White Paper

Public

The bridge to possible

Classification TCAM with Cisco CloudScale ASICs for Nexus 9000 Series Switches White Paper

Contents

Introduction

In 2016, Cisco made its debut of the Cisco Nexus® 9000 Series Switch line with products built on the revolutionary Cisco® Cloud Scale intelligent Application-Specific Integrated Circuits (ASICs). These initial Cloud Scale platforms enabled customers to establish high-performance, cost-effective data center networks, offering a transition from 10G and 40G Ethernet to more robust 25G and 100G connectivity options. Over the following years, Cisco continued to expand and enhance the product family with additional platforms, introducing numerous innovations to address the evolving demands of Cloud Scale data centers, converged and hyperconverged infrastructure, and virtualized and containerized applications.

The inclusion of 400G Ethernet technology further enriches the Cloud Scale portfolio by providing platforms that deliver high-density, top-of-rack aggregation, spine aggregation, and backbone connectivity options. These platforms utilize the GX, GX2A, GX2B, and the latest additions, H2R and H1 Cloud Scale ASICs. With 400G options available for both top-of-rack and modular systems, the Nexus 9000 series chassis stand at the forefront of the industry, incorporating innovations such as 400G QSFP-DD (double density) transceivers that offer full backward compatibility with existing QSFP28 (100G) and QSFP+ (40G) transceivers.

Cisco Nexus 9000 switches equipped with Cloud Scale ASICs operate in either NX-OS mode, based on Cisco NX-OS Software, or ACI mode, based on Cisco Application Centric Infrastructure (Cisco ACI™). This remarkable flexibility allows customers to deploy Cisco Nexus 9000 platform switches in the mode that best aligns with their current operational model. Additionally, it leaves the option open to migrate smoothly to the other mode without requiring additional hardware investment or replacement.

This comprehensive document provides an in-depth explanation of Cisco Cloud Scale ASIC ternary content-addressable memory (TCAM) carving in conjunction with the Nexus 9000 switch. It encompasses essential concepts, configurations, and error messages commonly encountered in this context. The primary aim of this document is to enable users to grasp the workings of TCAM allocation, facilitating the creation of customized configurations that align precisely with their requirements.

In situations where you need non-default features for the Nexus 9000, you must manually carve out TCAM space to accommodate these features. By default, the entire TCAM space is allocated, and this document equips users with the knowledge to optimize and tailor their TCAM usage for enhanced performance and functionality.

Target Audience

This document is for planning, implementation, and maintenance in DevOps teams.

CloudScale ASIC Family

The Cisco Nexus 9000 platform switches are equipped with cutting-edge Cisco Custom CloudScale technology ASICs. This unique approach of designing and owning both the silicon, Software SDK, and operating system confers significant competitive advantages to the Nexus 9000 series. It serves as a powerful vehicle for delivering an array of advanced features and functions.

Leveraging the advantages of the latest semiconductor device fabrication, these ASICs boast higher transistor density and lower power consumption. These features are crucial in enabling the creation of ASICs with increased bandwidth, a higher number of ports, larger forwarding tables, generous buffers, and the opportunity to implement novel, advanced capabilities.

Cisco's cloud-scale ASICs introduce a wide range of Ethernet speeds, including 25, 50, 100, 200, and 400 Gigabit Ethernet (GE), to data center networks at a cost point optimized for optimal performance. See Table 1 for the specific Cloud Scale ASICs used in each Cisco Nexus 9000 Switch Family. Table 2 highlights the major feature sets associated with each Cloud Scale ASIC.

Table 1 Cisco Could Scale ASIC family with their corresponding Nexus 9000 switch

CloudScale ASIC	Nexus 9000 Family	Platforms and Line Cards
LS 1800 EX	9300-EX, X9700-EX (LCs)	C93180YC-EX, C93108TC-EX, C93180LC-EX, X9732C-EX, X9736C-EX, X97160YC-EX
LS 1800 FX	9300-FX, X9700-FX (LCs)	C93180YC-FX, C93108TC-FX, C9348GC-FXP, X9732C-FX, X9736C-FX, X9788TC-FX
LS 3600 FX2	9300-FX2	C9336C-FX2, C9336C-FX2-E, C93240YC-FX2, C93360YC-FX2, C93216TC-FX2
LS 1800 FX3	9300-FX3	C93180YC-FX3, 93180YC-FX3S, C93108TC-FX3P, C93108TC-FX3, C9348GC-FX3, C9348GC-FX3PH
S 6400	9300C, FM-E2 (FMs)	9364C, 9332C,9508-FM-E2, 9516-FM-E2
LS 6400 GX	9300-GX, X9700-GX (LCs)	C9316D-GX, C93600CD-GX, C9364C-GX, X9716D-GX, 9504-FM-G, 9508-FM-G
LS 25600 GX2A LS 12800 GX2B	9300-GX2A, 9300-GX2B, 9408	9364D-GX2A, 9348D-GX2A, 9332D-GX2B, C9400-SW-GX2A
LS 12800 H2R LS 6400 H1	9300-H2R, 9300-H1	9332D-H2R, 9364C-H1, C93400LD-H1

Table 2 Cisco Could Scale ASIC family features

ASIC Feature	LS 1800 EX	LS 1800 FX	LS 3600 FX2	LS 1800 FX3	S 6400	LS 6400 GX	LS25600 GX2A	LS12800 GX2B	LS12800 H2R	LS6400 H1
Bandwidth (Tbps)	1.8T	1.8T	3.6T	1.8T	6.4T	6.4T	25.6T	12.8T	12.8T	6.4T
No. of Die/Slices	1 Die 2 Slices	1 Die 1 Slices	1 Die 2 Slices	1 Die 1 Slices	1 Dies 4 Slices	2 Dies 4 Slices	1 Die 8 Chiplets 8 Slices	1 Die 4 Chiplets 4 Slices	2 Dies 4 Slices	1 Die 2 Slices
Fabrication node	16nm	16nm	16nm	14nm	16nm	14nm	7nm	7nm	7nm	7nm
Max Ports (400/200/100/50 GE)	0/0/18/72	0/0/18/72	0/0/36/72	0/0/18/72	0/0/64/0	16/32/64/128	64/128/256/256	32/64/128/128	32/64/128/128	16/32/64/128
Buffer/Max-per-port (MB)	37.4/18.7	40/40	40/30	40/40	40/10	80/20	120/30	120/60	80/40	40/40

ASIC Feature	LS 1800 EX	LS 1800 FX	LS 3600 FX2	LS 1800 FX3	S 6400	LS 6400 GX	LS25600 GX2A	LS12800 GX2B	LS12800 H2R	LS6400 H1
External Deep Buffer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8G HBM	N/A
Telemetry	FT	FT, FTE	FT, FTE, SSX	FT, FTE, SSX	SSX	FT, FTE, SSX, INT-XD, INT-Transparent	FT, FTE, SSX, INT-XD	FT, FTE, SSX, INT-XD	FT, FTE, SSX, INT-MX, INT-MD, INT-XD	FT, FTE, SSX, INT-MX, INT-MD, INT-XD
Hardware Entries/Tiles	544K/17	1088K/34	544K/17	1088K/34	352K/11	1088K/34	640K/20	1280K/40	1280K/40	1280K/40
Classification TCAM (Ingress/ Egress) Per Slice	4K/2K	5K/2K	5K/2K	5K/2K	4K/2K	5K/2K	6K/3K	6K/3K	14K Shared	14K Shared

CloudScale ASIC Classification TCAM Architecture

CloudScale ASIC Ingress Forwarding Controller

The ingress forwarding controller operates as follows: when a packet is received from the MAC layer, it parses the packet headers and conducts several lookups to determine whether the packet should be accepted and how it should be forwarded to its intended destination. Additionally, the controller generates instructions for the data path to handle the storage and queuing of the packet. For a visual representation of this process, see Figure 1, showcasing the CloudScale ASIC ingress forwarding controller.

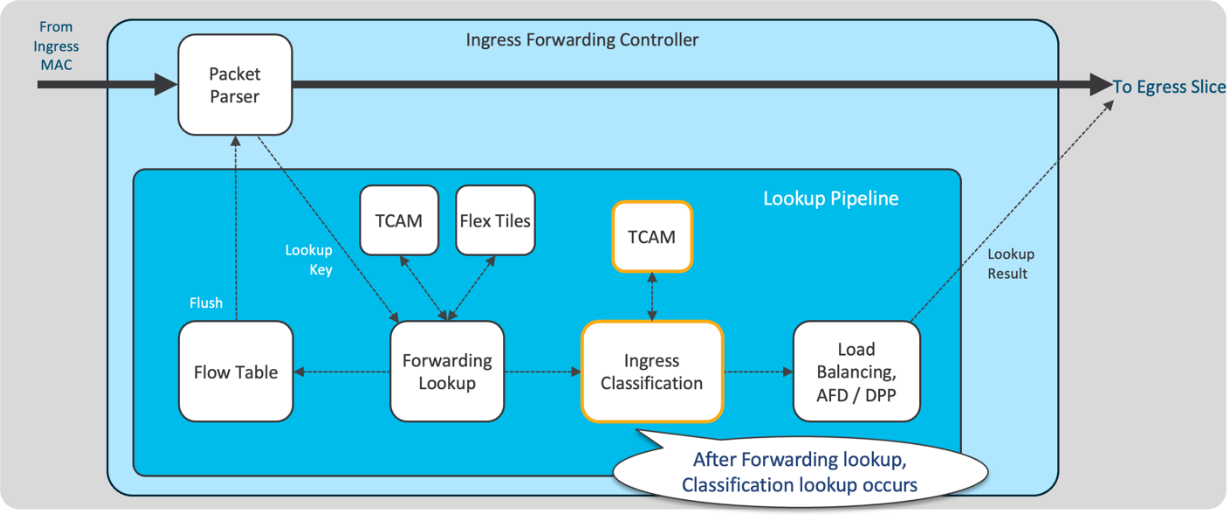


Figure 1 Cisco Could Scale ASIC ingress forwarding controller

After forwarding lookups, the packet undergoes ingress classification processing. The ingress matches are verified against the classification TCAM. These ACLs comprise various types, such as Routed ACLs (RACLs), VLAN ACLs (VACLs), Port ACLs (PACLs), Quality of Service (QoS), Network Address Translation (NAT) ACLs, and others.

CloudScale ASIC Egress Forwarding Controller

The egress forwarding controller is tasked with receiving packets from the buffer manager, along with their corresponding metadata, for transmission purposes. Its primary responsibilities include egress classification and managing all packet rewrites. You can observe the representation of the " Egress Forwarding Controller" in Figure 2, where the egress classification takes place. Egress RACLs and VACLs are the most commonly allocated TCAM resources for egress classification. Additionally, starting with LS25600 GX2A CloudScale ASICs, Egress PACLs are also supported.

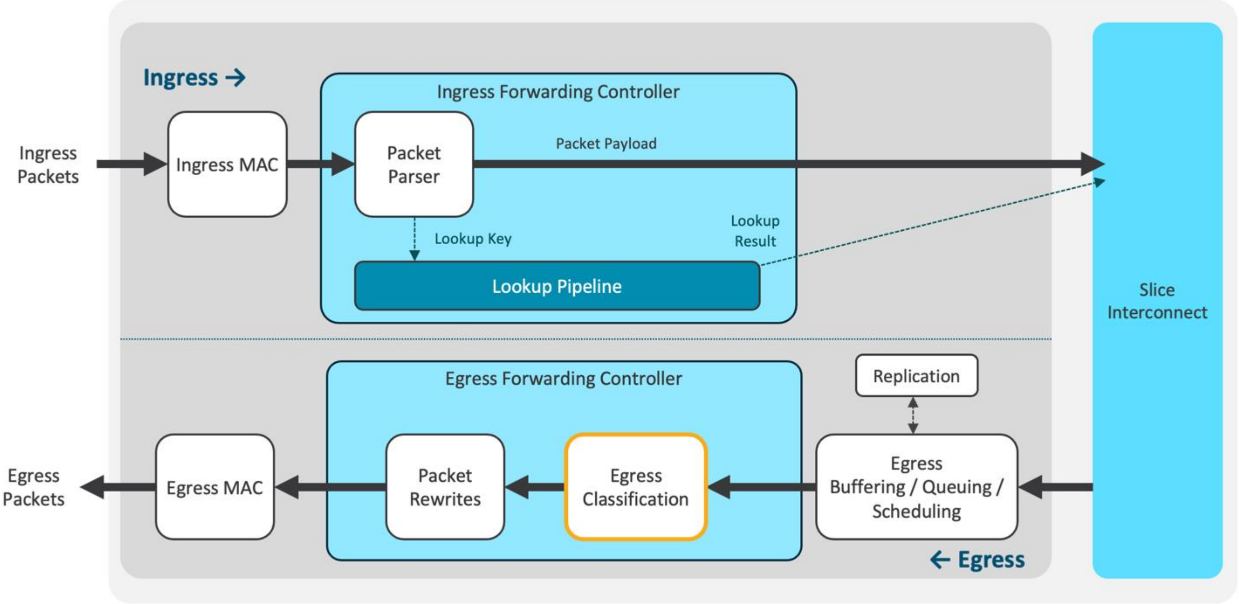


Figure 2 Cisco Could Scale ASIC egress forwarding controller

The classification entries are confined to individual ASIC slices and are programmed only where required. This approach optimizes the utilization of the classification TCAM in Cisco Nexus 9000 platform switches. In Figure 3, you can see that each ASIC is equipped with TCAM to support both system internal ACLs and user-defined ingress ACLs.

With the exception of LS12800 H2R and LS6400 H1, all Cloud Scale ASICs have dedicated ingress and egress TCAM space. On the other hand, LS12800 H2R and LS6400 H1 share a 14K TCAM space, which serves for both ingress and egress classifications.

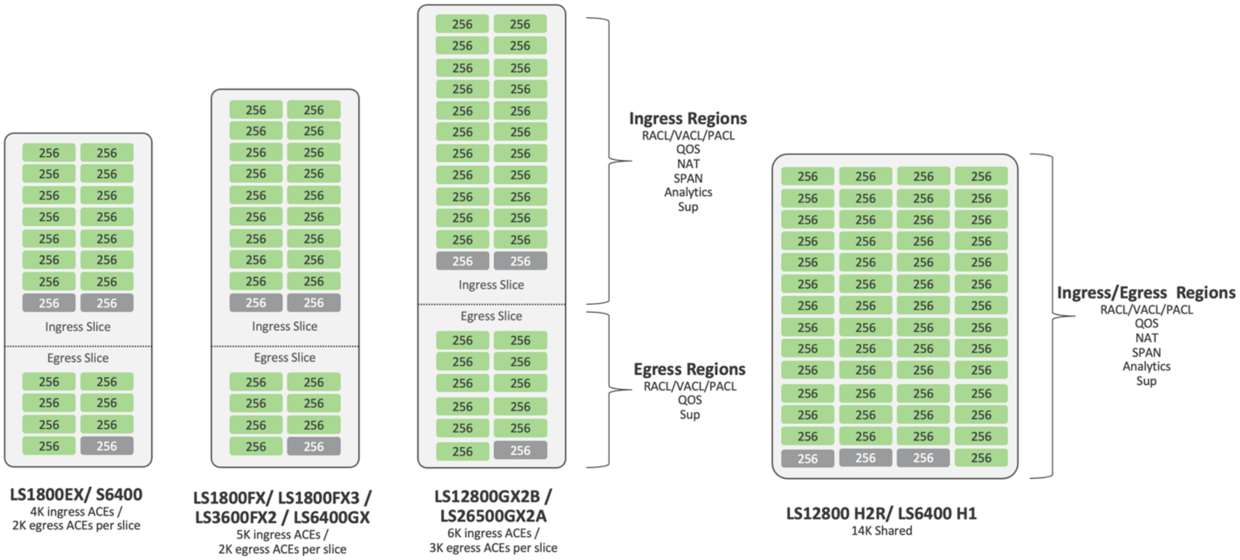
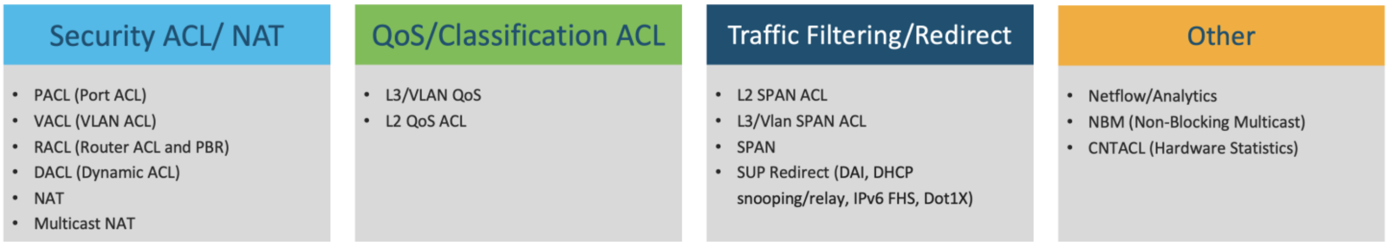


Figure 3 Cisco Could Scale ASIC ACL TCAM architecture

The carving of any region size is limited to values only in multiples of 256 entries, except for the SPAN region and NAT regions, which can only be carved in multiples of 512 entries. Notably, the " ing-sup" region requires a minimum size of 512 entries, while the " egr-sup" region necessitates a minimum size of 256 entries. You cannot configure these regions with lower values.

The Cisco CloudScale-based Nexus 9000 TCAM boasts a simplified design as compared to Merchant Silicon-based platforms. See Figure 4 for the ACL types supported by Cisco CloudScale ASICs.



Security ACL/ NAT

- PACL (Port ACL)
- VACL (VLAN ACL)
- RACL (Router ACL and PBR)
- DACL (Dynamic ACL)
- NAT
- Multicast NAT

QoS/Classification ACL

- L3/VLAN QoS
- L2 QoS ACL

Traffic Filtering/Redirect

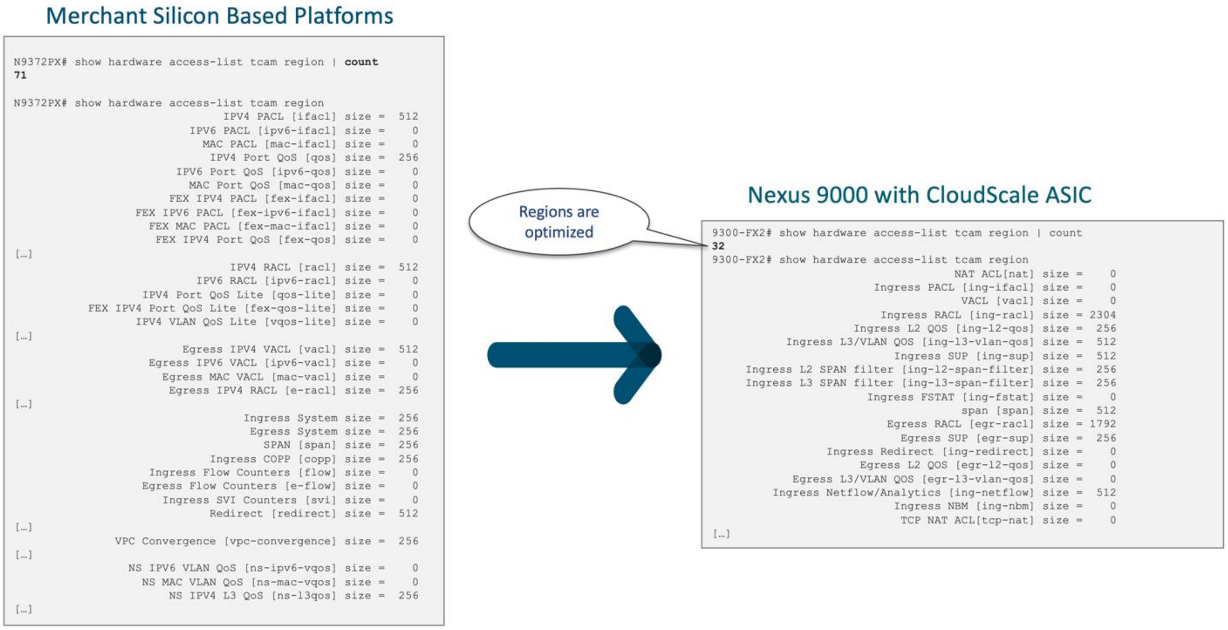
- L2 SPAN ACL
- L3/Vlan SPAN ACL
- SPAN
- SUP Redirect (DAI, DHCP snooping/relay, IPv6 FHS, Dot1X)

Other

- Netflow/Analytics
- NBM (Non-Blocking Multicast)
- CNTACL (Hardware Statistics)

Figure 4 Cisco CloudScale ASIC supported ACL types

The TCAM regions can handle entries of IPv4, IPv6, or MAC types, without the need for single- or double-wide configurations. Additionally, there is no requirement for QoS-lite regions. This approach significantly simplifies the ACL TCAM configuration for users of Nexus 9000 switches. For a visual comparison of the classification TCAM regions between the merchant silicon-based Nexus 9000 and the CloudScale-based Nexus 9000, see Figure 5.


Merchant Silicon Based Platforms
Regions are optimized
Nexus 9000 with CloudScale ASIC

```
N9372PX# show hardware access-list tcam region | count
71

N9372PX# show hardware access-list tcam region
                             IPV4 PACL [ifacl] size =  512
                        IPV6 PACL [ipv6-ifacl] size =    0
                          MAC PACL [mac-ifacl] size =    0
                           IPV4 Port QoS [qos] size =  256
                      IPV6 Port QoS [ipv6-qos] size =    0
                        MAC Port QoS [mac-qos] size =    0
                     FEX IPV4 PACL [fex-ifacl] size =    0
                FEX IPV6 PACL [fex-ipv6-ifacl] size =    0
                  FEX MAC PACL [fex-mac-ifacl] size =    0
                   FEX IPV4 Port QoS [fex-qos] size =    0
[…]
                              IPV4 RACL [racl] size =  512
                         IPV6 RACL [ipv6-racl] size =    0
                 IPV4 Port QoS Lite [qos-lite] size =    0
         FEX IPV4 Port QoS Lite [fex-qos-lite] size =    0
                IPV4 VLAN QoS Lite [vqos-lite] size =    0
[…]
                       Egress IPV4 VACL [vacl] size =  512
                  Egress IPV6 VACL [ipv6-vacl] size =    0
                    Egress MAC VACL [mac-vacl] size =    0
                     Egress IPV4 RACL [e-racl] size =  256
[…]
                                Ingress System size =  256
                                 Egress System size =  256
                                   SPAN [span] size =  256
                           Ingress COPP [copp] size =  256
                  Ingress Flow Counters [flow] size =    0
                 Egress Flow Counters [e-flow] size =    0
                    Ingress SVI Counters [svi] size =    0
                           Redirect [redirect] size =  512
[…]
             VPC Convergence [vpc-convergence] size =  256
[…]
               NS IPV6 VLAN QoS [ns-ipv6-vqos] size =    0
                 NS MAC VLAN QoS [ns-mac-vqos] size =    0
                     NS IPV4 L3 QoS [ns-l3qos] size =  256
[…]
```

```
9300-FX2# show hardware access-list tcam region | count
32
9300-FX2# show hardware access-list tcam region
                                    NAT ACL[nat] size =    0
                        Ingress PACL [ing-ifacl] size =    0
                                     VACL [vacl] size =    0
                         Ingress RACL [ing-racl] size = 2304
                     Ingress L2 QOS [ing-l2-qos] size =  256
           Ingress L3/VLAN QOS [ing-l3-vlan-qos] size =  512
                           Ingress SUP [ing-sup] size =  512
     Ingress L2 SPAN filter [ing-l2-span-filter] size =  256
     Ingress L3 SPAN filter [ing-l3-span-filter] size =  256
                       Ingress FSTAT [ing-fstat] size =    0
                                     span [span] size =  512
                          Egress RACL [egr-racl] size = 1792
                            Egress SUP [egr-sup] size =  256
                 Ingress Redirect [ing-redirect] size =    0
                      Egress L2 QOS [egr-l2-qos] size =    0
            Egress L3/VLAN QOS [egr-l3-vlan-qos] size =    0
         Ingress Netflow/Analytics [ing-netflow] size =  512
                           Ingress NBM [ing-nbm] size =    0
                           TCP NAT ACL[tcp-nat] size =    0
[…]
```

Figure 5 Classification TCAM regions between merchant silicon-based Nexus 9000 and the CloudScale based Nexus 9000

CloudScale ASIC TCAM Scalability

The Cloud Scale ASIC TCAM is optimized for scalability through slice-aware policy programming. PACL and RACLs are programmed only on slices where ports with these ACLs are present, and port channel ACLs are programmed solely on slices where the respective members exist. Similarly, VLAN ACLs are programmed exclusively on slices where the corresponding VLAN is present. To enable policy sharing, labels are used with label space localized to each slice. For specific Cisco CloudScale ASIC ACL TCAM scalability numbers, see Table 3. It's important to note that the TCAM scalability numbers were verified with all TCAM regions freed up except for the 'ing-sup' and 'egr-sup' regions.

