879529606
pkts/send 1
pri-6: pkts 83920827 bytes 34264110122
pkts/send 1
pri-7: pkts 160636635 bytes 64585622696
pkts/send 1
Total: pkts/send 1 cycl/pkt 442
send 1033104466 sendnow 41250092
forced 1776500651 poll 244223290 thd_poll 0
blocked 1060879040 retries 3499069 mbuf alloc err 0
TX Queue 0: full 0 current index 0 hiwater 31
TX Queue 1: full 718680 current index 0 hiwater 255
TX Queue 2: full 0 current index 0 hiwater 31
TX Queue 3: full 0 current index 0 hiwater 31
TX Queue 4: full 15232240 current index 0 hiwater 255
TX Queue 5: full 0 current index 0 hiwater 31
TX Queue 6: full 0 current index 0 hiwater 31
TX Queue 7: full 230668 current index 0 hiwater 224
pmd b1712d00 device Gi3
RX: pkts 1410702537 bytes 498597093510 return 0 badlen 0
pkts/burst 18 cycl/pkt 269 ext_cycl/pkt 321
Total ring read 1011915032, empty 934750846
TX: pkts 754803798 bytes 266331910366
pri-0: pkts 46992577 bytes 16616415156
pkts/send 1
pri-1: pkts 49194201 bytes 17379760716
pkts/send 1
pri-2: pkts 46991555 bytes 16616509252
pkts/send 1
pri-3: pkts 49195026 bytes 17381741474
pkts/send 1
pri-4: pkts 48875656 bytes 17283423414
pkts/send 1
pri-5: pkts 417370776 bytes 147056906106
pkts/send 6
pri-6: pkts 46992860 bytes 16617923068
pkts/send 1
pri-7: pkts 49191147 bytes 17379231180
pkts/send 1
Total: pkts/send 2 cycl/pkt 0
send 339705775 sendnow 366141927
forced 3138709511 poll 2888466204 thd_poll 0
blocked 1758644571 retries 27927046 mbuf alloc err 0
TX Queue 0: full 0 current index 0 hiwater 0
```

```
TX Queue 1: full 0 current index 0 hiwater 0
TX Queue 2: full 0 current index 0 hiwater 0
TX Queue 3: full 0 current index 0 hiwater 0
TX Queue 4: full 0 current index 1 hiwater 0
TX Queue 5: full 27077270 current index 0 hiwater 224
TX Queue 6: full 0 current index 0 hiwater 0
TX Queue 7: full 0 current index 0 hiwater 0
```

Sample output that shows the packet drops due to pps throttling done from AWS side, which can be observed via pps_allowance_exceeded counter:

```
C8k-AWS-2#show controllers | in errors|exceeded|Giga

GigabitEthernet1 - Gi1 is mapped to UIO on VXE
  rx_missed_errors 1750262
  rx_errors 0
  tx_errors 0
  rx_mbuf_allocation_errors 0
  rx_q0_errors 0
  rx_q1_errors 0
  rx_q2_errors 0
  rx_q3_errors 0
  bw_in_allowance_exceeded 0
  bw_out_allowance_exceeded 0
  pps_allowance_exceeded 11750
  conntrack_allowance_exceeded 0
  linklocal_allowance_exceeded 0
```