Table 3 Cisco Cloud Scale ASIC ACL TCAM scalability numbers

ASIC	Ingress PACL		Egress PACL		Ingress RACL		Egress RACL		Ingress VACL		Egress VACL	
Name/Slices	Per Slice	Total	Per Slice	Total	Per Slice	Total	Per Slice	Total	Per Slice	Total	Per Slice	Total
LS1800 EX (2 slices)	3584	7168	1792	3584	3584	7168	1792	3584	1792	3584	1792	3584
LS1800 EX (1 slice)	4608	4608	1792	1792	4608	4608	1792	1792	1792	1792	1792	1792
LS3600 FX2 (2 slices)	4608	9216	1792	3584	4608	9216	1792	3584	1792	3584	1792	3584
LS1800 FX3 (1 slice)	4608	4608	1792	1792	4608	4608	1792	1792	1792	1792	1792	1792
S 6400 (4 slices)	3584	14336	1792	7168	3584	14336	1792	7168	1792	7168	1792	7168
LS 6400 (4 slices)	4608	18432	1792	7168	18432	1792	1792	7168	1792	7168	1792	7168

ASIC	Ingress PACL		Egress PACL		Ingress RACL		Egress RACL		Ingress VACL		Egress VACL	
LS25600 GX2A (8 slices)	5632	45056	2816	22528	5632	45056	2816	22528	2816	2258	2816	22528
LS12800 GX2B (4 slices)	5632	22528	2816	11264	5632	22528	2816	11264	2816	11264	2816	11264
LS12800 H2R (4 slices)	13568	54272	13568	54272	13568	54272	13568	54272	13568	54272	13568	54272
LS6400 H1 (2 slices)	13568	27136	13568	27136	13568	27136	13568	27136	13568	27136	13568	27136

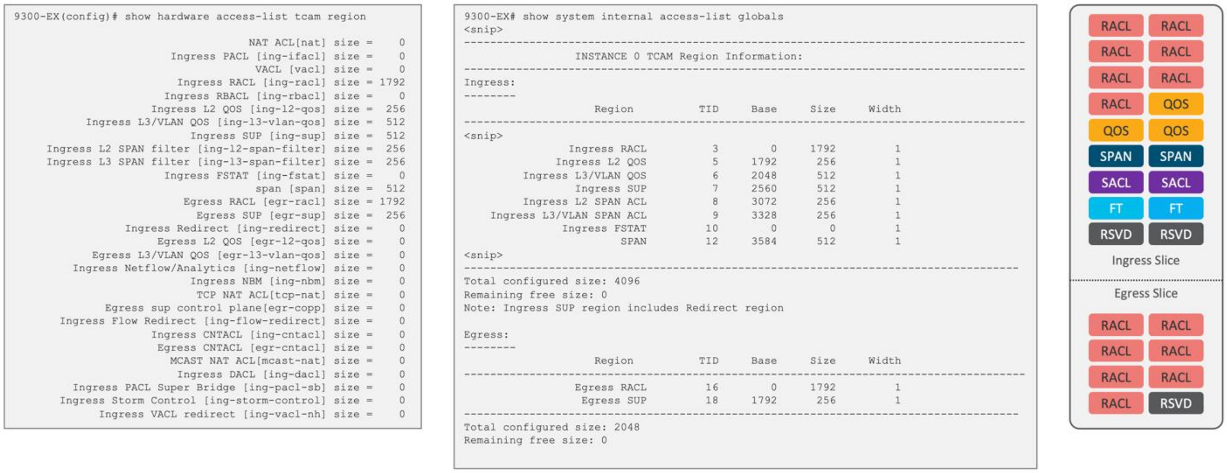
CloudScale ASIC Default ACL TCAM Allocation

The allocation of both ingress and egress ACL TCAM to different ACL types is user configurable. Each ACL type requires its dedicated bank/banks, and ACL programming is localized on a per ASIC basis. ACL entries are programmed into the TCAM only where they are required. By default, all available TCAM regions are allocated, except for Nexus 9300-GX2 and Nexus 9408 chassis.

In the case of Cisco Nexus 9300-H2R and 9300-H1, they are the only Nexus platforms with shared TCAM space for both Ingress and Egress slices. The default assignment is 10K for ingress and 4K for egress, although any bank can be reconfigured to function as either ingress or egress.

To illustrate the default classification TCAM regions for the Nexus 9300 series switches, see Figure 6 for 9300-EX and 9300C, Figure 7 for 9300-FX/FX2/FX3/GX, Figure 8 for 9300-GX2A/GX2B and 9408, and finally, Figure 9 for 9300-H2R/H1.

Nexus 9300-EX, Nexus 9364C, nexus 9332C (4K ingress, 2K Egress)

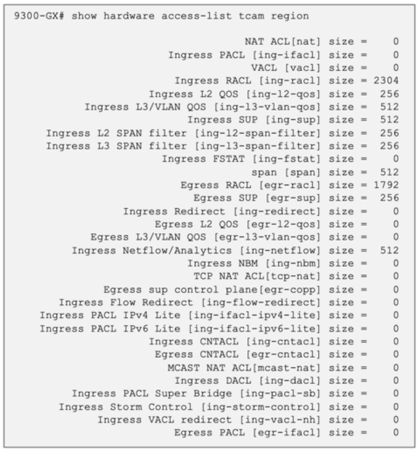


```
9300-EX(config)# show hardware access-list tcam region

                                   NAT ACL[nat] size =    0
                       Ingress PACL [ing-ifacl] size =    0
                                    VACL [vacl] size =    0
                        Ingress RACL [ing-racl] size = 1792
                      Ingress RBACL [ing-rbacl] size =    0
                    Ingress L2 QOS [ing-l2-qos] size =  256
          Ingress L3/VLAN QOS [ing-l3-vlan-qos] size =  512
                          Ingress SUP [ing-sup] size =  512
    Ingress L2 SPAN filter [ing-l2-span-filter] size =  256
    Ingress L3 SPAN filter [ing-l3-span-filter] size =  256
                      Ingress FSTAT [ing-fstat] size =    0
                                    span [span] size =  512
                         Egress RACL [egr-racl] size = 1792
                           Egress SUP [egr-sup] size =  256
                Ingress Redirect [ing-redirect] size =    0
                     Egress L2 QOS [egr-l2-qos] size =    0
           Egress L3/VLAN QOS [egr-l3-vlan-qos] size =    0
        Ingress Netflow/Analytics [ing-netflow] size =    0
                          Ingress NBM [ing-nbm] size =    0
                           TCP NAT ACL[tcp-nat] size =    0
             Egress sup control plane[egr-copp] size =    0
      Ingress Flow Redirect [ing-flow-redirect] size =    0
                    Ingress CNTACL [ing-cntacl] size =    0
                     Egress CNTACL [egr-cntacl] size =    0
                       MCAST NAT ACL[mcast-nat] size =    0
                        Ingress DACL [ing-dacl] size =    0
        Ingress PACL Super Bridge [ing-pacl-sb] size =    0
      Ingress Storm Control [ing-storm-control] size =    0
            Ingress VACL redirect [ing-vacl-nh] size =    0
```

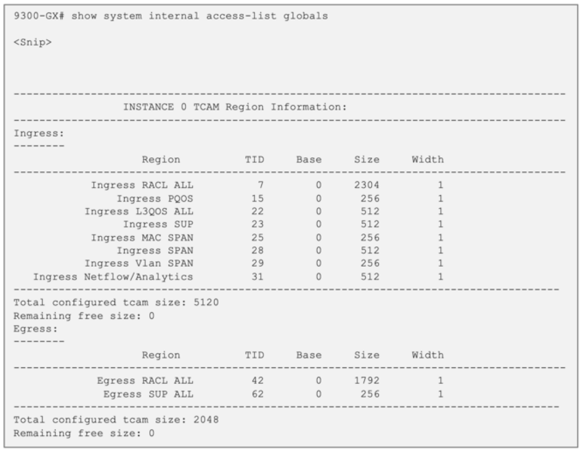
```
9300-EX# show system internal access-list globals
<snip>
--------------------------------------------------------------------------------------
                 INSTANCE 0 TCAM Region Information:
--------------------------------------------------------------------------------------
Ingress:
--------
                    Region          TID     Base     Size     Width
--------------------------------------------------------------------------------------
<snip>
                Ingress RACL          3        0     1792         1
              Ingress L2 QOS          5     1792      256         1
         Ingress L3/VLAN QOS          6     2048      512         1
                 Ingress SUP          7     2560      512         1
         Ingress L2 SPAN ACL          8     3072      256         1
    Ingress L3/VLAN SPAN ACL          9     3328      256         1
               Ingress FSTAT         10        0        0         1
                        SPAN         12     3584      512         1
<snip>
--------------------------------------------------------------------------------------
Total configured size: 4096
Remaining free size: 0
Note: Ingress SUP region includes Redirect region

Egress:
--------
                    Region          TID     Base     Size     Width
--------------------------------------------------------------------------------------
                 Egress RACL         16        0     1792         1
                  Egress SUP         18     1792      256         1
--------------------------------------------------------------------------------------
Total configured size: 2048
Remaining free size: 0
```

Figure 6 Default classification TCAM regions for Cisco Nexus 9300-EX and 9300C

Nexus 9300-FX, Nexus 9300-FX2, Nexus 9300-FX3, Nexus 9300-GX (5K Ingress,2K Egress)



```
9300-GX# show hardware access-list tcam region

                                    NAT ACL[nat] size =    0
                          Ingress PACL [ing-ifacl] size =    0
                                     VACL [vacl] size =    0
                           Ingress RACL [ing-racl] size = 2304
                        Ingress L2 QOS [ing-l2-qos] size =  256
                Ingress L3/VLAN QOS [ing-l3-vlan-qos] size =  512
                             Ingress SUP [ing-sup] size =  512
          Ingress L2 SPAN filter [ing-l2-span-filter] size =  256
          Ingress L3 SPAN filter [ing-l3-span-filter] size =  256
                         Ingress FSTAT [ing-fstat] size =    0
                                     span [span] size =  512
                            Egress RACL [egr-racl] size = 1792
                              Egress SUP [egr-sup] size =  256
                    Ingress Redirect [ing-redirect] size =    0
                        Egress L2 QOS [egr-l2-qos] size =    0
                Egress L3/VLAN QOS [egr-l3-vlan-qos] size =    0
             Ingress Netflow/Analytics [ing-netflow] size =  512
                             Ingress NBM [ing-nbm] size =    0
                              TCP NAT ACL[tcp-nat] size =    0
                  Egress sup control plane[egr-copp] size =    0
           Ingress Flow Redirect [ing-flow-redirect] size =    0
        Ingress PACL IPv4 Lite [ing-ifacl-ipv4-lite] size =    0
        Ingress PACL IPv6 Lite [ing-ifacl-ipv6-lite] size =    0
                       Ingress CNTACL [ing-cntacl] size =    0
                        Egress CNTACL [egr-cntacl] size =    0
                          MCAST NAT ACL[mcast-nat] size =    0
                           Ingress DACL [ing-dacl] size =    0
             Ingress PACL Super Bridge [ing-pacl-sb] size =    0
           Ingress Storm Control [ing-storm-control] size =    0
               Ingress VACL redirect [ing-vacl-nh] size =    0
                          Egress PACL [egr-ifacl] size =    0
```



```
9300-GX# show system internal access-list globals

<Snip>



--------------------------------------------------------------------------------------
                  INSTANCE 0 TCAM Region Information:
--------------------------------------------------------------------------------------
Ingress:
--------
                    Region          TID      Base      Size      Width
--------------------------------------------------------------------------------------
            Ingress RACL ALL          7         0      2304          1
                Ingress PQOS         15         0       256          1
            Ingress L3QOS ALL        22         0       512          1
                 Ingress SUP         23         0       512          1
             Ingress MAC SPAN        25         0       256          1
                Ingress SPAN         28         0       512          1
            Ingress Vlan SPAN        29         0       256          1
    Ingress Netflow/Analytics        31         0       512          1
-------------------------------------------------------------------------------------
Total configured tcam size: 5120
Remaining free size: 0
Egress:
--------
                    Region          TID      Base      Size      Width
--------------------------------------------------------------------------------------
             Egress RACL ALL         42         0      1792          1
              Egress SUP ALL         62         0       256          1
-------------------------------------------------------------------------------------
Total configured tcam size: 2048
Remaining free size: 0
```

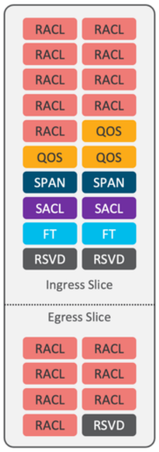
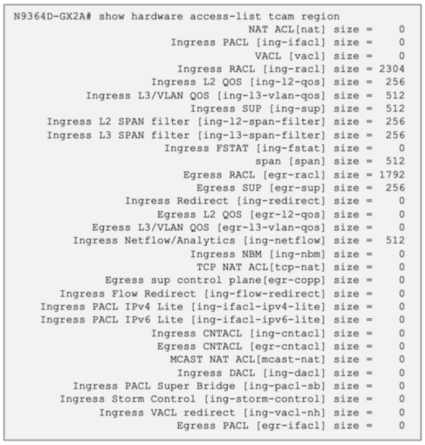
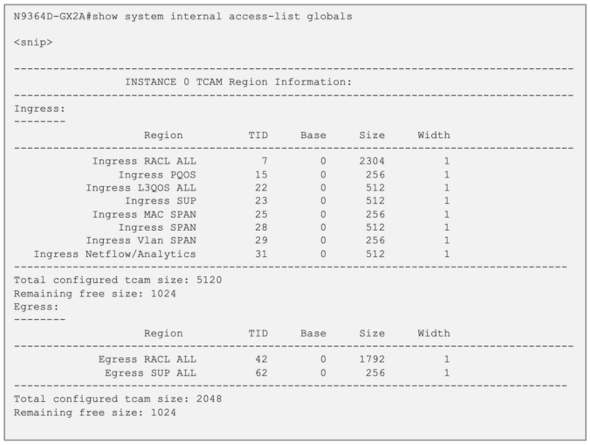


Figure 7 Default classification TCAM regions for Cisco Nexus 9300-FX/FX2/FX3/GX chassis

Nexus 9300-GX2A, 9300GX2B, 9408 (6K Ingress, 3K Egress)



```
N9364D-GX2A# show hardware access-list tcam region
                                    NAT ACL[nat] size =    0
                          Ingress PACL [ing-ifacl] size =    0
                                     VACL [vacl] size =    0
                           Ingress RACL [ing-racl] size = 2304
                        Ingress L2 QOS [ing-l2-qos] size =  256
                Ingress L3/VLAN QOS [ing-l3-vlan-qos] size =  512
                             Ingress SUP [ing-sup] size =  512
          Ingress L2 SPAN filter [ing-l2-span-filter] size =  256
          Ingress L3 SPAN filter [ing-l3-span-filter] size =  256
                         Ingress FSTAT [ing-fstat] size =    0
                                     span [span] size =  512
                            Egress RACL [egr-racl] size = 1792
                              Egress SUP [egr-sup] size =  256
                    Ingress Redirect [ing-redirect] size =    0
                        Egress L2 QOS [egr-l2-qos] size =    0
                Egress L3/VLAN QOS [egr-l3-vlan-qos] size =    0
             Ingress Netflow/Analytics [ing-netflow] size =  512
                             Ingress NBM [ing-nbm] size =    0
                              TCP NAT ACL[tcp-nat] size =    0
                  Egress sup control plane[egr-copp] size =    0
           Ingress Flow Redirect [ing-flow-redirect] size =    0
        Ingress PACL IPv4 Lite [ing-ifacl-ipv4-lite] size =    0
        Ingress PACL IPv6 Lite [ing-ifacl-ipv6-lite] size =    0
                       Ingress CNTACL [ing-cntacl] size =    0
                        Egress CNTACL [egr-cntacl] size =    0
                          MCAST NAT ACL[mcast-nat] size =    0
                           Ingress DACL [ing-dacl] size =    0
             Ingress PACL Super Bridge [ing-pacl-sb] size =    0
           Ingress Storm Control [ing-storm-control] size =    0
               Ingress VACL redirect [ing-vacl-nh] size =    0
                          Egress PACL [egr-ifacl] size =    0
```



```
N9364D-GX2A#show system internal access-list globals

<snip>

--------------------------------------------------------------------------------------
                  INSTANCE 0 TCAM Region Information:
--------------------------------------------------------------------------------------
Ingress:
--------
                    Region          TID      Base      Size      Width
--------------------------------------------------------------------------------------
            Ingress RACL ALL          7         0      2304          1
                Ingress PQOS         15         0       256          1
            Ingress L3QOS ALL        22         0       512          1
                 Ingress SUP         23         0       512          1
             Ingress MAC SPAN        25         0       256          1
                Ingress SPAN         28         0       512          1
            Ingress Vlan SPAN        29         0       256          1
    Ingress Netflow/Analytics        31         0       512          1
-------------------------------------------------------------------------------------
Total configured tcam size: 5120
Remaining free size: 1024
Egress:
--------
                    Region          TID      Base      Size      Width
--------------------------------------------------------------------------------------
             Egress RACL ALL         42         0      1792          1
              Egress SUP ALL         62         0       256          1
-------------------------------------------------------------------------------------
Total configured tcam size: 2048
Remaining free size: 1024
```

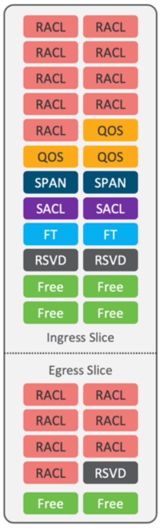
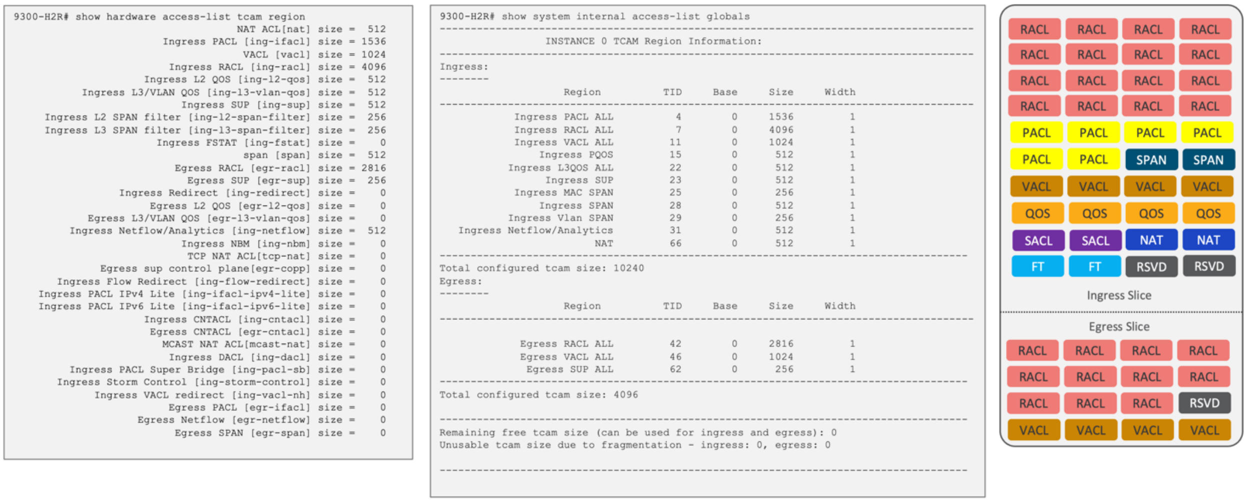


Figure 8 Default classification TCAM regions for Cisco Nexus 9300-GX2A/GX2B and Cisco Nexus 9408 chassis

Nexus 9300-H2R, 9300-H1 (14K Shared)



```
9300-H2R# show hardware access-list tcam region
                                   NAT ACL[nat] size =  512
                        Ingress PACL [ing-ifacl] size = 1536
                                   VACL [vacl] size = 1024
                         Ingress RACL [ing-racl] size = 4096
                     Ingress L2 QOS [ing-l2-qos] size =  512
           Ingress L3/VLAN QOS [ing-l3-vlan-qos] size =  512
                           Ingress SUP [ing-sup] size =  512
     Ingress L2 SPAN filter [ing-l2-span-filter] size =  256
     Ingress L3 SPAN filter [ing-l3-span-filter] size =  256
                       Ingress FSTAT [ing-fstat] size =    0
                                   span [span] size =  512
                          Egress RACL [egr-racl] size = 2816
                            Egress SUP [egr-sup] size =  256
                  Ingress Redirect [ing-redirect] size =    0
                      Egress L2 QOS [egr-l2-qos] size =    0
            Egress L3/VLAN QOS [egr-l3-vlan-qos] size =    0
        Ingress Netflow/Analytics [ing-netflow] size =  512
                           Ingress NBM [ing-nbm] size =    0
                            TCP NAT ACL[tcp-nat] size =    0
                Egress sup control plane[egr-copp] size =    0
          Ingress Flow Redirect [ing-flow-redirect] size =    0
      Ingress PACL IPv4 Lite [ing-ifacl-ipv4-lite] size =    0
      Ingress PACL IPv6 Lite [ing-ifacl-ipv6-lite] size =    0
                     Ingress CNTACL [ing-cntacl] size =    0
                      Egress CNTACL [egr-cntacl] size =    0
                        MCAST NAT ACL[mcast-nat] size =    0
                         Ingress DACL [ing-dacl] size =    0
        Ingress PACL Super Bridge [ing-pacl-sb] size =    0
          Ingress Storm Control [ing-storm-control] size =    0
            Ingress VACL redirect [ing-vacl-nh] size =    0
                         Egress PACL [egr-ifacl] size =    0
                     Egress Netflow [egr-netflow] size =    0
                         Egress SPAN [egr-span] size =    0
```

```
9300-H2R# show system internal access-list globals
----------------------------------------------------------------------------------
                  INSTANCE 0 TCAM Region Information:
----------------------------------------------------------------------------------
Ingress:
--------
                   Region           TID      Base      Size      Width
----------------------------------------------------------------------------------
           Ingress PACL ALL           4         0      1536          1
           Ingress RACL ALL           7         0      4096          1
           Ingress VACL ALL          11         0      1024          1
               Ingress PQOS          15         0       512          1
          Ingress L3QOS ALL          22         0       512          1
                Ingress SUP          23         0       512          1
           Ingress MAC SPAN          25         0       256          1
               Ingress SPAN          28         0       512          1
          Ingress Vlan SPAN          29         0       256          1
  Ingress Netflow/Analytics          31         0       512          1
                        NAT          66         0       512          1
---------------------------------------------------------------------------------
Total configured tcam size: 10240
Egress:
--------
                   Region           TID      Base      Size      Width
----------------------------------------------------------------------------------


            Egress RACL ALL          42         0      2816          1
            Egress VACL ALL          46         0      1024          1
             Egress SUP ALL          62         0       256          1
---------------------------------------------------------------------------------
Total configured tcam size: 4096

---------------------------------------------------------------------------------
Remaining free tcam size (can be used for ingress and egress): 0
Unusable tcam size due to fragmentation - ingress: 0, egress: 0

---------------------------------------------------------------------------------
```

RACL	RACL	RACL	RACL
RACL	RACL	RACL	RACL
RACL	RACL	RACL	RACL
RACL	RACL	RACL	RACL
PACL	PACL	PACL	PACL
PACL	PACL	SPAN	SPAN
VACL	VACL	VACL	VACL
QOS	QOS	QOS	QOS
SACL	SACL	NAT	NAT
FT	FT	RSVD	RSVD

Ingress Slice

Egress Slice

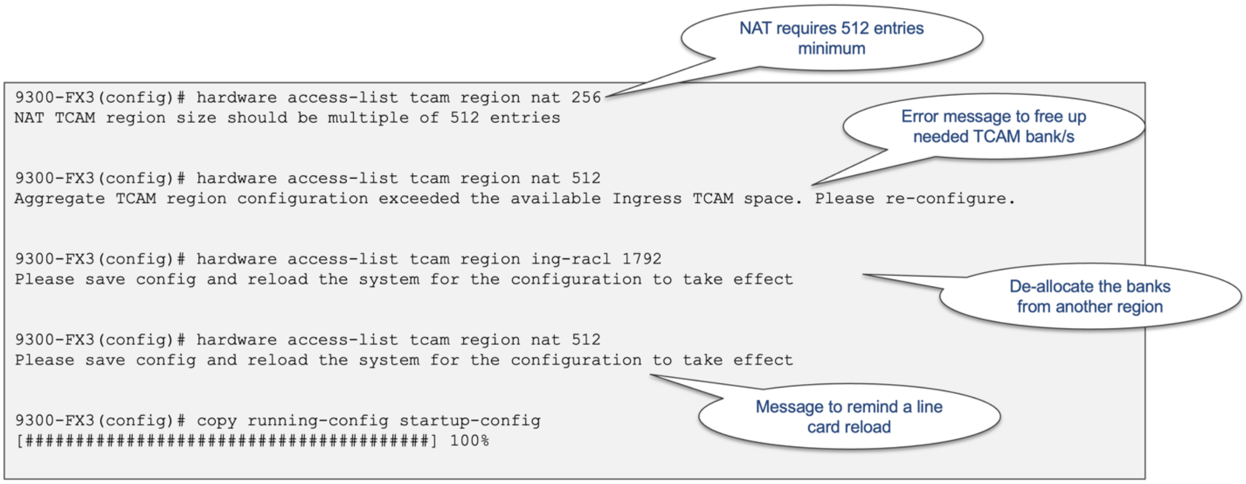
RACL	RACL	RACL	RACL
RACL	RACL	RACL	RACL
RACL	RACL	RACL	RSVD
VACL	VACL	VACL	VACL

Figure 9 Default classification TCAM regions for Cisco Nexus 9300-H2R/H1 chassis

CloudScale ASIC TCAM Carving

If a non-default feature is required for Nexus 9000, you must manually allocate TCAM space for those features. By default, all TCAM space is allocated, except for Nexus 9300-GX2 and Nexus 9408 chassis. If you wish to assign more banks to a specific region, you must first free up an equal number of banks from other regions before allocating them to the targeted region.

For example, in Figure 10, we can observe the TCAM carving for Cisco Nexus 9300-FX3, where no entries are initially allocated to NAT. However, for NAT, a minimum of 512 entries in TCAM will be needed to accommodate the required functionality.

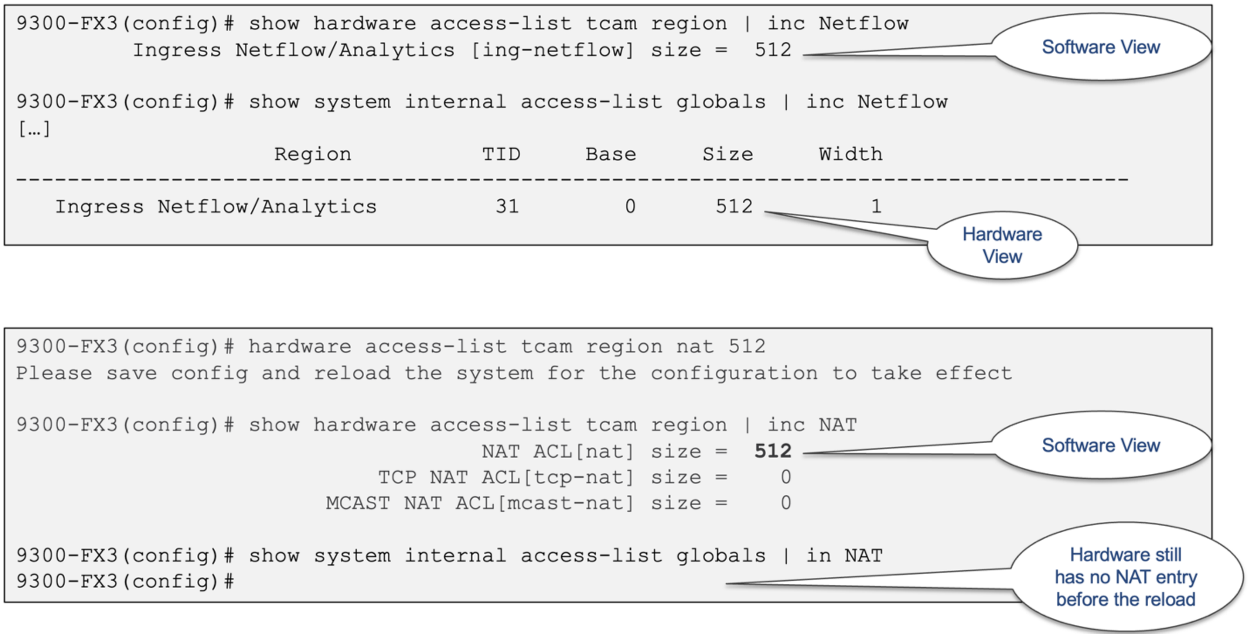


```
9300-FX3(config)# hardware access-list tcam region nat 256
NAT TCAM region size should be multiple of 512 entries


9300-FX3(config)# hardware access-list tcam region nat 512
Aggregate TCAM region configuration exceeded the available Ingress TCAM space. Please re-configure.


9300-FX3(config)# hardware access-list tcam region ing-racl 1792
Please save config and reload the system for the configuration to take effect


9300-FX3(config)# hardware access-list tcam region nat 512
Please save config and reload the system for the configuration to take effect


9300-FX3(config)# copy running-config startup-config
[########################################] 100%
```

NAT requires 512 entries minimum
Error message to free up needed TCAM bank/s
De-allocate the banks from another region
Message to remind a line card reload

Figure 10 TCAM carving for NAT

Modifications to ACL TCAM region carving necessitate a switch/line card reload. When configuring the " hardware access-list tcam region" command, the changes only apply to the software allocation. To enforce the reallocation of regions in the hardware, you must reload the system, as depicted in Figure 11.



```
9300-FX3(config)# show hardware access-list tcam region | inc Netflow
         Ingress Netflow/Analytics [ing-netflow] size =  512

9300-FX3(config)# show system internal access-list globals | inc Netflow
[…]
                    Region          TID     Base     Size     Width
-------------------------------------------------------------------------------------
   Ingress Netflow/Analytics         31        0      512         1
```

Software View

Hardware View

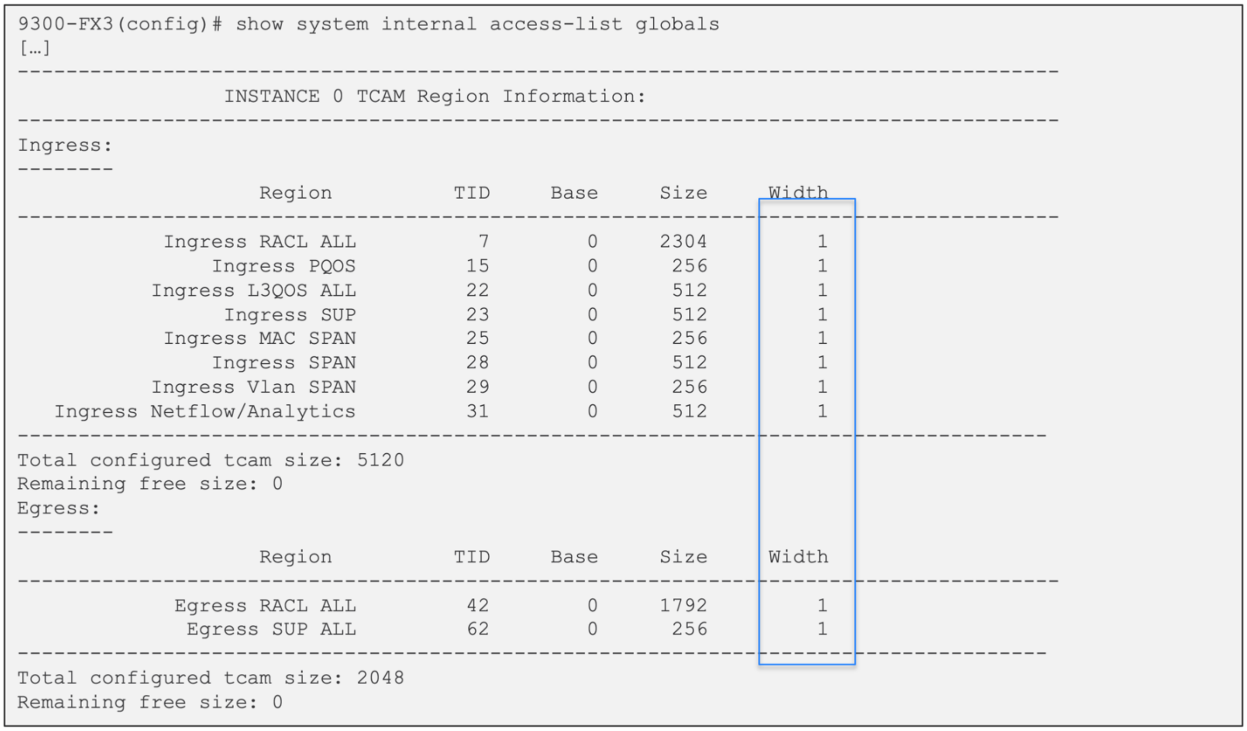
```
9300-FX3(config)# hardware access-list tcam region nat 512
Please save config and reload the system for the configuration to take effect

9300-FX3(config)# show hardware access-list tcam region | inc NAT
                                    NAT ACL[nat] size =  512
                            TCP NAT ACL[tcp-nat] size =    0
                        MCAST NAT ACL[mcast-nat] size =    0

9300-FX3(config)# show system internal access-list globals | in NAT
9300-FX3(config)#
```

Software View

Hardware still has no NAT entry before the reload

Figure 11 Software and hardware show commands for NAT TCAM allocation

The distinction between single- and double-wide regions does not apply to Cloud Scale ASICs. For examle, the ing-ifacl region is capable of accommodating IPv4, IPv6, or MAC type entries. IPv4 and MAC types occupy one TCAM entry, whereas IPv6 types occupy two TCAM entries. When using the " show system internal access-list globals" command, all allocated regions display a single width, as illustrated in Figure 12.



```
9300-FX3(config)# show system internal access-list globals
[…]
--------------------------------------------------------------------------------
                INSTANCE 0 TCAM Region Information:
--------------------------------------------------------------------------------
Ingress:
--------
                   Region          TID     Base     Size     Width
--------------------------------------------------------------------------------
           Ingress RACL ALL          7        0     2304         1
               Ingress PQOS         15        0      256         1
          Ingress L3QOS ALL         22        0      512         1
                Ingress SUP         23        0      512         1
           Ingress MAC SPAN         25        0      256         1
               Ingress SPAN         28        0      512         1
          Ingress Vlan SPAN         29        0      256         1
  Ingress Netflow/Analytics         31        0      512         1
-------------------------------------------------------------------------------
Total configured tcam size: 5120
Remaining free size: 0
Egress:
--------
                   Region          TID     Base     Size     Width
--------------------------------------------------------------------------------
            Egress RACL ALL         42        0     1792         1
             Egress SUP ALL         62        0      256         1
-------------------------------------------------------------------------------
Total configured tcam size: 2048
Remaining free size: 0
```

Figure 12 Simplified TCAM regions with Cisco CloudScale ASIC

CloudScale ASIC TCAM Regions

Security ACL Regions

The security Access Control Lists (ACLs) are divided into three distinct categories, namely PACL, VACL, and RACL. Table 4 clearly defines each category, along with providing a configuration example. Policy-based routing (PBR) also makes use of the ingress RACL region.

It is essential to emphasize that traditionally, PACL has been utilized in the ingress direction with Cisco Nexus 9000 switches, making the PACL TCAM region applicable solely for ingress operations. However, with the advent of Cisco NX-OS release 10.2(1)F, egress PACL is now supported on the Nexus 9364D-GX2A and 9332D-GX2B platform switches. Moreover, the support for egress PACL has been extended to the Nexus 9348D-GX2A with 10.2(3)F and Nexus 9408 running 10.3(2)F release.

Table 4 Cisco Cloud Scale ASIC security ACL TCAM regions

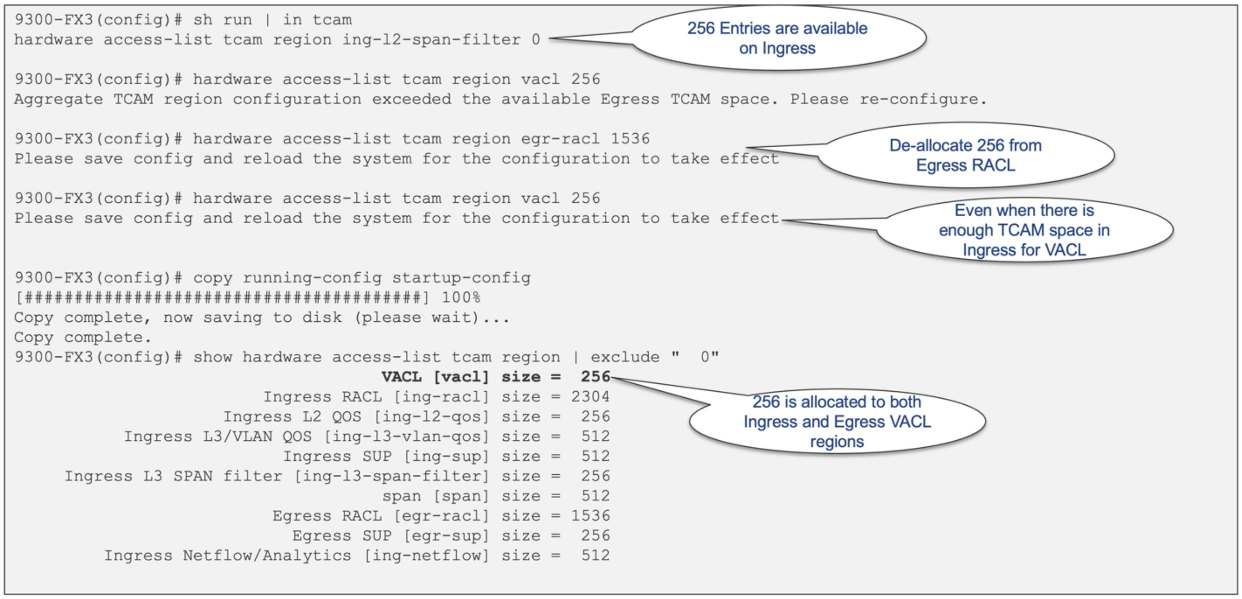
Name	Description	CLI Configuration	Region Name

PACL	ACL applied to a Layer 2 switchport interface. It cannot be applied on any other type of interface, and it works only in the ingress direction with exception of 9300-GX2 where an egress PACL is also supported. The security boundary is to permit or deny traffic within a VLAN. PACL TCAM is automatically shared when the same PACL is applied to multiple ports on the same ASIC. Only supported in the ingress direction.	`ip access-list pacl permit tcp any any`
		`interface Ethernet 1/1 switchport ip port access-group pacl in`
			• **ing-ifacl**: For ingress IPv4, IPv6, and MAC port ACLs.
			• **egr-ifacl**: For ingress IPv4, IPv6, and MAC port ACLs. Only supported with 9300-GX2 and Nexus 9408 chassis.

VACL	ACL that is applied to a VLAN. It can be applied only to a VLAN, not any other type of interface. The security boundary is to permit or deny moving traffic between VLANs and permit or deny traffic within a VLAN.	`ip access-list vacl permit ip any 10.1.1.0 0.0.0.255`
		`vlan access-map myvacl 10 match ip address vacl action forward`
		`vlan filter myvacl vlan-list 10-15`
			• vacl: The same TCAM size is allocated to both ingress and egress.

RACL	ACL that is applied to an interface that has a Layer 3 address assigned to it. It can be applied to any port that has an IP address, such as routed interfaces, loopback interfaces, and VLAN interfaces. The security boundary is to permit or deny traffic moving between subnets or networks.	`ip access-list racl permit ip host 1.1.1.1 host 2.2.2.20`
		`interface e1/1 no switchport ip address 2.2.2.1 255.255.255.0 ip access-group racl in`
			• ing-racl: For ingress IPv4 and IPv6 RACLs and PBR.
			• egr-racl: For egress IPv4 and IPv6 RACLs.

When configuring the VACL region, the same value is allocated for both ingress and egress. As a result, you must ensure that both the ingress and egress TCAM regions have sufficient space. If the specified region size cannot fit in either direction, the configuration is rejected, as shown in Figure 13.

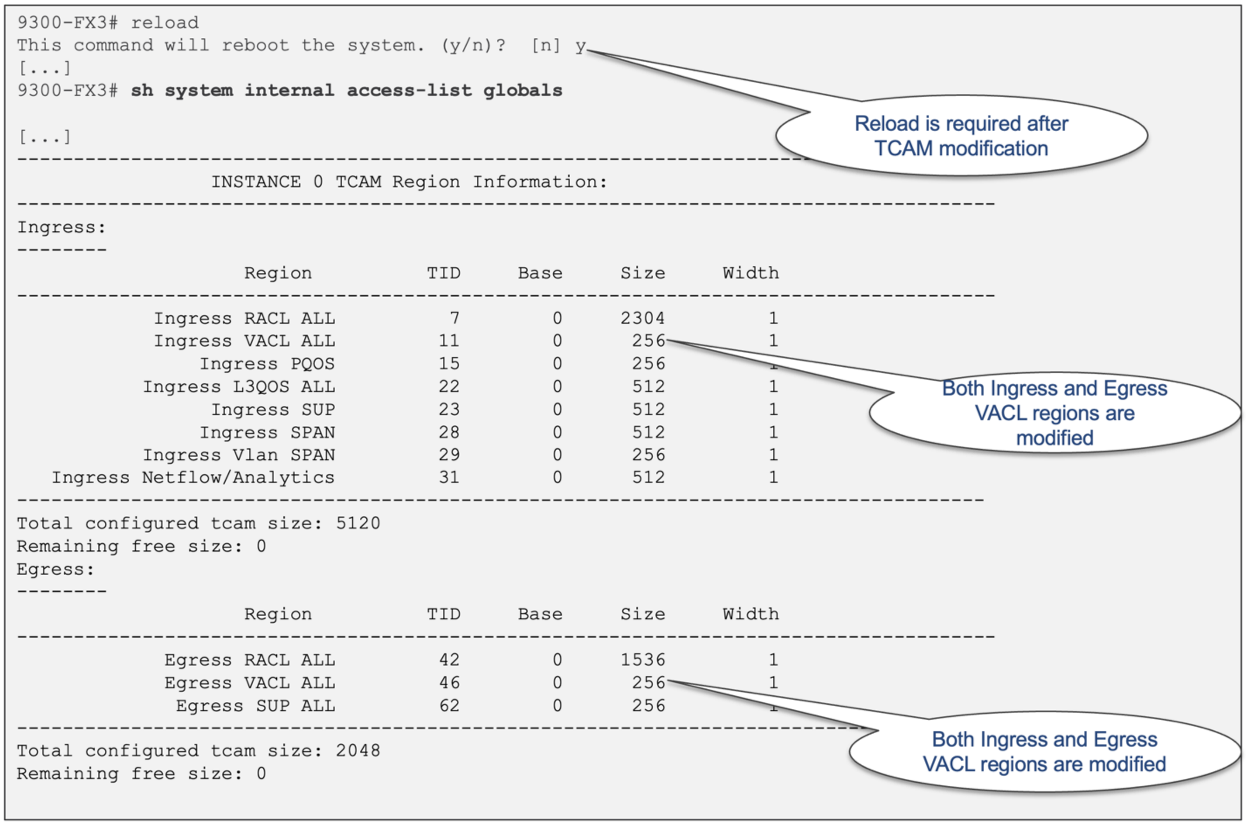


```
9300-FX3(config)# sh run | in tcam
hardware access-list tcam region ing-l2-span-filter 0

9300-FX3(config)# hardware access-list tcam region vacl 256
Aggregate TCAM region configuration exceeded the available Egress TCAM space. Please re-configure.

9300-FX3(config)# hardware access-list tcam region egr-racl 1536
Please save config and reload the system for the configuration to take effect

9300-FX3(config)# hardware access-list tcam region vacl 256
Please save config and reload the system for the configuration to take effect


9300-FX3(config)# copy running-config startup-config
[########################################] 100%
Copy complete, now saving to disk (please wait)...
Copy complete.
9300-FX3(config)# show hardware access-list tcam region | exclude "  0"
                                     VACL [vacl] size =  256
                         Ingress RACL [ing-racl] size = 2304
                     Ingress L2 QOS [ing-l2-qos] size =  256
            Ingress L3/VLAN QOS [ing-l3-vlan-qos] size =  512
                           Ingress SUP [ing-sup] size =  512
      Ingress L3 SPAN filter [ing-l3-span-filter] size =  256
                                     span [span] size =  512
                          Egress RACL [egr-racl] size = 1536
                            Egress SUP [egr-sup] size =  256
         Ingress Netflow/Analytics [ing-netflow] size =  512
```

256 Entries are available on Ingress
De-allocate 256 from Egress RACL
Even when there is enough TCAM space in Ingress for VACL
256 is allocated to both Ingress and Egress VACL regions

Figure 13 VACL region need to match for both ingress and egress

After reloading the chassis, both ingress and egress VACL regions undergo modifications, as illustrated in Figure 14.

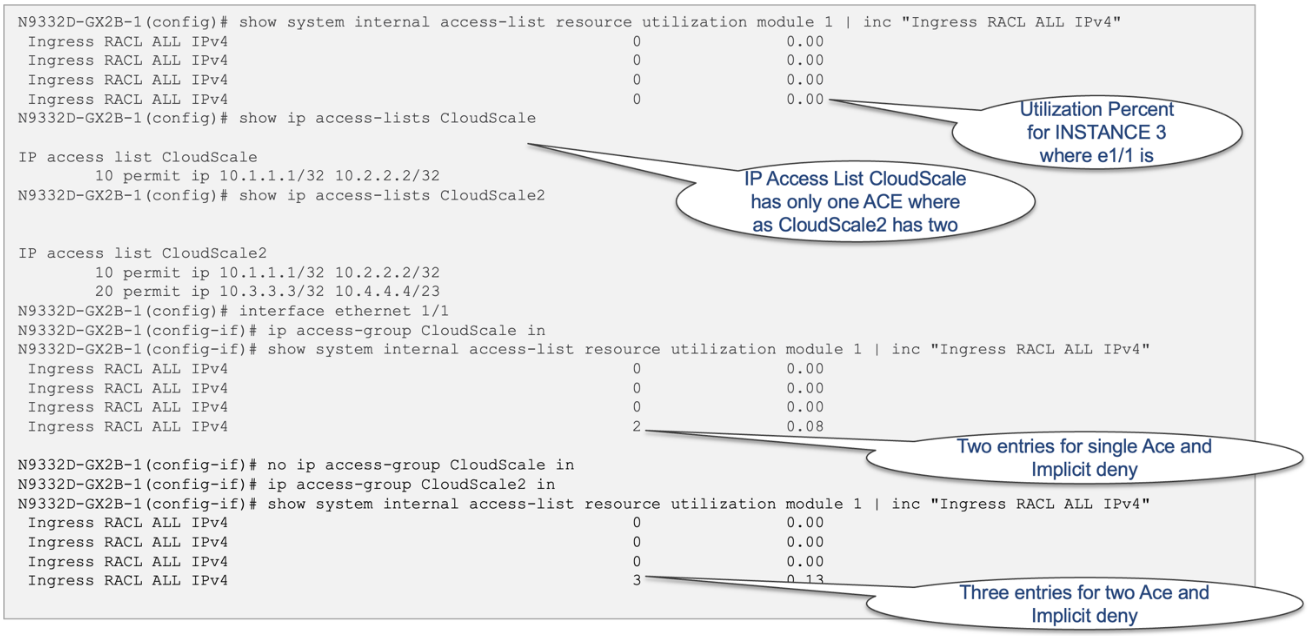


```
9300-FX3# reload
This command will reboot the system. (y/n)?  [n] y
[...]
9300-FX3# sh system internal access-list globals

[...]
--------------------------------------------------------------------------------------
                 INSTANCE 0 TCAM Region Information:
--------------------------------------------------------------------------------------
Ingress:
--------
                    Region          TID     Base     Size     Width
--------------------------------------------------------------------------------------
            Ingress RACL ALL          7        0     2304         1
            Ingress VACL ALL         11        0      256         1
                Ingress PQOS         15        0      256         1
           Ingress L3QOS ALL         22        0      512         1
                 Ingress SUP         23        0      512         1
                Ingress SPAN         28        0      512         1
           Ingress Vlan SPAN         29        0      256         1
   Ingress Netflow/Analytics         31        0      512         1
-------------------------------------------------------------------------------------
Total configured tcam size: 5120
Remaining free size: 0
Egress:
--------
                    Region          TID     Base     Size     Width
--------------------------------------------------------------------------------------
             Egress RACL ALL         42        0     1536         1
             Egress VACL ALL         46        0      256         1
              Egress SUP ALL         62        0      256         1
--------------------------------------------------------------------------------------
Total configured tcam size: 2048
Remaining free size: 0
```

Reload is required after TCAM modification
Both Ingress and Egress VACL regions are modified
Both Ingress and Egress VACL regions are modified

Figure 14 Hardware entries for both ingress and egress VACL after system reboot

For IPv4 RACLs, each Access Control Entry (ACE) occupies one entry in TCAM. Additionally, a single entry is utilized for the implicit deny all clause based on the ACL logic. Figure 15 illustrates this utilization for both a single line and a two-line ACL.

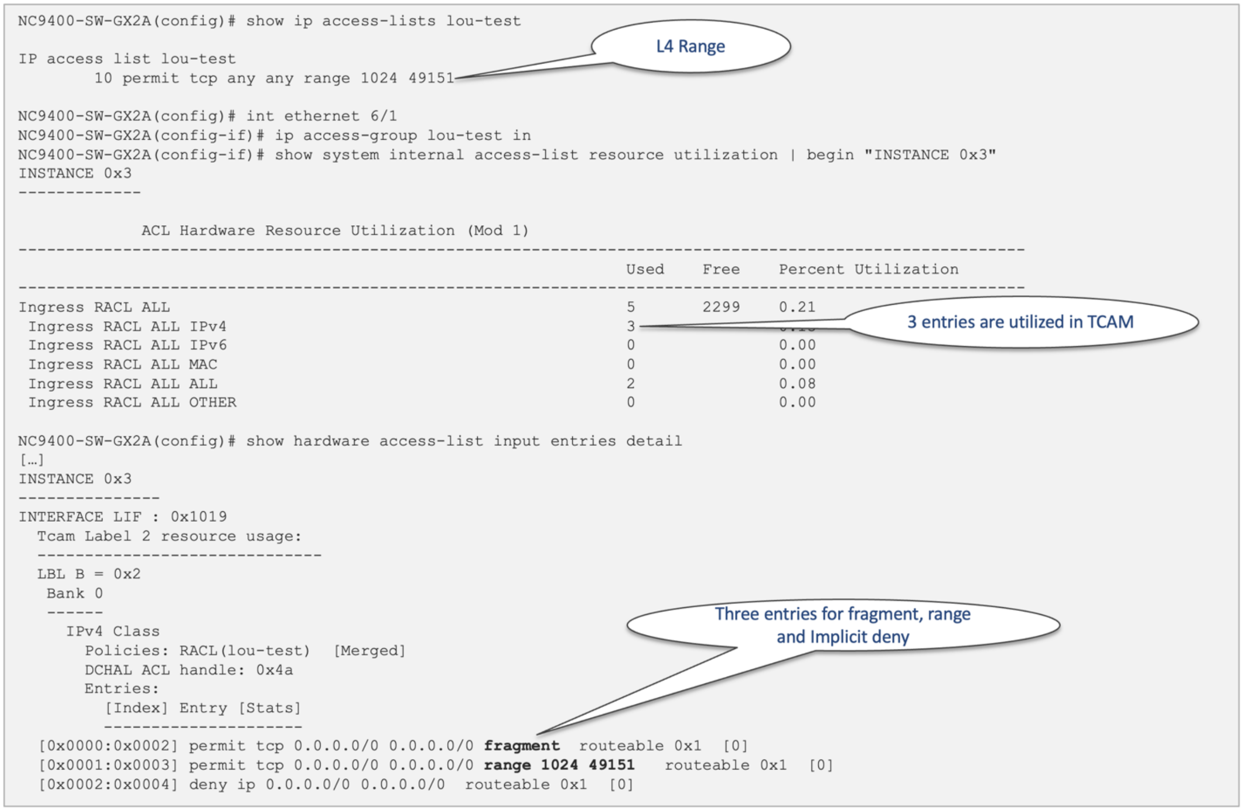


```
N9332D-GX2B-1(config)# show system internal access-list resource utilization module 1 | inc "Ingress RACL ALL IPv4"
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv4                                        0               0.00
N9332D-GX2B-1(config)# show ip access-lists CloudScale

IP access list CloudScale
        10 permit ip 10.1.1.1/32 10.2.2.2/32
N9332D-GX2B-1(config)# show ip access-lists CloudScale2


IP access list CloudScale2
        10 permit ip 10.1.1.1/32 10.2.2.2/32
        20 permit ip 10.3.3.3/32 10.4.4.4/23
N9332D-GX2B-1(config)# interface ethernet 1/1
N9332D-GX2B-1(config-if)# ip access-group CloudScale in
N9332D-GX2B-1(config-if)# show system internal access-list resource utilization module 1 | inc "Ingress RACL ALL IPv4"
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv4                                        2               0.08

N9332D-GX2B-1(config-if)# no ip access-group CloudScale in
N9332D-GX2B-1(config-if)# ip access-group CloudScale2 in
N9332D-GX2B-1(config-if)# show system internal access-list resource utilization module 1 | inc "Ingress RACL ALL IPv4"
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv4                                        3               0.13
```

Utilization Percent for INSTANCE 3 where e1/1 is
IP Access List CloudScale has only one ACE where as CloudScale2 has two
Two entries for single Ace and Implicit deny
Three entries for two Ace and Implicit deny

Figure 15 RACL utilization for one and two ACE entry RACLs

In cases where you configured a Layer 4 match within the ACL, an additional fragment ACE per Layer 4 match is introduced. Figure 16 illustrates this utilization for a single-line ACL with a Layer 4 range.

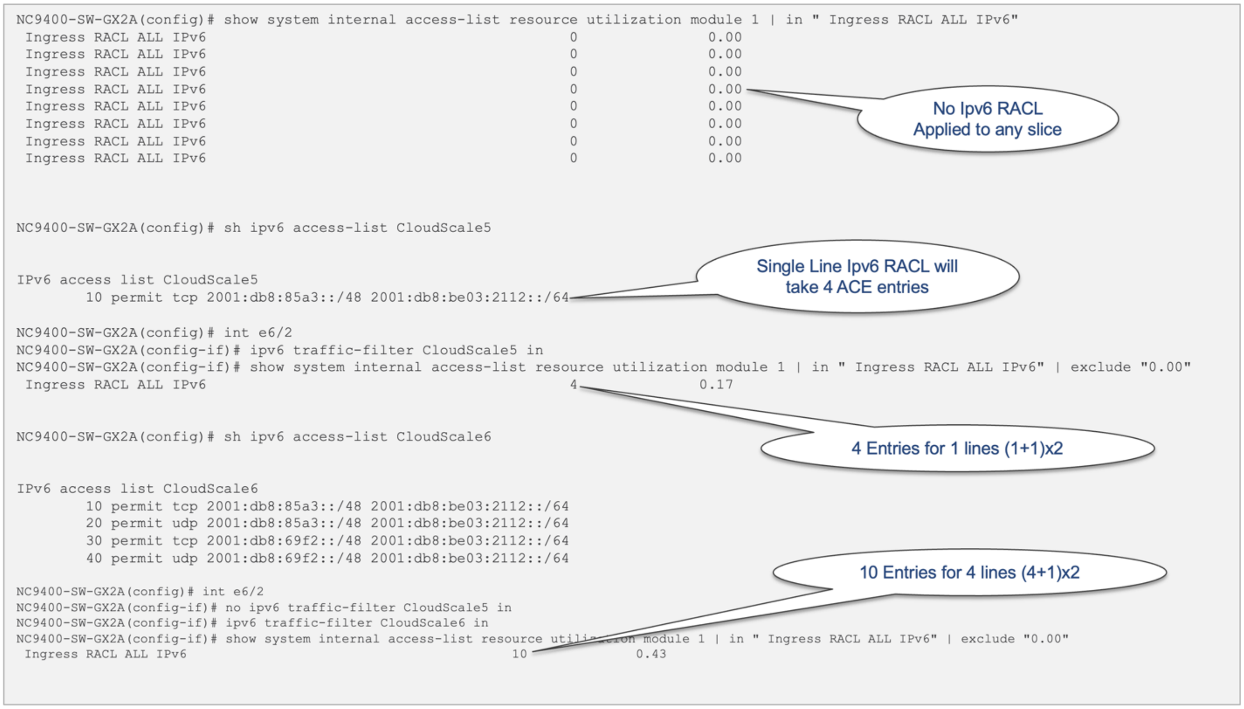


```
NC9400-SW-GX2A(config)# show ip access-lists lou-test

IP access list lou-test
        10 permit tcp any any range 1024 49151

NC9400-SW-GX2A(config)# int ethernet 6/1
NC9400-SW-GX2A(config-if)# ip access-group lou-test in
NC9400-SW-GX2A(config-if)# show system internal access-list resource utilization | begin "INSTANCE 0x3"
INSTANCE 0x3
-------------

             ACL Hardware Resource Utilization (Mod 1)
--------------------------------------------------------------------------------------------------------------
                                                                Used    Free    Percent Utilization
--------------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                                5       2299    0.21
 Ingress RACL ALL IPv4                                          3               0.13
 Ingress RACL ALL IPv6                                          0               0.00
 Ingress RACL ALL MAC                                           0               0.00
 Ingress RACL ALL ALL                                           2               0.08
 Ingress RACL ALL OTHER                                         0               0.00

NC9400-SW-GX2A(config)# show hardware access-list input entries detail
[…]
INSTANCE 0x3
---------------
INTERFACE LIF : 0x1019
  Tcam Label 2 resource usage:
  ------------------------------
  LBL B = 0x2
   Bank 0
   ------
     IPv4 Class
       Policies: RACL(lou-test)  [Merged]
       DCHAL ACL handle: 0x4a
       Entries:
         [Index] Entry [Stats]
         ---------------------
  [0x0000:0x0002] permit tcp 0.0.0.0/0 0.0.0.0/0 fragment  routeable 0x1  [0]
  [0x0001:0x0003] permit tcp 0.0.0.0/0 0.0.0.0/0 range 1024 49151   routeable 0x1  [0]
  [0x0002:0x0004] deny ip 0.0.0.0/0 0.0.0.0/0  routeable 0x1  [0]
```

L4 Range
3 entries are utilized in TCAM
Three entries for fragment, range and Implicit deny

Figure 16 RACL utilization for L4 port range

For IPv6 RACLs, each Access Control Entry (ACE) line occupies two entries in the TCAM. For example, as shown in Figure 17, if the IPv6 RACL has only one ACE line, it utilizes (1+1 implicit deny) x 2 entries in the TCAM.



```
NC9400-SW-GX2A(config)# show system internal access-list resource utilization module 1 | in " Ingress RACL ALL IPv6"
 Ingress RACL ALL IPv6                                          0                0.00
 Ingress RACL ALL IPv6                                          0                0.00
 Ingress RACL ALL IPv6                                          0                0.00
 Ingress RACL ALL IPv6                                          0                0.00
 Ingress RACL ALL IPv6                                          0                0.00
 Ingress RACL ALL IPv6                                          0                0.00
 Ingress RACL ALL IPv6                                          0                0.00
 Ingress RACL ALL IPv6                                          0                0.00


NC9400-SW-GX2A(config)# sh ipv6 access-list CloudScale5


IPv6 access list CloudScale5
        10 permit tcp 2001:db8:85a3::/48 2001:db8:be03:2112::/64

NC9400-SW-GX2A(config)# int e6/2
NC9400-SW-GX2A(config-if)# ipv6 traffic-filter CloudScale5 in
NC9400-SW-GX2A(config-if)# show system internal access-list resource utilization module 1 | in " Ingress RACL ALL IPv6" | exclude "0.00"
 Ingress RACL ALL IPv6                                          4               0.17


NC9400-SW-GX2A(config)# sh ipv6 access-list CloudScale6


IPv6 access list CloudScale6
        10 permit tcp 2001:db8:85a3::/48 2001:db8:be03:2112::/64
        20 permit udp 2001:db8:85a3::/48 2001:db8:be03:2112::/64
        30 permit tcp 2001:db8:69f2::/48 2001:db8:be03:2112::/64
        40 permit udp 2001:db8:69f2::/48 2001:db8:be03:2112::/64

NC9400-SW-GX2A(config)# int e6/2
NC9400-SW-GX2A(config-if)# no ipv6 traffic-filter CloudScale5 in
NC9400-SW-GX2A(config-if)# ipv6 traffic-filter CloudScale6 in
NC9400-SW-GX2A(config-if)# show system internal access-list resource utilization module 1 | in " Ingress RACL ALL IPv6" | exclude "0.00"
 Ingress RACL ALL IPv6                                          10               0.43
```

No Ipv6 RACL
Applied to any slice

Single Line Ipv6 RACL will
take 4 ACE entries

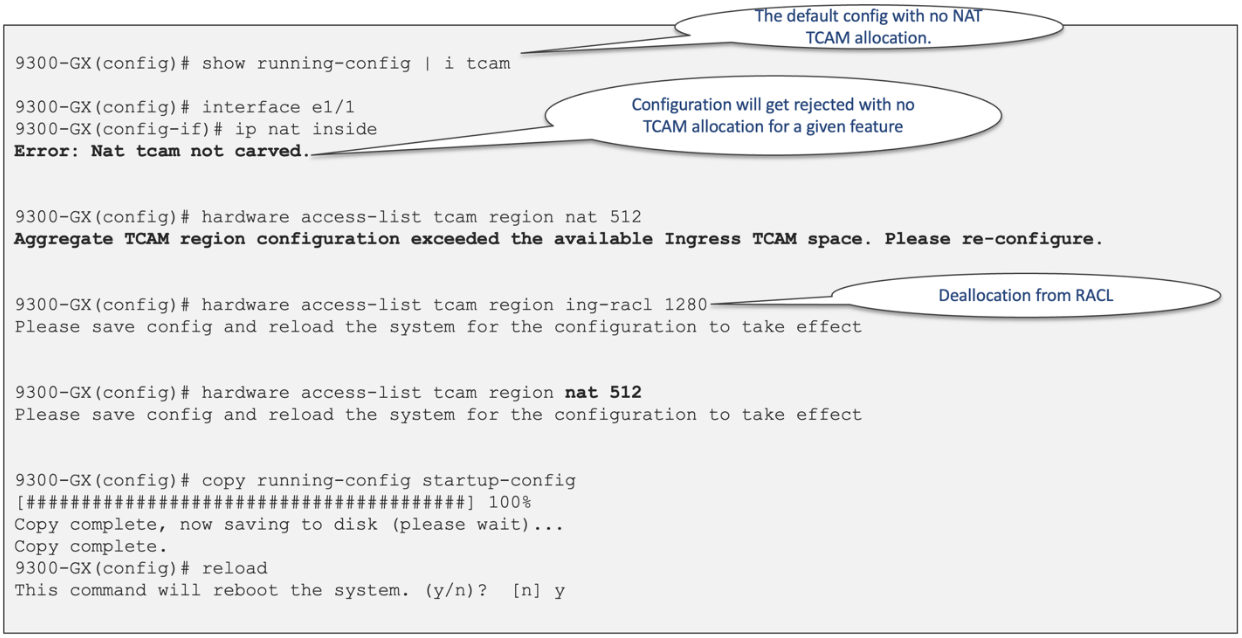
4 Entries for 1 lines (1+1)x2

10 Entries for 4 lines (4+1)x2

Figure 17 TCAM utilization for IPv6 RACLs

NAT TCAM Region

By default, no TCAM entries are allocated for the NAT feature, except for Nexus 9300-H2R and Nexus 9300-H1. To enable the NAT feature, you must allocate TCAM space by adjusting the TCAM size of other features. You can achieve this using the " hardware access-list tcam region nat tcam-size" command. In Cisco Nexus 9000 family switches, NAT utilizes the TCAM table for packet matching based on IP address or port. If you attempt to configure a TCAM-required feature before allocating sufficient TCAM space, the configuration is rejected when it is applied to the interface. For the specific configuration of NAT TCAM on Cisco Nexus 9300-GX, see Figure 18. As always, you must reload the system for the TCAM configuration to take effect. In the event that a required TCAM region for a particular feature is removed while the feature is in use, after the switch is reloaded, the interface-level configuration of that specific feature is also removed. Figure 19 illustrates an example of NAT configuration removal after the NAT TCAM region has been taken out.



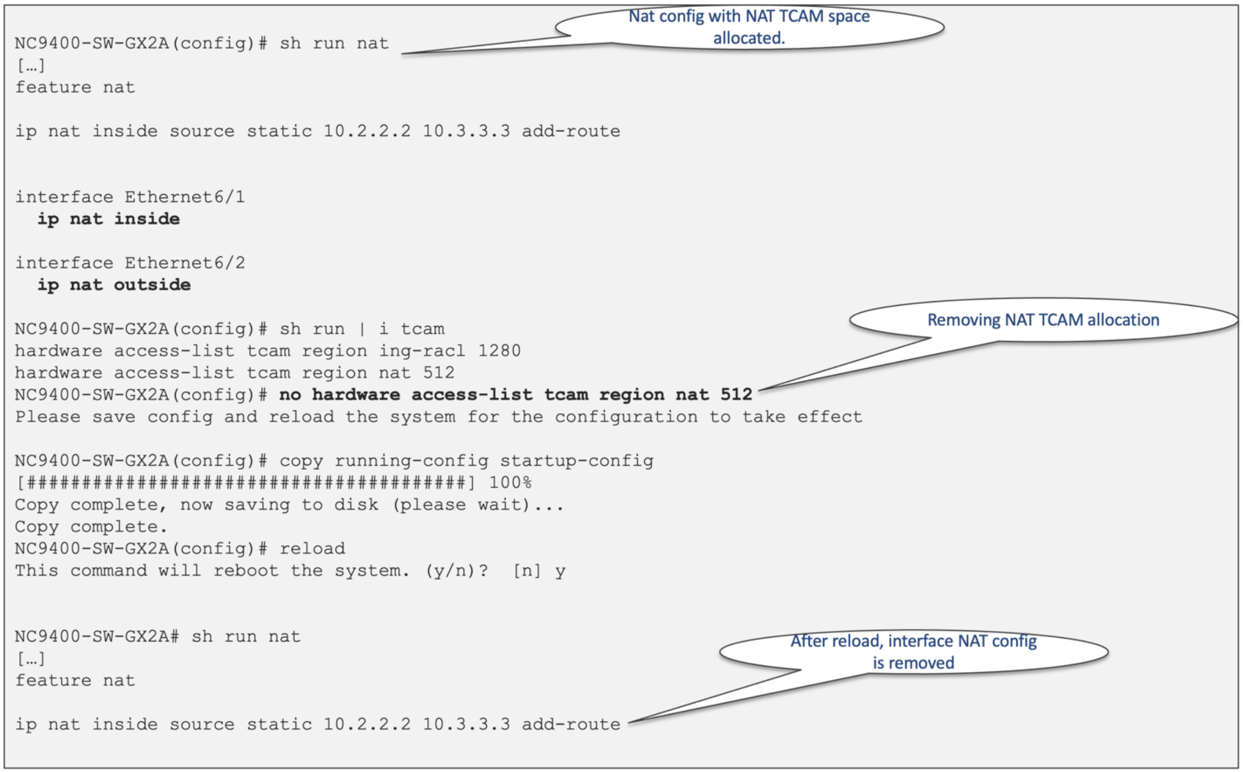
```
9300-GX(config)# show running-config | i tcam

9300-GX(config)# interface e1/1
9300-GX(config-if)# ip nat inside
Error: Nat tcam not carved.


9300-GX(config)# hardware access-list tcam region nat 512
Aggregate TCAM region configuration exceeded the available Ingress TCAM space. Please re-configure.


9300-GX(config)# hardware access-list tcam region ing-racl 1280
Please save config and reload the system for the configuration to take effect


9300-GX(config)# hardware access-list tcam region nat 512
Please save config and reload the system for the configuration to take effect


9300-GX(config)# copy running-config startup-config
[########################################] 100%
Copy complete, now saving to disk (please wait)...
Copy complete.
9300-GX(config)# reload
This command will reboot the system. (y/n)?  [n] y
```

The default config with no NAT TCAM allocation.

Configuration will get rejected with no TCAM allocation for a given feature

Deallocation from RACL

Figure 18 TCAM allocation for NAT with Nexus 9300-GX



```
NC9400-SW-GX2A(config)# sh run nat
[…]
feature nat

ip nat inside source static 10.2.2.2 10.3.3.3 add-route


interface Ethernet6/1
  ip nat inside

interface Ethernet6/2
  ip nat outside

NC9400-SW-GX2A(config)# sh run | i tcam
hardware access-list tcam region ing-racl 1280
hardware access-list tcam region nat 512
NC9400-SW-GX2A(config)# no hardware access-list tcam region nat 512
Please save config and reload the system for the configuration to take effect

NC9400-SW-GX2A(config)# copy running-config startup-config
[########################################] 100%
Copy complete, now saving to disk (please wait)...
Copy complete.
NC9400-SW-GX2A(config)# reload
This command will reboot the system. (y/n)?  [n] y


NC9400-SW-GX2A# sh run nat
[…]
feature nat

ip nat inside source static 10.2.2.2 10.3.3.3 add-route
```

Nat config with NAT TCAM space allocated.

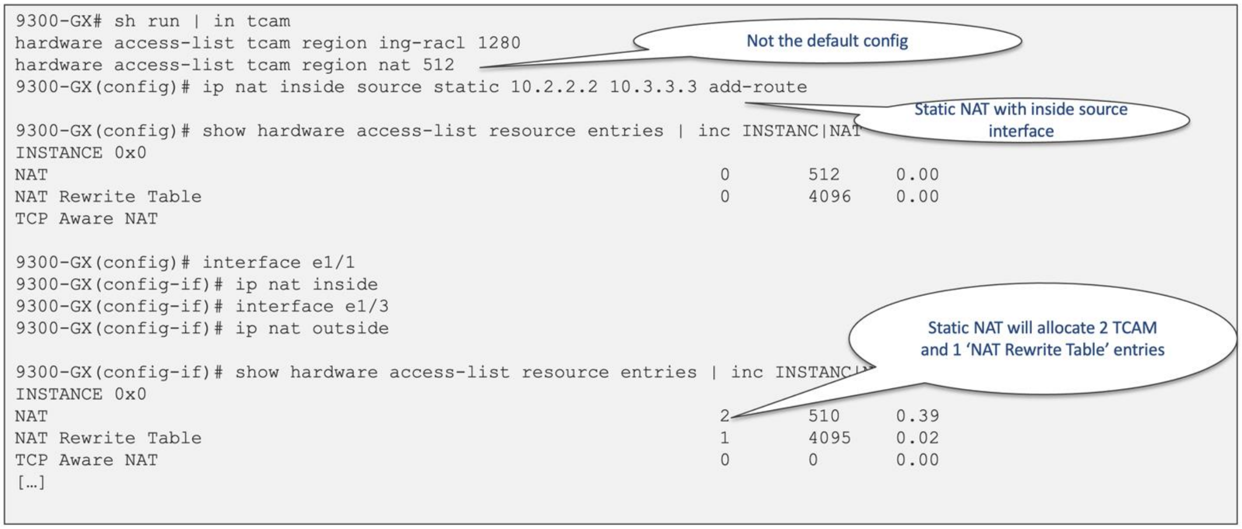
Removing NAT TCAM allocation

After reload, interface NAT config is removed

Figure 19 Interface configuration removal after TCAM space deallocation

In addition to the TCAM table, NAT rewrites and translations are stored in the " NAT Rewrite Table," which exists outside of the NAT TCAM region. The 'NAT Rewrite Table' has a fixed size of 2048 entries for Nexus 9300-EX/FX/FX2/9300C and 4096 entries for Nexus 9300-FX3/GX/GX2A/GX2B/H2R/H1. This table is exclusively used for NAT translations.

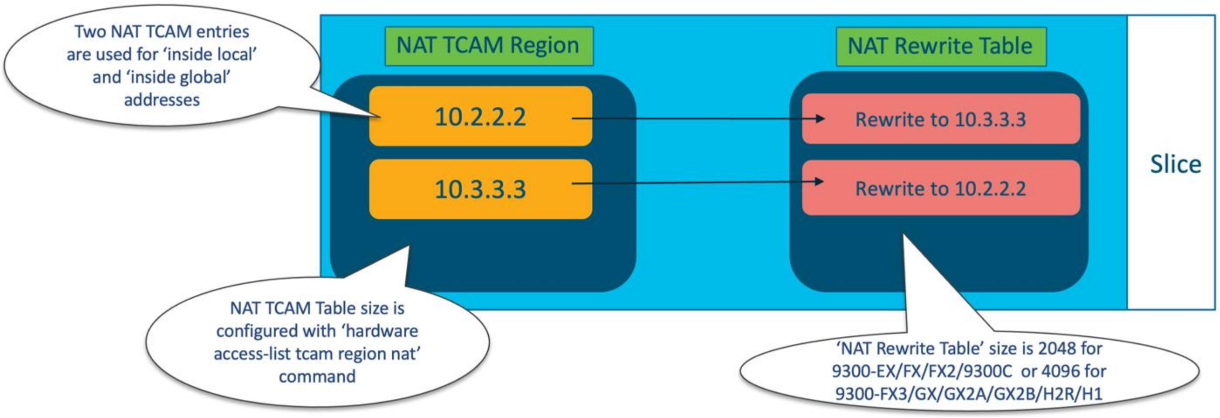
Each Static NAT/PAT entry for inside or outside source addresses requires two NAT TCAM entries and one " NAT Rewrite Table" entry, as shown in Figure 20. Additionally, Figure 21 illustrates the NAT translation architecture with Cisco Nexus 9000.



```
9300-GX# sh run | in tcam
hardware access-list tcam region ing-racl 1280
hardware access-list tcam region nat 512
9300-GX(config)# ip nat inside source static 10.2.2.2 10.3.3.3 add-route

9300-GX(config)# show hardware access-list resource entries | inc INSTANC|NAT
INSTANCE 0x0
NAT                                                          0       512     0.00
NAT Rewrite Table                                            0       4096    0.00
TCP Aware NAT

9300-GX(config)# interface e1/1
9300-GX(config-if)# ip nat inside
9300-GX(config-if)# interface e1/3
9300-GX(config-if)# ip nat outside

9300-GX(config-if)# show hardware access-list resource entries | inc INSTANC|
INSTANCE 0x0
NAT                                                          2       510     0.39
NAT Rewrite Table                                            1       4095    0.02
TCP Aware NAT                                                0       0       0.00
[…]
```

Not the default config
Static NAT with inside source interface
Static NAT will allocate 2 TCAM and 1 'NAT Rewrite Table' entries

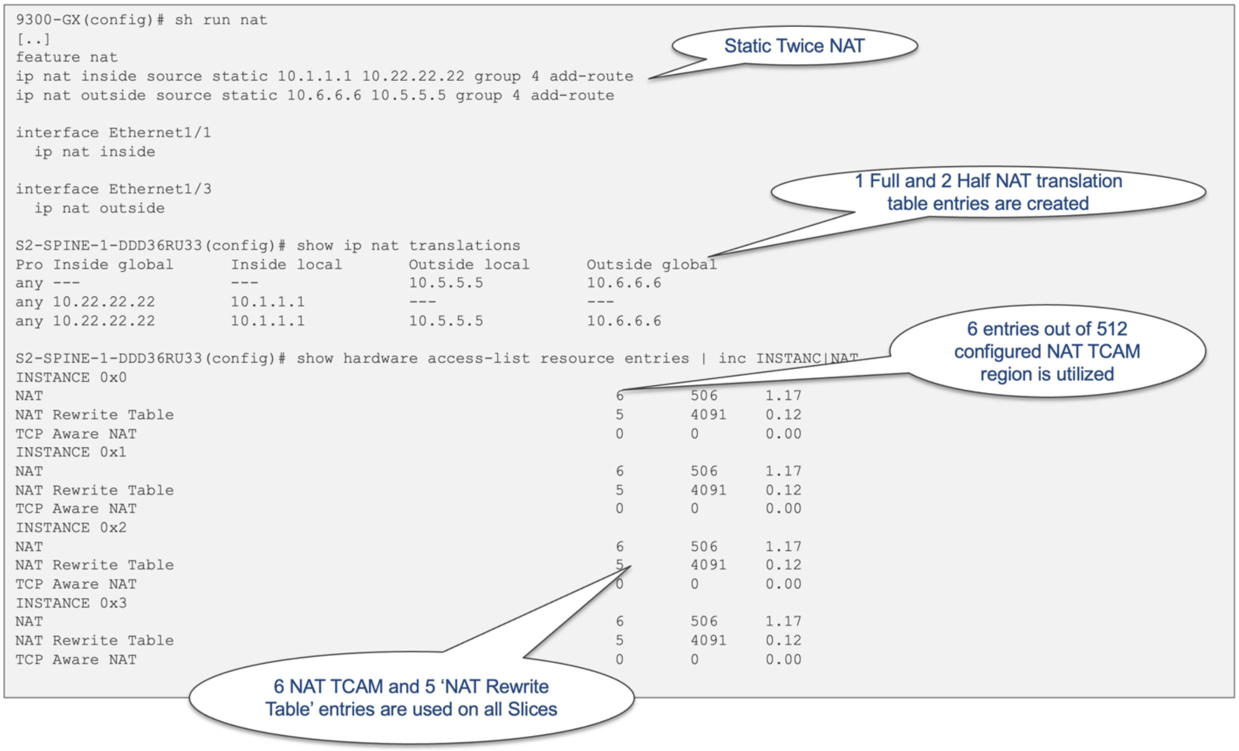
Figure 20 Static NAT/PAT TACM utilization



Two NAT TCAM entries are used for 'inside local' and 'inside global' addresses
NAT TCAM Region
10.2.2.2
10.3.3.3
NAT Rewrite Table
Rewrite to 10.3.3.3
Rewrite to 10.2.2.2
Slice
NAT TCAM Table size is configured with 'hardware access-list tcam region nat' command
'NAT Rewrite Table' size is 2048 for 9300-EX/FX/FX2/9300C or 4096 for 9300-FX3/GX/GX2A/GX2B/H2R/H1

Figure 21 NAT TCAM region and the "NAT Rewrite" table

The utilization of NAT TCAM and the " NAT Rewrite Table" depends on the specific NAT configuration. For example, a static twice NAT configuration will allocate 6 TCAM entries and 5 " NAT Rewrite Table" entries, as depicted in Figure 22. It is important to note that all ASIC slices will have identical allocation for NAT resources.



```
9300-GX(config)# sh run nat
[..]
feature nat
ip nat inside source static 10.1.1.1 10.22.22.22 group 4 add-route
ip nat outside source static 10.6.6.6 10.5.5.5 group 4 add-route

interface Ethernet1/1
  ip nat inside

interface Ethernet1/3
  ip nat outside

S2-SPINE-1-DDD36RU33(config)# show ip nat translations
Pro Inside global      Inside local       Outside local      Outside global
any ---                ---                10.5.5.5           10.6.6.6
any 10.22.22.22        10.1.1.1           ---                ---
any 10.22.22.22        10.1.1.1           10.5.5.5           10.6.6.6

S2-SPINE-1-DDD36RU33(config)# show hardware access-list resource entries | inc INSTANC|NAT
INSTANCE 0x0
NAT                                                         6       506     1.17
NAT Rewrite Table                                           5       4091    0.12
TCP Aware NAT                                               0       0       0.00
INSTANCE 0x1
NAT                                                         6       506     1.17
NAT Rewrite Table                                           5       4091    0.12
TCP Aware NAT                                               0       0       0.00
INSTANCE 0x2
NAT                                                         6       506     1.17
NAT Rewrite Table                                           5       4091    0.12
TCP Aware NAT                                               0       0       0.00
INSTANCE 0x3
NAT                                                         6       506     1.17
NAT Rewrite Table                                           5       4091    0.12
TCP Aware NAT                                               0       0       0.00
```

Static Twice NAT

1 Full and 2 Half NAT translation table entries are created

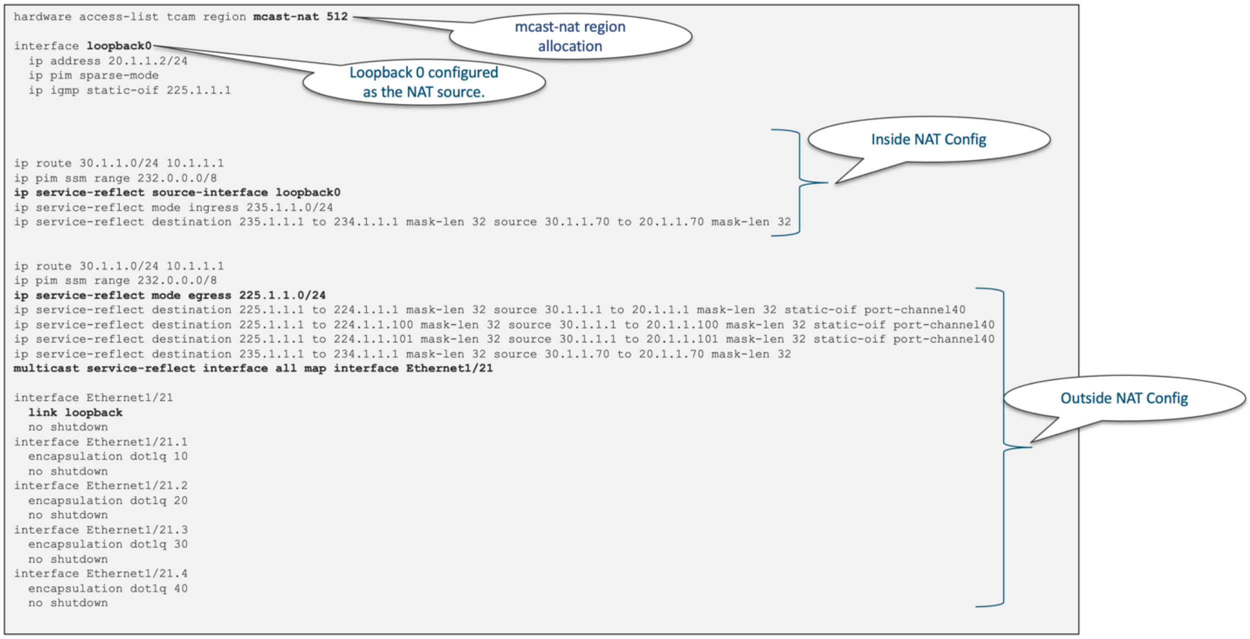
6 entries out of 512 configured NAT TCAM region is utilized

6 NAT TCAM and 5 'NAT Rewrite Table' entries are used on all Slices

Figure 22 Static twice NAT TCAM allocation

Multicast NAT TCAM Region

The Multicast Service Reflection feature enables you to translate externally received multicast destination addresses to addresses that conform to your organization's internal addressing policy. It is the multicast Network Address Translation (NAT) of an externally received multicast stream (S1,G1) to (S2,G2) into the internal domain. Unlike IP NAT, which only translates the source IP address, Multicast Service Reflection translates both the source and destination addresses. For Nexus 9000 to support the Multicast Service Reflection feature, you must carve the " mcast-nat" TCAM region before configuring multicast NAT. Figure 23 illustrates a sample configuration for Multicast Service Reflection.



```
hardware access-list tcam region mcast-nat 512

interface loopback0
  ip address 20.1.1.2/24
  ip pim sparse-mode
  ip igmp static-oif 225.1.1.1



ip route 30.1.1.0/24 10.1.1.1
ip pim ssm range 232.0.0.0/8
ip service-reflect source-interface loopback0
ip service-reflect mode ingress 235.1.1.0/24
ip service-reflect destination 235.1.1.1 to 234.1.1.1 mask-len 32 source 30.1.1.70 to 20.1.1.70 mask-len 32


ip route 30.1.1.0/24 10.1.1.1
ip pim ssm range 232.0.0.0/8
ip service-reflect mode egress 225.1.1.0/24
ip service-reflect destination 225.1.1.1 to 224.1.1.1 mask-len 32 source 30.1.1.1 to 20.1.1.1 mask-len 32 static-oif port-channel40
ip service-reflect destination 225.1.1.1 to 224.1.1.100 mask-len 32 source 30.1.1.1 to 20.1.1.100 mask-len 32 static-oif port-channel40
ip service-reflect destination 225.1.1.1 to 224.1.1.101 mask-len 32 source 30.1.1.1 to 20.1.1.101 mask-len 32 static-oif port-channel40
ip service-reflect destination 235.1.1.1 to 234.1.1.1 mask-len 32 source 30.1.1.70 to 20.1.1.70 mask-len 32
multicast service-reflect interface all map interface Ethernet1/21

interface Ethernet1/21
  link loopback
  no shutdown
interface Ethernet1/21.1
  encapsulation dot1q 10
  no shutdown
interface Ethernet1/21.2
  encapsulation dot1q 20
  no shutdown
interface Ethernet1/21.3
  encapsulation dot1q 30
  no shutdown
interface Ethernet1/21.4
  encapsulation dot1q 40
  no shutdown
```

mcast-nat region allocation

Loopback 0 configured as the NAT source.

Inside NAT Config

Outside NAT Config

Figure 23 Multicast service reflection configuration

Dynamic ACL (DACL) Region

Dynamic ACL (DACL) is a single ACL that contains permissions of what users and groups can access. It restricts access to the dot1q MAB client. The DACL policy is pushed from the Cisco ISE server to block list a MAC address. It applies ACLs on the block listed MAC, enabling limited access to the MAB. A single DACL supports all block listed MAB clients. For all block listed clients, DACLs support a single global ACL on the switch. The ACL name received from the centralized ISE server should match the preconfigured ACL name on the switch. Block listed client traffic is filtered based on the fixed ACL rules applied for DNS, DHCP, and BOOTPC protocols. For the specifics of the DACL TCAM regions, see Table 5.

Table 5 Cisco Cloud Scale DACL TCAM region

Name	Description	CLI Configuration	Region Name

DACL	Dynamic ACL (DACL) is a single ACL that contains permissions of what users and groups can access. It restricts access to the dot1q MAB client. DACLs support authentication only by MAC Authentication Bypass. In Cisco NX-OS release 9.3(5), the DACL is preconfigured on the Cisco Nexus switches.
	Beginning with Cisco NX-OS release 9.3(5), DACLs are supported on Cisco Nexus 9336-FX2, Nexus 9236C, Nexus 93108TC-EX, and Nexus 93180YC-EX switches.
	Beginning with Cisco NX-OS release 10.1(2), DACLs are supported on the N9K-C9364D-GX2A and N9K-C9332D-GX2B platform switches.
		`hardware access-list tcam region ing-dacl 256`
		`ip access-list creative_blocklist`
			ing-dacl: For ingress only. The configured ACL name on the device must match the acl-name received from the ISE server.
			The ACL policy is pushed from the ISE server.
			`"show ip access-lists dynamic" displays the details.`

ACL TCAM Regions for QoS Policy

Cisco Nexus 9000 supports three types of policy maps: network-qos, QoS, and queueing. The QoS policy map is primarily used for classification, marking, and policing, mostly on ingress, except for egress policing. The queueing policy map, on the other hand, is utilized for egress queueing and scheduling. Among these three types, only the QoS policy requires TCAM resources.

QoS policies can be applied to Layer 3 interfaces, switch ports, port channels, VLANs, and logical interfaces such as Network Virtual Interface (NVE). The specific QoS TCAM region to be carved depends on where the policy is applied and which classifier is used. There are two QoS regions in the Cisco Cloud Scale ASIC:

1. The ingress Layer 2 QoS or "ing-l2-qos" region is used when classification is on a Layer 2 interface. The same TCAM bank is shared for MAC, IPv4, and IPv6 entries. IPv4 and MAC types occupy one TCAM entry, whereas IPv6 types occupy two TCAM entries.
2. The ingress Layer 3/VLAN QoS or "ing-l3-vlan-qos" is used when classification is on a Layer 3 or SVI interface. Similar to "ing-l2-qos," the TCAM bank is shared for MAC, IPv4, and IPv6 entries.

For the specifics of the two QoS ACL TCAM regions, see Table 6.

Table 6 Cisco Cloud Scale ACL TCAM regions for QoS policy

Name	Description	CLI Configuration	Region Name
Ingress Layer 2	When classification is on a Layer 2 interface. The same TCAM bank is shared for MAC, IPv4, and IPv6 entries. IPv4 and MAC types occupy one TCAM entry whereas	`class-map type qos match-any class_dscp match dscp 18`	**ing-l2-qos**: For ingress IPv4, IPv6, and MAC port

Name	Description	CLI Configuration	Region Name

QOS	IPv6 types occupy two TCAM entries.	`policy-map type qos CS_policy class class_dscp set qos-group 2`
		`interface Ethernet 6/3 switchport switchport mode trunk service-policy type qos input CS_policy`
			ACLs.

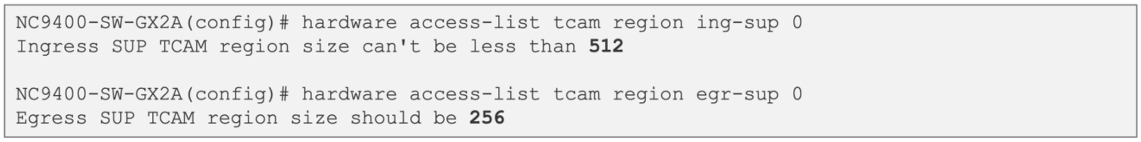
Ingress Layer 3/VLAN QOS	When classification is on a Layer 3 or SVI interface. The same TCAM bank is shared for MAC, IPv4, and IPv6 entries. IPv4 and MAC types occupy one TCAM entry whereas IPv6 types occupy two TCAM entries.	`class-map type qos match-any class_dscp match dscp 18`
		`policy-map type qos CS_policy class class_dscp set qos-group 2`
		`interface Ethernet 6/2 service-policy type qos input CS_policy ip address 172.16.33.1/24`
			ing-l3-vlan-qos: For ingress IPv4, IPv6, and MAC port ACLs.

Ing-redirect, Ing-sup and Egr-sup TCAM Regions

With the Cisco Nexus 9000 switch family, the " ing-redirect" TCAM region is considered as additional entries to the " ing-sup" region. Control plane traffic, such as BFD and CoPP, exclusively utilizes the " ing-sup" region. For DHCPv4/v6, the default configuration utilizes the " ing-sup" region, and no additional TCAM carving is required. However, when you enable the " ip dhcp relay subnet-broadcast" command, more TCAM entries per subnet/per interface become necessary. As a result, with the use of the " ip dhcp relay subnet-broadcast" command, DHCP also requires the " ing-redirect" TCAM region.

On the other hand, the " egr-sup" region is reserved for system messages. The default TCAM entry for the " ing-sup" region is 512 for Nexus 9300 and 768 for Nexus 9500 with CloudScale ASIC LCs. For the " ing-redirect" region, the default TCAM entry is 0 for Nexus 9300 and 256 for Nexus 9500 with CloudScale ASIC line cards. You must increase the default " ing-sup" and " egr-sup" regions with large custom Control Plane Policing (CoPP) policies.

It is important to note that the " ing-sup" region cannot be set lower than 512 entries, while the minimum size for the " egr-sup" region is 256 entries. For a visual representation of the required minimum entries for these regions, see Figure 24.



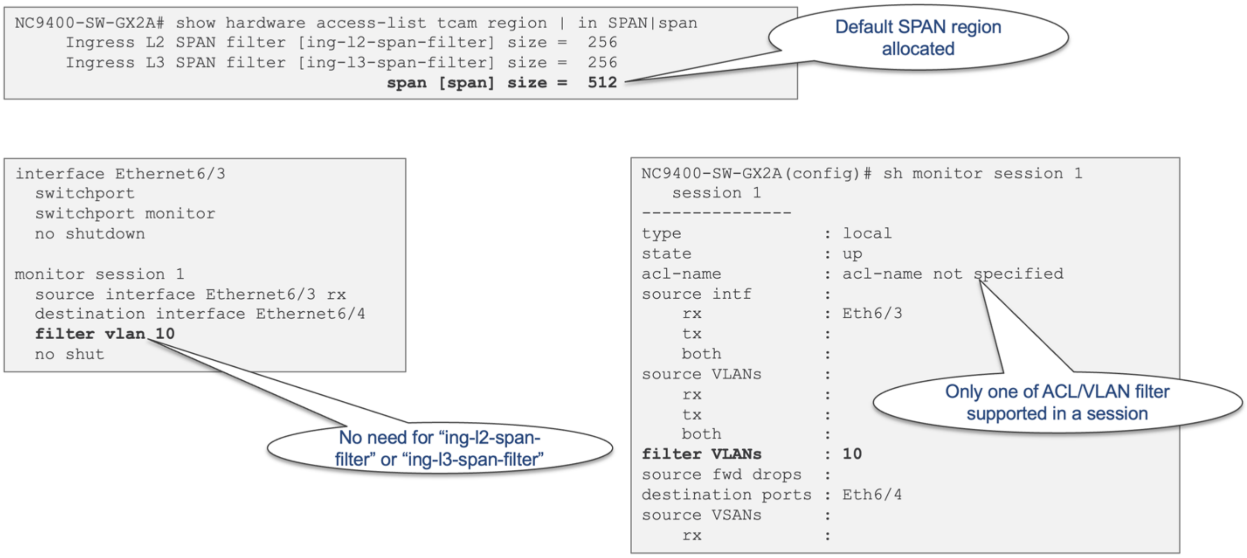
```
NC9400-SW-GX2A(config)# hardware access-list tcam region ing-sup 0
Ingress SUP TCAM region size can't be less than 512

NC9400-SW-GX2A(config)# hardware access-list tcam region egr-sup 0
Egress SUP TCAM region size should be 256
```

Figure 24 Minimum required space for "ing-sup" and "egr-sup"

SPAN TCAM Region

SPAN TCAM entries are essential when enabling SPAN on Cisco Nexus 9000 switches for any port and any port type. However, a VLAN filter used in SPAN also utilizes the SPAN region, and no additional region is required for it. Additionally, sFlow also utilizes the TCAM SPAN region.

Starting with the Cisco Nexus 9300-FX2 model, simultaneous utilization of sFlow and SPAN features becomes viable. However, for earlier Nexus 9300-EX and Nexus 9300-FX models, activating both SPAN and sFlow features concurrently is not achievable. The default allocation for the SPAN TCAM region is 512 entries, and it can only be carved in multiples of 512 entries. For a visual representation of the default SPAN region allocation, see Figure 25.



```
NC9400-SW-GX2A# show hardware access-list tcam region | in SPAN|span
     Ingress L2 SPAN filter [ing-l2-span-filter] size =  256
     Ingress L3 SPAN filter [ing-l3-span-filter] size =  256
                                   span [span] size =  512
```

Default SPAN region allocated

```
interface Ethernet6/3
  switchport
  switchport monitor
  no shutdown

monitor session 1
  source interface Ethernet6/3 rx
  destination interface Ethernet6/4
  filter vlan 10
  no shut
```

No need for “ing-l2-span-filter” or “ing-l3-span-filter”

```
NC9400-SW-GX2A(config)# sh monitor session 1
   session 1
---------------
type              : local
state             : up
acl-name          : acl-name not specified
source intf       :
    rx            : Eth6/3
    tx            :
    both          :
source VLANs      :
    rx            :
    tx            :
    both          :
filter VLANs      : 10
source fwd drops  :
destination ports : Eth6/4
source VSANs      :
    rx            :
```

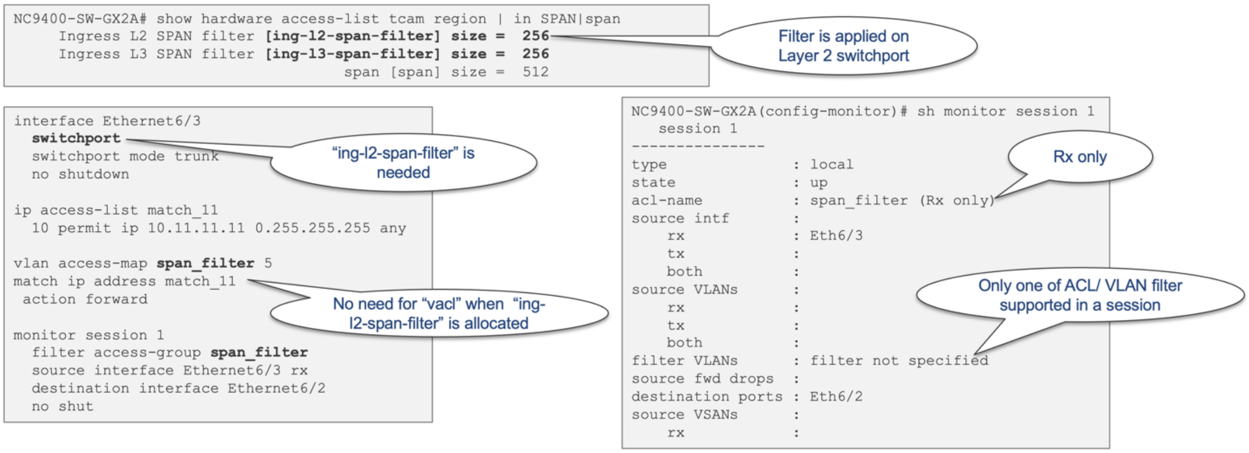
Only one of ACL/VLAN filter supported in a session

Figure 25 Default SPAN region allocation for Cisco Nexus 9408 chassis

Layer 2 and Layer 3 SPAN Filter TCAM Regions

The Layer 2 and Layer 3 SPAN filter TCAM regions come into play when configuring access group filtering in a SPAN session. This ensures that only the traffic aligning with the ACL on the source interfaces will be subjected to SPAN. The " ing-l2-span-filter" region is necessary when SPAN filtering is applied to a Layer 2 port, while the " ing-l3-span-filter" region is used when SPAN filtering is applied to a Layer 3 interface. Both Layer 2 and Layer 3 SPAN filter regions are initially allocated with 256 entries in the default configuration.

When setting up an access-group filter in a SPAN session, it must be configured as a vlan-accessmap. However, the VACL region is not required for SPAN ACL filter support. To better understand the use case for these two regions, see Figure 26.



```
NC9400-SW-GX2A# show hardware access-list tcam region | in SPAN|span
     Ingress L2 SPAN filter [ing-l2-span-filter] size =  256
     Ingress L3 SPAN filter [ing-l3-span-filter] size =  256
                                   span [span] size =  512
```

Filter is applied on Layer 2 switchport

```
interface Ethernet6/3
  switchport
  switchport mode trunk
  no shutdown

ip access-list match_11
  10 permit ip 10.11.11.11 0.255.255.255 any

vlan access-map span_filter 5
match ip address match_11
 action forward

monitor session 1
  filter access-group span_filter
  source interface Ethernet6/3 rx
  destination interface Ethernet6/2
  no shut
```

“ing-l2-span-filter” is needed

No need for “vacl” when “ing-l2-span-filter” is allocated

```
NC9400-SW-GX2A(config-monitor)# sh monitor session 1
   session 1
---------------
type              : local
state             : up
acl-name          : span_filter (Rx only)
source intf       :
    rx            : Eth6/3
    tx            :
    both          :
source VLANs      :
    rx            :
    tx            :
    both          :
filter VLANs      : filter not specified
source fwd drops  :
destination ports : Eth6/2
source VSANs      :
    rx            :
```

Rx only

Only one of ACL/ VLAN filter supported in a session

Figure 26 Ingress Layer 2 and Layer 3 SPAN filter use case

NetFlow and Analytics TCAM Region

Cisco NX-OS supports the flexible NetFlow feature that enables enhanced network anomalies and security detection by identification of packet flows for ingress IP packets and provides statistics based on these packet flows. Flexible NetFlow allows customers to define an optimal flow record for a particular application by selecting the keys from a large collection of predefined fields.

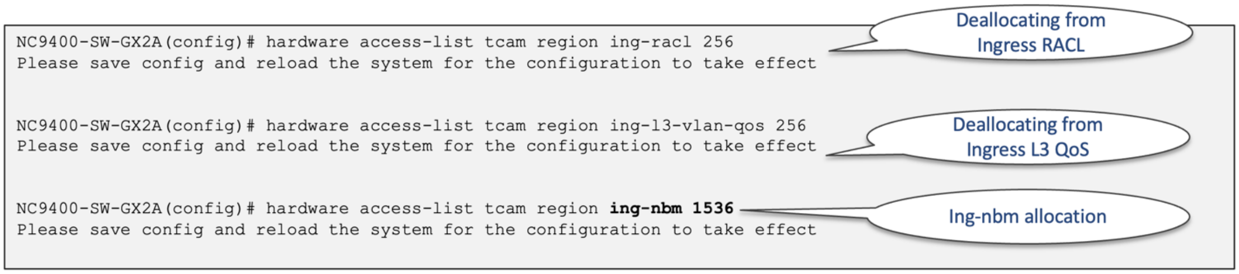
By default, all Cisco Nexus 9300 switches have 512 TCAM entries allocated to the " ing-netflow" TCAM region and no additional carving is needed for NetFlow to work. This region is also used for flow table hardware telemetry that is exported to Cisco Nexus Dashboard Insights (NDI).

Non-Blocking Multicast (NBM) TCAM Region

In IT data centers, Equal-Cost Multipath (ECMP) is highly efficient due to the predominance of Transmission Control Protocol (TCP)-based traffic, which generates numerous flows and results in a more uniform distribution of the load across all paths. However, in media data centers that handle uncompressed video, audio, and ancillary flows, ECMP routing may not always be efficient. In such scenarios, there's a risk that all video flows will be hashed along the same path, causing oversubscription of that particular path.

To address the limitations, Cisco developed the Non-Blocking Multicast (NBM) process on NX-OS, which enhances the intelligence of PIM. NBM introduces bandwidth awareness to PIM, allowing it to consider bandwidth availability when setting up flow paths. By combining NBM and PIM, a network can achieve intelligent and efficient multicast delivery, preventing oversubscription and ensuring sufficient bandwidth for the multicast traffic.

By default, the " ing-nbm" region is not allocated any TCAM space. Figure 27 illustrates the TCAM allocation for the " ing-nbm" region.



```
NC9400-SW-GX2A(config)# hardware access-list tcam region ing-racl 256
Please save config and reload the system for the configuration to take effect


NC9400-SW-GX2A(config)# hardware access-list tcam region ing-l3-vlan-qos 256
Please save config and reload the system for the configuration to take effect


NC9400-SW-GX2A(config)# hardware access-list tcam region ing-nbm 1536
Please save config and reload the system for the configuration to take effect
```

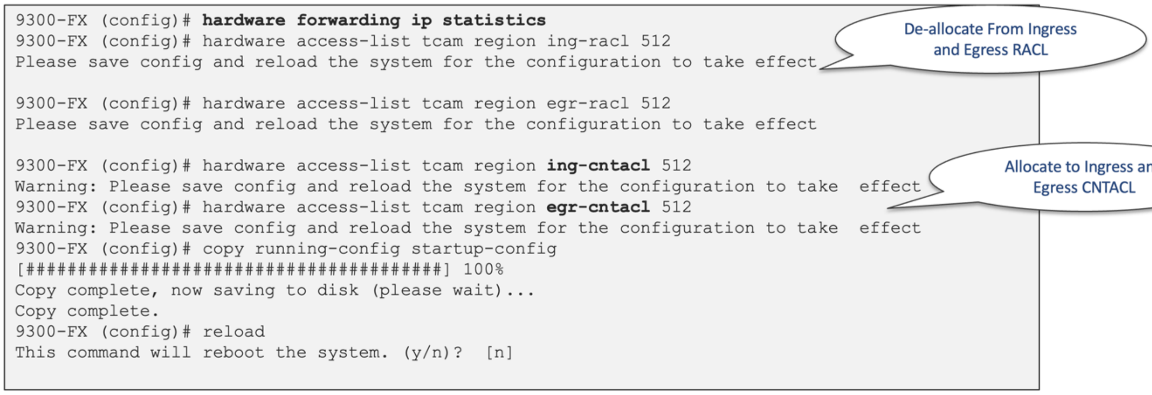
Deallocating from Ingress RACL
Deallocating from Ingress L3 QoS
Ing-nbm allocation

Figure 27 Ingress NBM TCAM allocation

Hardware Statistics " ing-cntacl" and " egr-cntacl" TCAM Regions

Starting from Cisco NX-OS release 10.1(1), the " hardware forwarding ip statistics" command allows customers to enable the Nexus 9000 Switch to export hardware forwarded IPv4/IPv6 interface statistics. These statistics include interface IPv4 and IPv6 Rx and Tx packets, as well as byte counters, which can be polled through SNMP using the ipIfStatsTable.

By default, Cisco NX-OS exports only IPv4/IPv6 interface counters for the packets forwarded by the IPv4/IPv6 Netstack software running on the SUP CPU. With the introduction of the " hardware forwarding ip statistics" command, you can now retrieve additional hardware forwarded interface statistics through SNMP. To configure " hardware forwarding ip statistics" on a device, you must carve the required CNTACL TCAM region. To better understand the use case for these two regions, see Figure 28.



```
9300-FX (config)# hardware forwarding ip statistics
9300-FX (config)# hardware access-list tcam region ing-racl 512
Please save config and reload the system for the configuration to take effect

9300-FX (config)# hardware access-list tcam region egr-racl 512
Please save config and reload the system for the configuration to take effect

9300-FX (config)# hardware access-list tcam region ing-cntacl 512
Warning: Please save config and reload the system for the configuration to take  effect
9300-FX (config)# hardware access-list tcam region egr-cntacl 512
Warning: Please save config and reload the system for the configuration to take  effect
9300-FX (config)# copy running-config startup-config
[########################################] 100%
Copy complete, now saving to disk (please wait)...
Copy complete.
9300-FX (config)# reload
This command will reboot the system. (y/n)?  [n]
```

De-allocate From Ingress and Egress RACL

Allocate to Ingress and Egress CNTACL

Figure 28 Hardware statistics configuration example

CloudScale ASIC TCAM Sharing

CloudScale ASIC Slice

A CloudScale ASIC slice refers to a self-contained forwarding complex responsible for handling both ingress and egress functions for a specific subset of ports. Each slice is further divided into separate sections for ingress and egress functions. The ingress portion of each slice is interconnected to all egress portions of other slices via a slice interconnect, which enables non-blocking any-to-any interconnection between slices. For a visual representation of the Cisco CloudScale ASIC slice architecture, see Figure 29.

When it comes to ACLs, PACL and RACLs are exclusively programmed on slices that have ports associated with these ACLs. Similarly, VLAN ACLs are programmed on slices that have the respective VLAN present. Likewise, port channel ACLs are programmed only on slices where the members of the port channel are present.

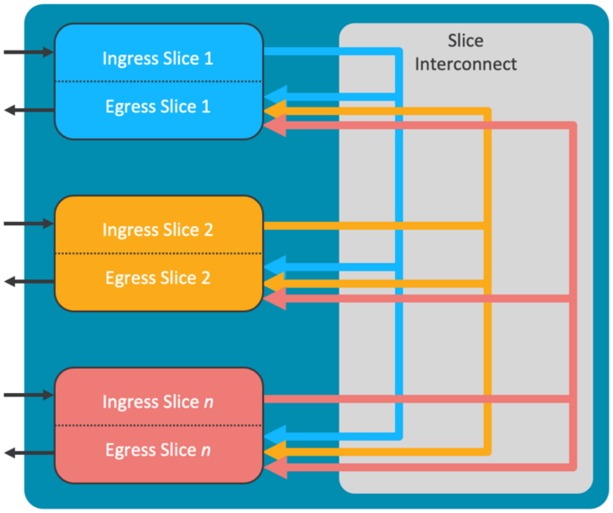
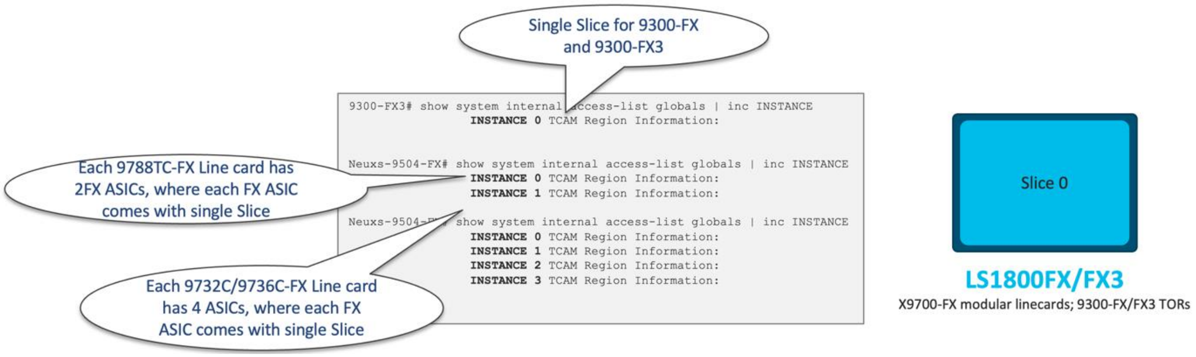


Figure 29 CloudScale ASIC slice architecture

The Cisco LS1800FX ASIC, utilized in Nexus 9300-FX, and the LS1800FX3 ASIC, used in Nexus 9300-FX3, both come with a single slice. However, the Nexus X9700-FX line cards are equipped with multiple ASICs, resulting in each line card having multiple slices. For example, the X9788TC-FX line card has two ASICs, thus having a total of two slices. Similarly, the X9732C-FX and X9736-FX line cards have four slices each. For a visual representation of the single slice ASIC architecture, see Figure 30. Each slice is represented by a unique instance number, which can be obtained from the " show system internal access-list globals" command.



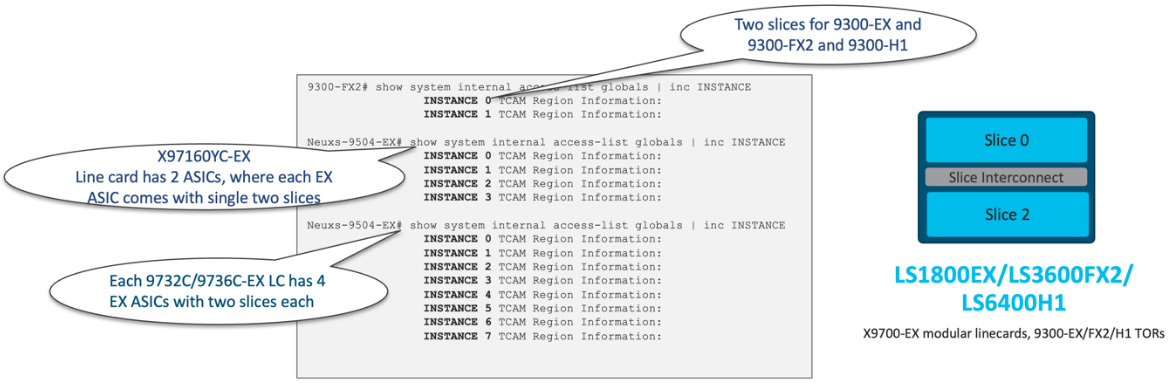
```
9300-FX3# show system internal access-list globals | inc INSTANCE
                 INSTANCE 0 TCAM Region Information:

Neuxs-9504-FX# show system internal access-list globals | inc INSTANCE
                 INSTANCE 0 TCAM Region Information:
                 INSTANCE 1 TCAM Region Information:

Neuxs-9504-FX# show system internal access-list globals | inc INSTANCE
                 INSTANCE 0 TCAM Region Information:
                 INSTANCE 1 TCAM Region Information:
                 INSTANCE 2 TCAM Region Information:
                 INSTANCE 3 TCAM Region Information:
```

Single Slice for 9300-FX and 9300-FX3
Each 9788TC-FX Line card has 2FX ASICs, where each FX ASIC comes with single Slice
Each 9732C/9736C-FX Line card has 4 ASICs, where each FX ASIC comes with single Slice
Slice 0
LS1800FX/FX3
X9700-FX modular linecards; 9300-FX/FX3 TORs

Figure 30 CloudScale ASICs with single slice

The Cisco LS1800EX ASIC, employed in Nexus 9300-EX, and the LS3600FX2 ASIC, used in Nexus 9300-FX2, along with the LS6400H1 ASIC utilized in Nexus 9300-H1, all come with two slices. For a visual representation of the two-slice ASIC architecture, see Figure 31.

Furthermore, the X97160YC-EX line card is equipped with two ASICs, resulting in a total of four slices. Similarly, the X9732C-EX and X9736-EX line cards will have a total of 8 slices.

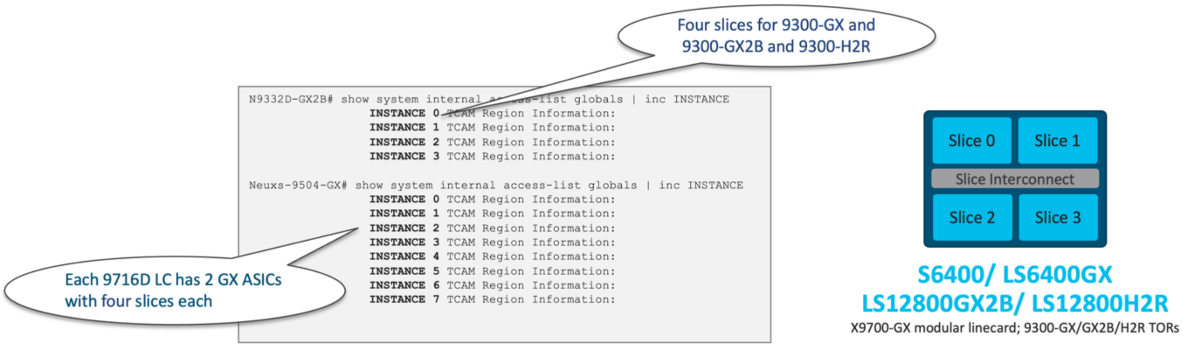


```
9300-FX2# show system internal access-list globals | inc INSTANCE
                 INSTANCE 0 TCAM Region Information:
                 INSTANCE 1 TCAM Region Information:

Neuxs-9504-EX# show system internal access-list globals | inc INSTANCE
                 INSTANCE 0 TCAM Region Information:
                 INSTANCE 1 TCAM Region Information:
                 INSTANCE 2 TCAM Region Information:
                 INSTANCE 3 TCAM Region Information:

Neuxs-9504-EX# show system internal access-list globals | inc INSTANCE
                 INSTANCE 0 TCAM Region Information:
                 INSTANCE 1 TCAM Region Information:
                 INSTANCE 2 TCAM Region Information:
                 INSTANCE 3 TCAM Region Information:
                 INSTANCE 4 TCAM Region Information:
                 INSTANCE 5 TCAM Region Information:
                 INSTANCE 6 TCAM Region Information:
                 INSTANCE 7 TCAM Region Information:
```

Two slices for 9300-EX and 9300-FX2 and 9300-H1
X97160YC-EX Line card has 2 ASICs, where each EX ASIC comes with single two slices
Each 9732C/9736C-EX LC has 4 EX ASICs with two slices each
Slice 0
Slice Interconnect
Slice 2
LS1800EX/LS3600FX2/ LS6400H1
X9700-EX modular linecards, 9300-EX/FX2/H1 TORs

Figure 31 CloudScale ASICs with two slices

The Cisco S6400 ASIC, utilized in Nexus 9300C, and the LS6400GX ASIC, used in Nexus 9300-GX, X9716D-GX line card, LS12800GX2B used in 9300-GX2B, and LS12800H2R used in 9300-H2R, all consist of 4 slices. However, the X9716D-GX Line card has only two LS6400GX ASICs, resulting in a total of 8 slices for that line card. For a visual representation of the 4 slice ASIC architecture, see Figure 32.

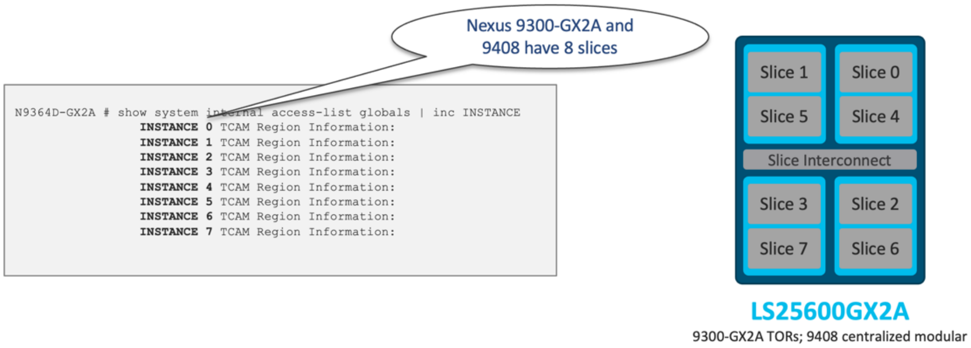


```
N9332D-GX2B# show system internal access-list globals | inc INSTANCE
                 INSTANCE 0 TCAM Region Information:
                 INSTANCE 1 TCAM Region Information:
                 INSTANCE 2 TCAM Region Information:
                 INSTANCE 3 TCAM Region Information:

Neuxs-9504-GX# show system internal access-list globals | inc INSTANCE
                 INSTANCE 0 TCAM Region Information:
                 INSTANCE 1 TCAM Region Information:
                 INSTANCE 2 TCAM Region Information:
                 INSTANCE 3 TCAM Region Information:
                 INSTANCE 4 TCAM Region Information:
                 INSTANCE 5 TCAM Region Information:
                 INSTANCE 6 TCAM Region Information:
                 INSTANCE 7 TCAM Region Information:
```

Four slices for 9300-GX and 9300-GX2B and 9300-H2R
Each 9716D LC has 2 GX ASICs with four slices each
Slice 0
Slice 1
Slice Interconnect
Slice 2
Slice 3
S6400/ LS6400GX LS12800GX2B/ LS12800H2R
X9700-GX modular linecard; 9300-GX/GX2B/H2R TORs

Figure 32 CloudScale ASICs with four slices

Lastly, the Cisco LS25600GX2A, utilized in Nexus 9300-GX2A, and the Nexus 9408 both have 8 slices. For a visual representation of the 8 slice ASIC architecture, see Figure 33.

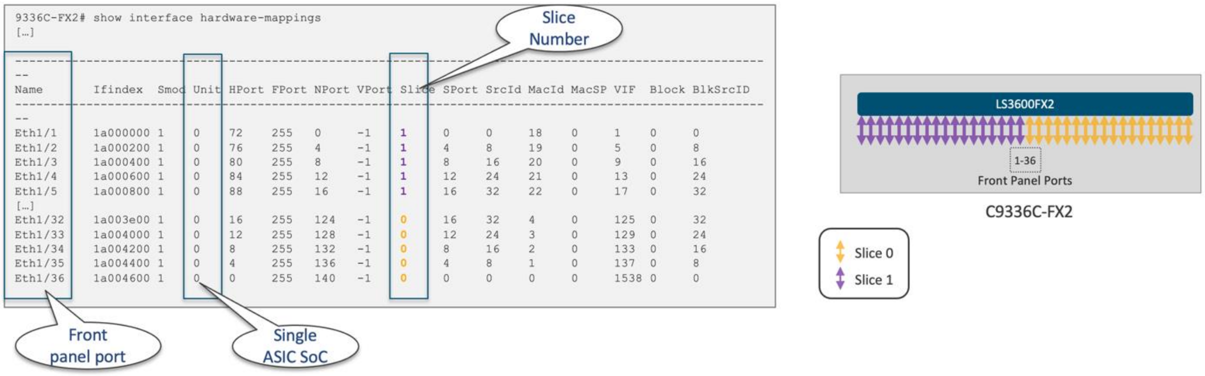


```
N9364D-GX2A # show system internal access-list globals | inc INSTANCE
                  INSTANCE 0 TCAM Region Information:
                  INSTANCE 1 TCAM Region Information:
                  INSTANCE 2 TCAM Region Information:
                  INSTANCE 3 TCAM Region Information:
                  INSTANCE 4 TCAM Region Information:
                  INSTANCE 5 TCAM Region Information:
                  INSTANCE 6 TCAM Region Information:
                  INSTANCE 7 TCAM Region Information:
```

Figure 33 CloudScale ASICs with eight slices

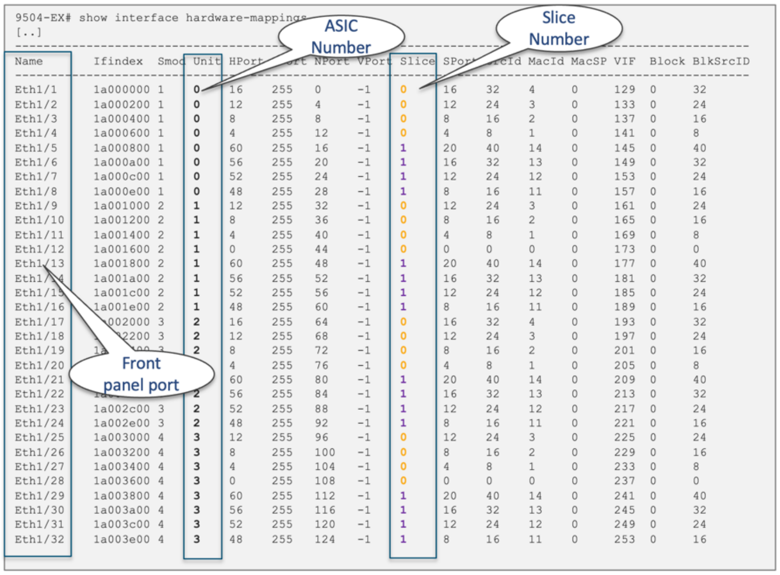
Front Panel to ASIC Slice Mapping

When designing the network, understanding the linkage between front panel ports and each ASIC slice is crucial to maximize scalability, as each slice has its dedicated TCAM space. You can use the " show interface hardware-mappings" command to view the interface ASIC port mapping and its associated slice. For example, Figure 34 illustrates the port mapping for Nexus 9336-FX with a single LS3600FX2 ASIC, while Figure 35 shows the port mapping for Cisco Nexus X9732-EX with four LS1800EX ASICs.



```
9336C-FX2# show interface hardware-mappings
[…]

-----------------------------------------------------------------------------------------------
--
Name        Ifindex  Smod Unit HPort FPort NPort VPort Slice SPort SrcId MacId MacSP VIF  Block BlkSrcID
-----------------------------------------------------------------------------------------------
--
Eth1/1      1a000000 1    0    72    255   0     -1    1     0     0     18    0     1    0     0
Eth1/2      1a000200 1    0    76    255   4     -1    1     4     8     19    0     5    0     8
Eth1/3      1a000400 1    0    80    255   8     -1    1     8     16    20    0     9    0     16
Eth1/4      1a000600 1    0    84    255   12    -1    1     12    24    21    0     13   0     24
Eth1/5      1a000800 1    0    88    255   16    -1    1     16    32    22    0     17   0     32
[…]
Eth1/32     1a003e00 1    0    16    255   124   -1    0     16    32    4     0     125  0     32
Eth1/33     1a004000 1    0    12    255   128   -1    0     12    24    3     0     129  0     24
Eth1/34     1a004200 1    0    8     255   132   -1    0     8     16    2     0     133  0     16
Eth1/35     1a004400 1    0    4     255   136   -1    0     4     8     1     0     137  0     8
Eth1/36     1a004600 1    0    0     255   140   -1    0     0     0     0     0     1538 0     0
```

Figure 34 Cisco Nexus 9336-FX2 with single LS3600FX2 ASIC port mapping



```
9504-EX# show interface hardware-mappings
[..]
-------------------------------------------------------------------------------------------------------
Name       Ifindex  Smod Unit HPort FPort NPort VPort Slice SPort SrcId MacId MacSP VIF  Block BlkSrcID
-------------------------------------------------------------------------------------------------------
Eth1/1     1a000000 1    0    16    255   0     -1    0     16    32    4     0     129  0     32
Eth1/2     1a000200 1    0    12    255   4     -1    0     12    24    3     0     133  0     24
Eth1/3     1a000400 1    0    8     255   8     -1    0     8     16    2     0     137  0     16
Eth1/4     1a000600 1    0    4     255   12    -1    0     4     8     1     0     141  0     8
Eth1/5     1a000800 1    0    60    255   16    -1    1     20    40    14    0     145  0     40
Eth1/6     1a000a00 1    0    56    255   20    -1    1     16    32    13    0     149  0     32
Eth1/7     1a000c00 1    0    52    255   24    -1    1     12    24    12    0     153  0     24
Eth1/8     1a000e00 1    0    48    255   28    -1    1     8     16    11    0     157  0     16
Eth1/9     1a001000 2    1    12    255   32    -1    0     12    24    3     0     161  0     24
Eth1/10    1a001200 2    1    8     255   36    -1    0     8     16    2     0     165  0     16
Eth1/11    1a001400 2    1    4     255   40    -1    0     4     8     1     0     169  0     8
Eth1/12    1a001600 2    1    0     255   44    -1    0     0     0     0     0     173  0     0
Eth1/13    1a001800 2    1    60    255   48    -1    1     20    40    14    0     177  0     40
Eth1/14    1a001a00 2    1    56    255   52    -1    1     16    32    13    0     181  0     32
Eth1/15    1a001c00 2    1    52    255   56    -1    1     12    24    12    0     185  0     24
Eth1/16    1a001e00 2    1    48    255   60    -1    1     8     16    11    0     189  0     16
Eth1/17      002000 3    2    16    255   64    -1    0     16    32    4     0     193  0     32
Eth1/18       2200 3     2    12    255   68    -1    0     12    24    3     0     197  0     24
Eth1/19    1a            2    8     255   72    -1    0     8     16    2     0     201  0     16
Eth1/20                       4     255   76    -1    0     4     8     1     0     205  0     8
Eth1/21                       60    255   80    -1    1     20    40    14    0     209  0     40
Eth1/22    1a            2    56    255   84    -1    1     16    32    13    0     213  0     32
Eth1/23    1a002c00 3    2    52    255   88    -1    1     12    24    12    0     217  0     24
Eth1/24    1a002e00 3    2    48    255   92    -1    1     8     16    11    0     221  0     16
Eth1/25    1a003000 4    3    12    255   96    -1    0     12    24    3     0     225  0     24
Eth1/26    1a003200 4    3    8     255   100   -1    0     8     16    2     0     229  0     16
Eth1/27    1a003400 4    3    4     255   104   -1    0     4     8     1     0     233  0     8
Eth1/28    1a003600 4    3    0     255   108   -1    0     0     0     0     0     237  0     0
Eth1/29    1a003800 4    3    60    255   112   -1    1     20    40    14    0     241  0     40
Eth1/30    1a003a00 4    3    56    255   116   -1    1     16    32    13    0     245  0     32
Eth1/31    1a003c00 4    3    52    255   120   -1    1     12    24    12    0     249  0     24
Eth1/32    1a003e00 4    3    48    255   124   -1    1     8     16    11    0     253  0     16
```

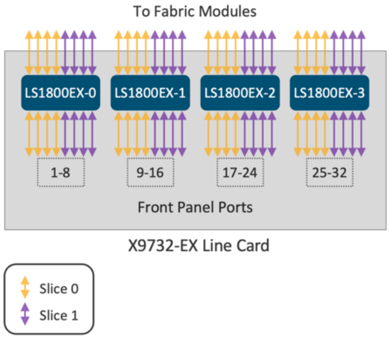


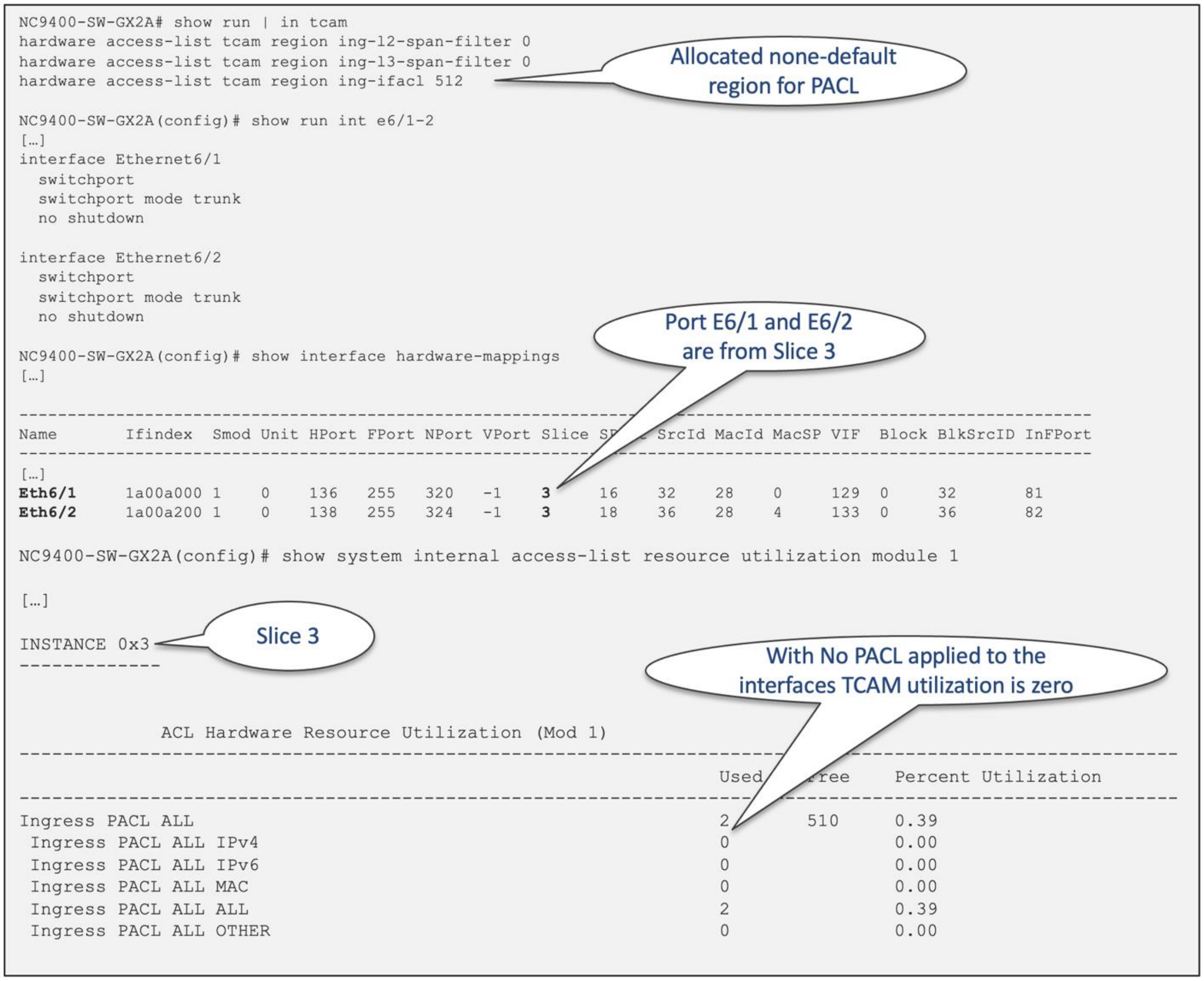
Figure 35 Cisco Nexus X9732-EX with four LS1800EX ASICs port mapping

ACL Entries label Sharing

When applying the same "set" of policies such as security ACLs (PACL, VACL, RACL), QoS or NAT to multiple interfaces or VLANs in a given direction (ingress or egress), only one copy is programmed in the TCAM, which is then shared among those interfaces and VLANs. To achieve this, each ACL policy is associated with a label. By assigning the same label to multiple interfaces and VLANs, the same TCAM rule can be applied to them all. However, only 62 unique ACLs can be configured per slice.

If the same ACL is configured on multiple interfaces, the same label is shared among them. Conversely, if each ACL has unique entries, the ACL labels are not shared. By default, ACL statistics are disabled, but they are enabled by default for QoS policies. Under ACL configuration, individuals have the option to activate ACL statistics using the "statistics per-entry" command through the CLI.

For label sharing to occur, the ACL target interfaces (such as port, VLAN, SVI) must be situated on the same slice, aside from sharing identical policies. Here's an example to illustrate this feature: Trunk ports E6/1 and E6/2 are part of Slice 3 of the LS25600GX2A ASIC. Before configuring any PACLs to these interfaces, the PACL TCAM utilization for Slice 3 is zero, as displayed in Figure 36.

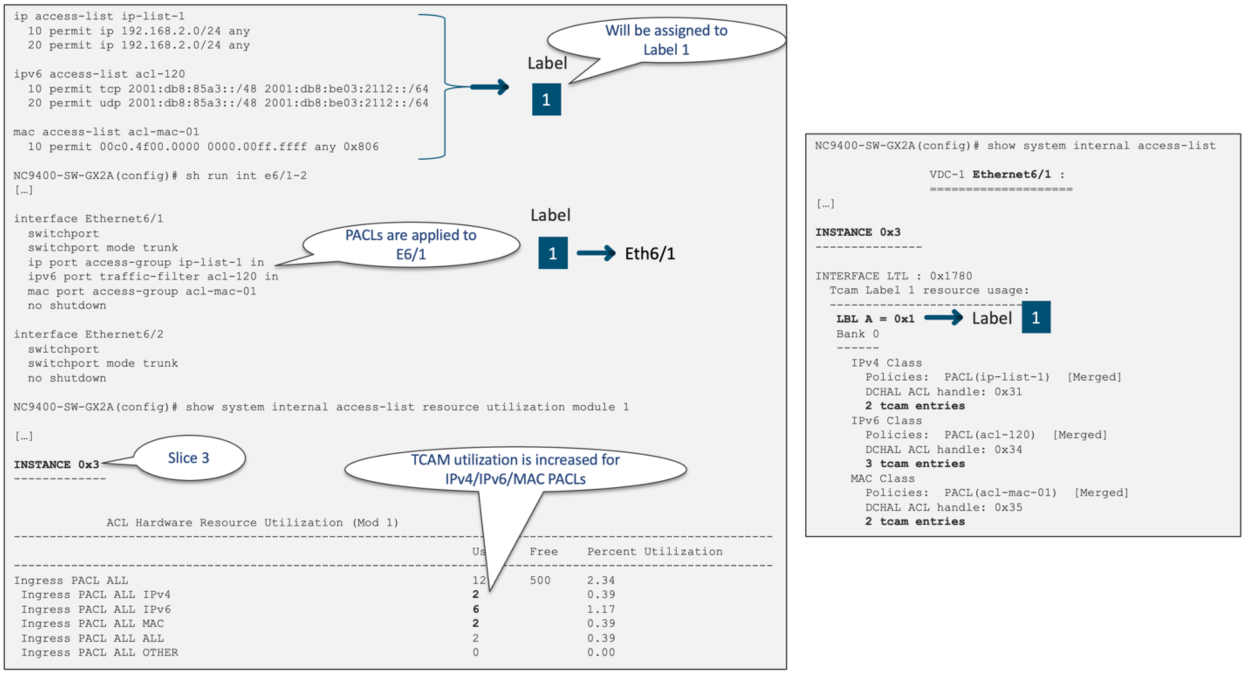


Allocated none-default region for PACL
Port E6/1 and E6/2 are from Slice 3
Slice 3
With No PACL applied to the interfaces TCAM utilization is zero

```
NC9400-SW-GX2A# show run | in tcam
hardware access-list tcam region ing-l2-span-filter 0
hardware access-list tcam region ing-l3-span-filter 0
hardware access-list tcam region ing-ifacl 512

NC9400-SW-GX2A(config)# show run int e6/1-2
[…]
interface Ethernet6/1
  switchport
  switchport mode trunk
  no shutdown

interface Ethernet6/2
  switchport
  switchport mode trunk
  no shutdown

NC9400-SW-GX2A(config)# show interface hardware-mappings
[…]

--------------------------------------------------------------------------------------------------------------------
Name       Ifindex  Smod Unit HPort FPort NPort VPort Slice SP  t SrcId MacId MacSP VIF  Block BlkSrcID InFPort
--------------------------------------------------------------------------------------------------------------------
[…]
Eth6/1     1a00a000 1    0    136   255   320   -1    3     16    32    28    0     129  0     32       81
Eth6/2     1a00a200 1    0    138   255   324   -1    3     18    36    28    4     133  0     36       82

NC9400-SW-GX2A(config)# show system internal access-list resource utilization module 1

[…]

INSTANCE 0x3
-------------


              ACL Hardware Resource Utilization (Mod 1)
------------------------------------------------------------------------------------------
                                                             Used    ree    Percent Utilization
------------------------------------------------------------------------------------------
Ingress PACL ALL                                             2       510    0.39
 Ingress PACL ALL IPv4                                       0              0.00
 Ingress PACL ALL IPv6                                       0              0.00
 Ingress PACL ALL MAC                                        0              0.00
 Ingress PACL ALL ALL                                        2              0.39
 Ingress PACL ALL OTHER                                      0              0.00
```

Figure 36 TCAM utilization before PACLs configured under E6/1 and E6/2

Once IPv4/IPv6/MAC PACLs are configured for interfaces E6/1, the PACL TCAM utilization for Slice 3 increases accordingly. To view the label allocated to interface E6/1, you can use the " show system internal access-list" command, which will display the information, as shown in Figure 37.



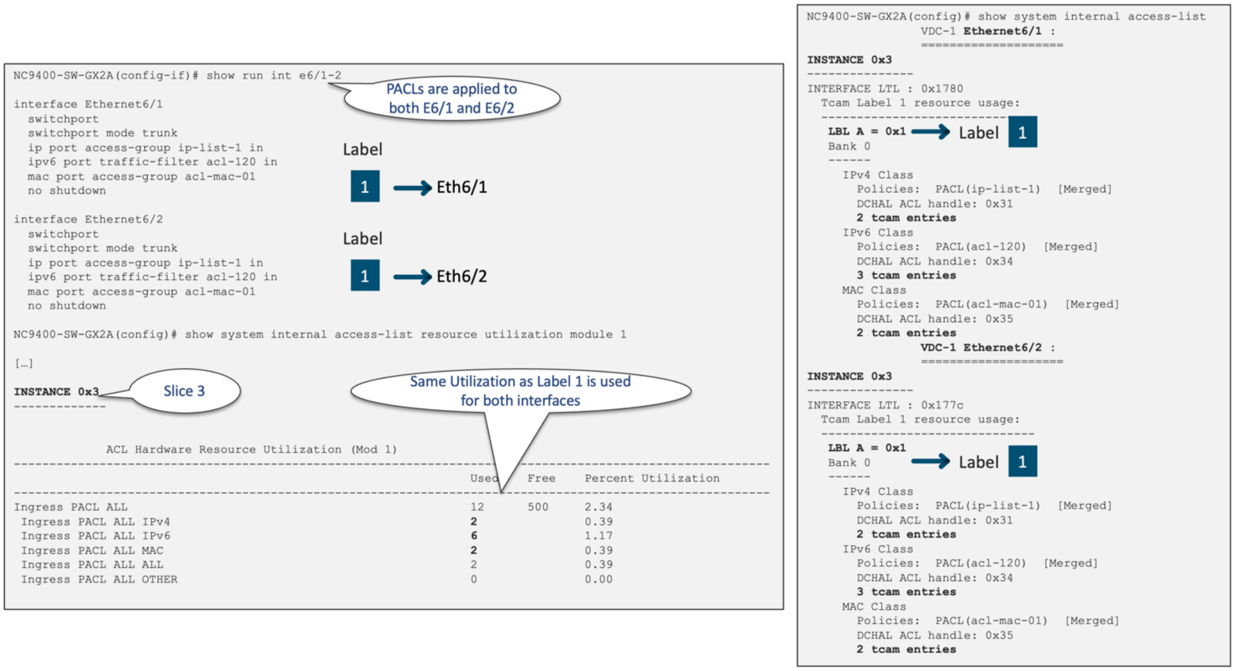
```
ip access-list ip-list-1
  10 permit ip 192.168.2.0/24 any
  20 permit ip 192.168.2.0/24 any

ipv6 access-list acl-120
  10 permit tcp 2001:db8:85a3::/48 2001:db8:be03:2112::/64
  20 permit udp 2001:db8:85a3::/48 2001:db8:be03:2112::/64

mac access-list acl-mac-01
  10 permit 00c0.4f00.0000 0000.00ff.ffff any 0x806

NC9400-SW-GX2A(config)# sh run int e6/1-2
[…]

interface Ethernet6/1
  switchport
  switchport mode trunk
  ip port access-group ip-list-1 in
  ipv6 port traffic-filter acl-120 in
  mac port access-group acl-mac-01
  no shutdown

interface Ethernet6/2
  switchport
  switchport mode trunk
  no shutdown

NC9400-SW-GX2A(config)# show system internal access-list resource utilization module 1

[…]

INSTANCE 0x3
-------------

             ACL Hardware Resource Utilization (Mod 1)
-----------------------------------------------------------------------------------------------------------
                                                              Us        Free     Percent Utilization
-----------------------------------------------------------------------------------------------------------
Ingress PACL ALL                                              12        500      2.34
 Ingress PACL ALL IPv4                                        2                  0.39
 Ingress PACL ALL IPv6                                        6                  1.17
 Ingress PACL ALL MAC                                         2                  0.39
 Ingress PACL ALL ALL                                         2                  0.39
 Ingress PACL ALL OTHER                                       0                  0.00
```

```
NC9400-SW-GX2A(config)# show system internal access-list

                VDC-1 Ethernet6/1 :
                ====================
[…]

INSTANCE 0x3
---------------

INTERFACE LTL : 0x1780
  Tcam Label 1 resource usage:
  ---------------------------
   LBL A = 0x1
   Bank 0
   ------
     IPv4 Class
       Policies:  PACL(ip-list-1)  [Merged]
       DCHAL ACL handle: 0x31
       2 tcam entries
     IPv6 Class
       Policies:  PACL(acl-120)  [Merged]
       DCHAL ACL handle: 0x34
       3 tcam entries
     MAC Class
       Policies:  PACL(acl-mac-01)  [Merged]
       DCHAL ACL handle: 0x35
       2 tcam entries
```

Will be assigned to Label 1
Label
1
PACLs are applied to E6/1
Label
1
Eth6/1
Slice 3
TCAM utilization is increased for IPv4/IPv6/MAC PACLs
Label
1

Figure 37 TCAM utilization after PACLs configured under E6/1

When the same PACL configuration is applied to interfaces E6/2, the PACL TCAM utilization for Slice 3 will not increase. This is because the same label (Label 1) is assigned to both E6/1 and E6/2. To view the labels allocated to interfaces E6/1 and E6/2, you can use the " show system internal access-list" command, which will display the information, as shown in Figure 38.



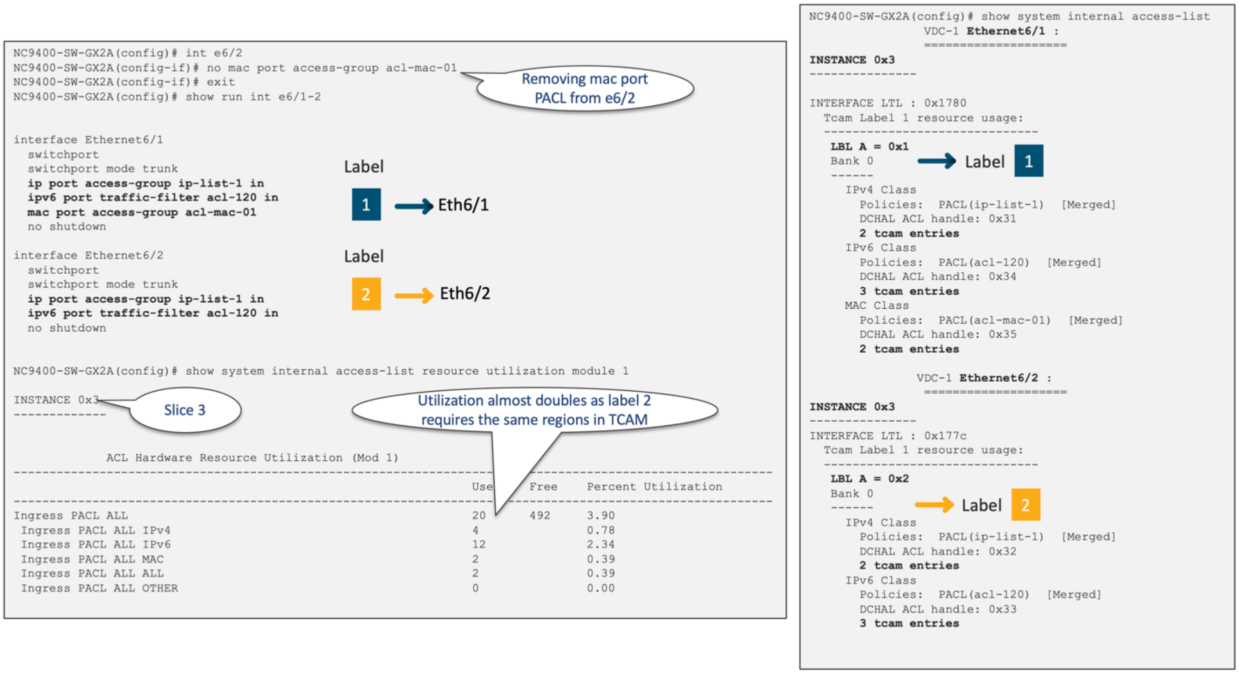
```
NC9400-SW-GX2A(config-if)# show run int e6/1-2

interface Ethernet6/1
  switchport
  switchport mode trunk
  ip port access-group ip-list-1 in
  ipv6 port traffic-filter acl-120 in
  mac port access-group acl-mac-01
  no shutdown

interface Ethernet6/2
  switchport
  switchport mode trunk
  ip port access-group ip-list-1 in
  ipv6 port traffic-filter acl-120 in
  mac port access-group acl-mac-01
  no shutdown

NC9400-SW-GX2A(config)# show system internal access-list resource utilization module 1

[…]

INSTANCE 0x3
-------------

             ACL Hardware Resource Utilization (Mod 1)
-----------------------------------------------------------------------------------------------------------
                                                              Used      Free     Percent Utilization
-----------------------------------------------------------------------------------------------------------
Ingress PACL ALL                                              12        500      2.34
 Ingress PACL ALL IPv4                                        2                  0.39
 Ingress PACL ALL IPv6                                        6                  1.17
 Ingress PACL ALL MAC                                         2                  0.39
 Ingress PACL ALL ALL                                         2                  0.39
 Ingress PACL ALL OTHER                                       0                  0.00
```

```
NC9400-SW-GX2A(config)# show system internal access-list
                VDC-1 Ethernet6/1 :
                ====================
INSTANCE 0x3
---------------
INTERFACE LTL : 0x1780
  Tcam Label 1 resource usage:
  ---------------------------
   LBL A = 0x1
   Bank 0
   ------
     IPv4 Class
       Policies:  PACL(ip-list-1)  [Merged]
       DCHAL ACL handle: 0x31
       2 tcam entries
     IPv6 Class
       Policies:  PACL(acl-120)  [Merged]
       DCHAL ACL handle: 0x34
       3 tcam entries
     MAC Class
       Policies:  PACL(acl-mac-01)  [Merged]
       DCHAL ACL handle: 0x35
       2 tcam entries
                VDC-1 Ethernet6/2 :
                ====================
INSTANCE 0x3
---------------
INTERFACE LTL : 0x177c
  Tcam Label 1 resource usage:
  -----------------------------
   LBL A = 0x1
   Bank 0
   ------
     IPv4 Class
       Policies:  PACL(ip-list-1)  [Merged]
       DCHAL ACL handle: 0x31
       2 tcam entries
     IPv6 Class
       Policies:  PACL(acl-120)  [Merged]
       DCHAL ACL handle: 0x34
       3 tcam entries
     MAC Class
       Policies:  PACL(acl-mac-01)  [Merged]
       DCHAL ACL handle: 0x35
       2 tcam entries
```

PACLs are applied to both E6/1 and E6/2
Label
1
Eth6/1
Label
1
Eth6/2
Slice 3
Same Utilization as Label 1 is used for both interfaces
Label
1
Label
1

Figure 38 TCAM utilization after same PACLs configured under E6/1 and E6/2

To enable label sharing between interfaces, the ACL target (such as port, VLAN, and SVI) must belong to the same slice (in this example, Slice 3). Additionally, the same set of features and ACLs need to be configured under each interface. For example, if you remove the " mac port access-group" configuration from E6/2, the same label cannot be used for both E6/1 and E6/2, resulting in increased label/TCAM utilization, as depicted in Figure 39.



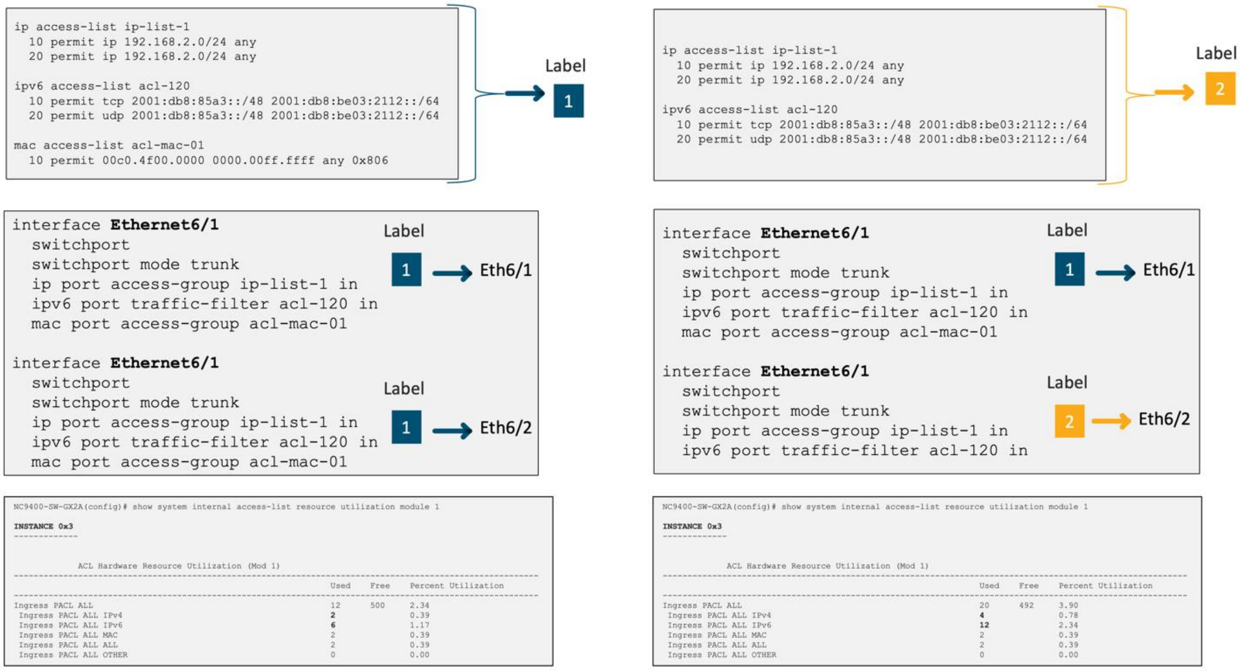
```
NC9400-SW-GX2A(config)# int e6/2
NC9400-SW-GX2A(config-if)# no mac port access-group acl-mac-01
NC9400-SW-GX2A(config-if)# exit
NC9400-SW-GX2A(config)# show run int e6/1-2

interface Ethernet6/1
  switchport
  switchport mode trunk
  ip port access-group ip-list-1 in
  ipv6 port traffic-filter acl-120 in
  mac port access-group acl-mac-01
  no shutdown

interface Ethernet6/2
  switchport
  switchport mode trunk
  ip port access-group ip-list-1 in
  ipv6 port traffic-filter acl-120 in
  no shutdown

NC9400-SW-GX2A(config)# show system internal access-list resource utilization module 1

INSTANCE 0x3
-------------

             ACL Hardware Resource Utilization (Mod 1)
--------------------------------------------------------------------------------------------------------
                                                                Use      Free      Percent Utilization
--------------------------------------------------------------------------------------------------------
Ingress PACL ALL                                                20       492       3.90
 Ingress PACL ALL IPv4                                          4                  0.78
 Ingress PACL ALL IPv6                                          12                 2.34
 Ingress PACL ALL MAC                                           2                  0.39
 Ingress PACL ALL ALL                                           2                  0.39
 Ingress PACL ALL OTHER                                         0                  0.00
```

```
NC9400-SW-GX2A(config)# show system internal access-list
                VDC-1 Ethernet6/1 :
                ====================

INSTANCE 0x3
---------------

INTERFACE LTL : 0x1780
  Tcam Label 1 resource usage:
  -----------------------------
   LBL A = 0x1
   Bank 0
   ------
     IPv4 Class
       Policies:  PACL(ip-list-1)  [Merged]
       DCHAL ACL handle: 0x31
       2 tcam entries
     IPv6 Class
       Policies:  PACL(acl-120)  [Merged]
       DCHAL ACL handle: 0x34
       3 tcam entries
     MAC Class
       Policies:  PACL(acl-mac-01)  [Merged]
       DCHAL ACL handle: 0x35
       2 tcam entries

               VDC-1 Ethernet6/2 :
                ====================

INSTANCE 0x3
---------------

INTERFACE LTL : 0x177c
  Tcam Label 1 resource usage:
  -----------------------------
   LBL A = 0x2
   Bank 0
   ------
     IPv4 Class
       Policies:  PACL(ip-list-1)  [Merged]
       DCHAL ACL handle: 0x32
       2 tcam entries
     IPv6 Class
       Policies:  PACL(acl-120)  [Merged]
       DCHAL ACL handle: 0x33
       3 tcam entries
```

Removing mac port PACL from e6/2
Label
1
Eth6/1
Label
2
Eth6/2
Slice 3
Utilization almost doubles as label 2 requires the same regions in TCAM
Label
1
Label
2

Figure 39 TCAM utilization after configuring different PACLs under E6/1 and E6/2

In this example, Label 1 currently utilizes 10 entries, and Label 2 utilizes 8 entries. When the MAC PACL was removed from E6/2, the TCAM utilization increased from 10 entries to 18 entries. Figure 40 provides a summary of this behavior.



```
ip access-list ip-list-1
  10 permit ip 192.168.2.0/24 any
  20 permit ip 192.168.2.0/24 any

ipv6 access-list acl-120
  10 permit tcp 2001:db8:85a3::/48 2001:db8:be03:2112::/64
  20 permit udp 2001:db8:85a3::/48 2001:db8:be03:2112::/64

mac access-list acl-mac-01
  10 permit 00c0.4f00.0000 0000.00ff.ffff any 0x806
```

```
interface Ethernet6/1
  switchport
  switchport mode trunk
  ip port access-group ip-list-1 in
  ipv6 port traffic-filter acl-120 in
  mac port access-group acl-mac-01

interface Ethernet6/1
  switchport
  switchport mode trunk
  ip port access-group ip-list-1 in
  ipv6 port traffic-filter acl-120 in
  mac port access-group acl-mac-01
```

```
NC9400-SW-GX2A(config)# show system internal access-list resource utilization module 1

INSTANCE 0x3
-------------

             ACL Hardware Resource Utilization (Mod 1)
--------------------------------------------------------------------------------------------------------
                                                                Used     Free      Percent Utilization
--------------------------------------------------------------------------------------------------------
Ingress PACL ALL                                                12       500       2.34
 Ingress PACL ALL IPv4                                          2                  0.39
 Ingress PACL ALL IPv6                                          6                  1.17
 Ingress PACL ALL MAC                                           2                  0.39
 Ingress PACL ALL ALL                                           2                  0.39
 Ingress PACL ALL OTHER                                         0                  0.00
```

```
ip access-list ip-list-1
  10 permit ip 192.168.2.0/24 any
  20 permit ip 192.168.2.0/24 any

ipv6 access-list acl-120
  10 permit tcp 2001:db8:85a3::/48 2001:db8:be03:2112::/64
  20 permit udp 2001:db8:85a3::/48 2001:db8:be03:2112::/64
```

```
interface Ethernet6/1
  switchport
  switchport mode trunk
  ip port access-group ip-list-1 in
  ipv6 port traffic-filter acl-120 in
  mac port access-group acl-mac-01

interface Ethernet6/1
  switchport
  switchport mode trunk
  ip port access-group ip-list-1 in
  ipv6 port traffic-filter acl-120 in
```

```
NC9400-SW-GX2A(config)# show system internal access-list resource utilization module 1

INSTANCE 0x3
-------------

             ACL Hardware Resource Utilization (Mod 1)
--------------------------------------------------------------------------------------------------------
                                                                Used     Free      Percent Utilization
--------------------------------------------------------------------------------------------------------
Ingress PACL ALL                                                20       492       3.90
 Ingress PACL ALL IPv4                                          4                  0.78
 Ingress PACL ALL IPv6                                          12                 2.34
 Ingress PACL ALL MAC                                           2                  0.39
 Ingress PACL ALL ALL                                           2                  0.39
 Ingress PACL ALL OTHER                                         0                  0.00
```

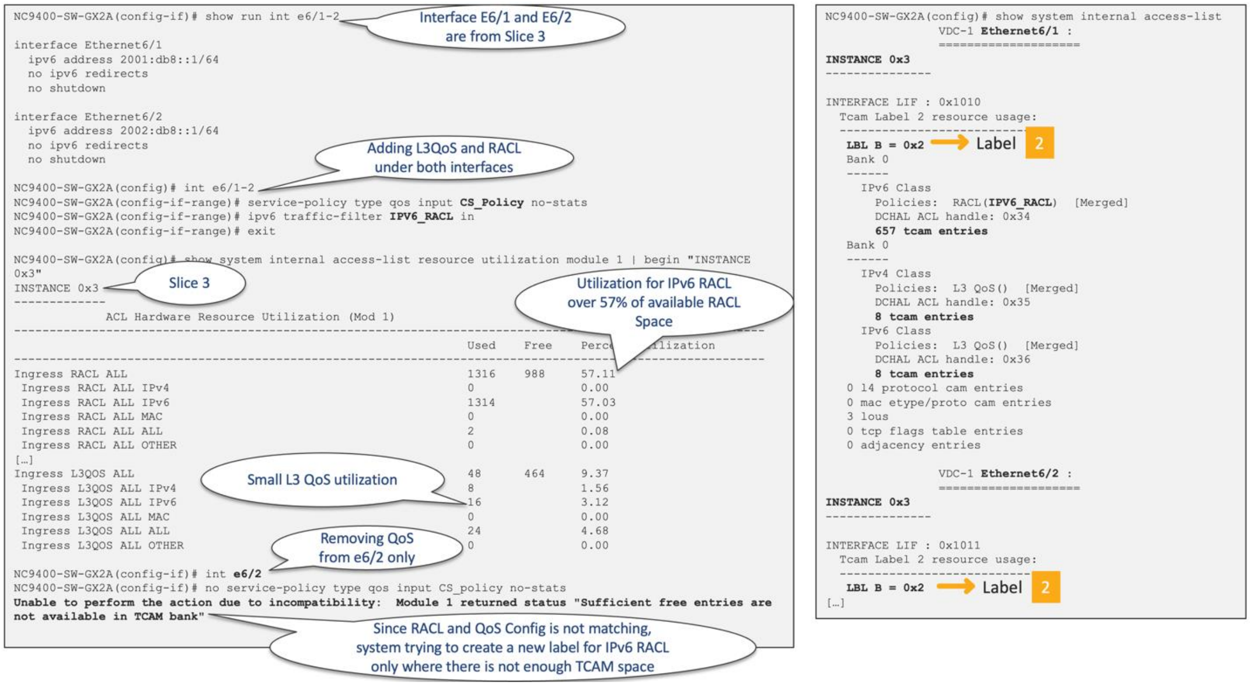
Figure 40 TCAM utilization with single label vs two labels

Table 7 illustrates the Nexus 9000 feature sets that will share the same label when applied to interfaces on the same slice.

Table 7 Cisco Nexus 9000 TCAM label sharing features

Ingress Layer 3	Ingress Layer 2	Engress Layer 3
• Ingress RACL, VACL • PBR • Ingress Layer 3 QoS • Layer 3/VLAN SPAN ACL	• Ingress PACL • Ingress Layer 2 QoS • Layer 2 SPAN ACL	• Egress RACL • Egress QoS

As an example, if you configure the same ingress RACL and Ingress Layer 3 QoS policy on multiple interfaces allocated to the same slice, they all share the same label. However, if you remove QoS from one of the interfaces, it requires a new label, and this change might result in potentially utilizing more TCAM space. Figure 41 illustrates this scenario.



```
NC9400-SW-GX2A(config-if)# show run int e6/1-2

interface Ethernet6/1
  ipv6 address 2001:db8::1/64
  no ipv6 redirects
  no shutdown

interface Ethernet6/2
  ipv6 address 2002:db8::1/64
  no ipv6 redirects
  no shutdown

NC9400-SW-GX2A(config)# int e6/1-2
NC9400-SW-GX2A(config-if-range)# service-policy type qos input CS_Policy no-stats
NC9400-SW-GX2A(config-if-range)# ipv6 traffic-filter IPV6_RACL in
NC9400-SW-GX2A(config-if-range)# exit

NC9400-SW-GX2A(config)# show system internal access-list resource utilization module 1 | begin "INSTANCE
0x3"
INSTANCE 0x3
-------------
             ACL Hardware Resource Utilization (Mod 1)
---------------------------------------------------------------------------------------------------------
                                                              Used    Free    Perc      ilization
---------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                              1316    988     57.11
 Ingress RACL ALL IPv4                                        0               0.00
 Ingress RACL ALL IPv6                                        1314            57.03
 Ingress RACL ALL MAC                                         0               0.00
 Ingress RACL ALL ALL                                         2               0.08
 Ingress RACL ALL OTHER                                       0               0.00
[…]
Ingress L3QOS ALL                                             48      464     9.37
 Ingress L3QOS ALL IPv4                                       8               1.56
 Ingress L3QOS ALL IPv6                                       16              3.12
 Ingress L3QOS ALL MAC                                        0               0.00
 Ingress L3QOS ALL ALL                                        24              4.68
 Ingress L3QOS ALL OTHER                                      0               0.00

NC9400-SW-GX2A(config-if)# int e6/2
NC9400-SW-GX2A(config-if)# no service-policy type qos input CS_policy no-stats
Unable to perform the action due to incompatibility:  Module 1 returned status "Sufficient free entries are
not available in TCAM bank"
```

```
NC9400-SW-GX2A(config)# show system internal access-list
                    VDC-1 Ethernet6/1 :
                    ====================
INSTANCE 0x3
---------------

INTERFACE LIF : 0x1010
  Tcam Label 2 resource usage:
  ----------------------------
   LBL B = 0x2
   Bank 0
   ------
     IPv6 Class
       Policies:  RACL(IPV6_RACL)  [Merged]
       DCHAL ACL handle: 0x34
       657 tcam entries
   Bank 0
   ------
     IPv4 Class
       Policies:  L3 QoS()  [Merged]
       DCHAL ACL handle: 0x35
       8 tcam entries
     IPv6 Class
       Policies:  L3 QoS()  [Merged]
       DCHAL ACL handle: 0x36
       8 tcam entries
   0 14 protocol cam entries
   0 mac etype/proto cam entries
   3 lous
   0 tcp flags table entries
   0 adjacency entries

                    VDC-1 Ethernet6/2 :
                    ====================
INSTANCE 0x3
---------------

INTERFACE LIF : 0x1011
  Tcam Label 2 resource usage:
  ----------------------------
   LBL B = 0x2
[…]
```

Interface E6/1 and E6/2 are from Slice 3
Adding L3QoS and RACL under both interfaces
Slice 3
Utilization for IPv6 RACL over 57% of available RACL Space
Small L3 QoS utilization
Removing QoS from e6/2 only
Since RACL and QoS Config is not matching, system trying to create a new label for IPv6 RACL only where there is not enough TCAM space
Label 2
Label 2

Figure 41 Ingress RACL and Ingress L3 QoS are sharing the same label

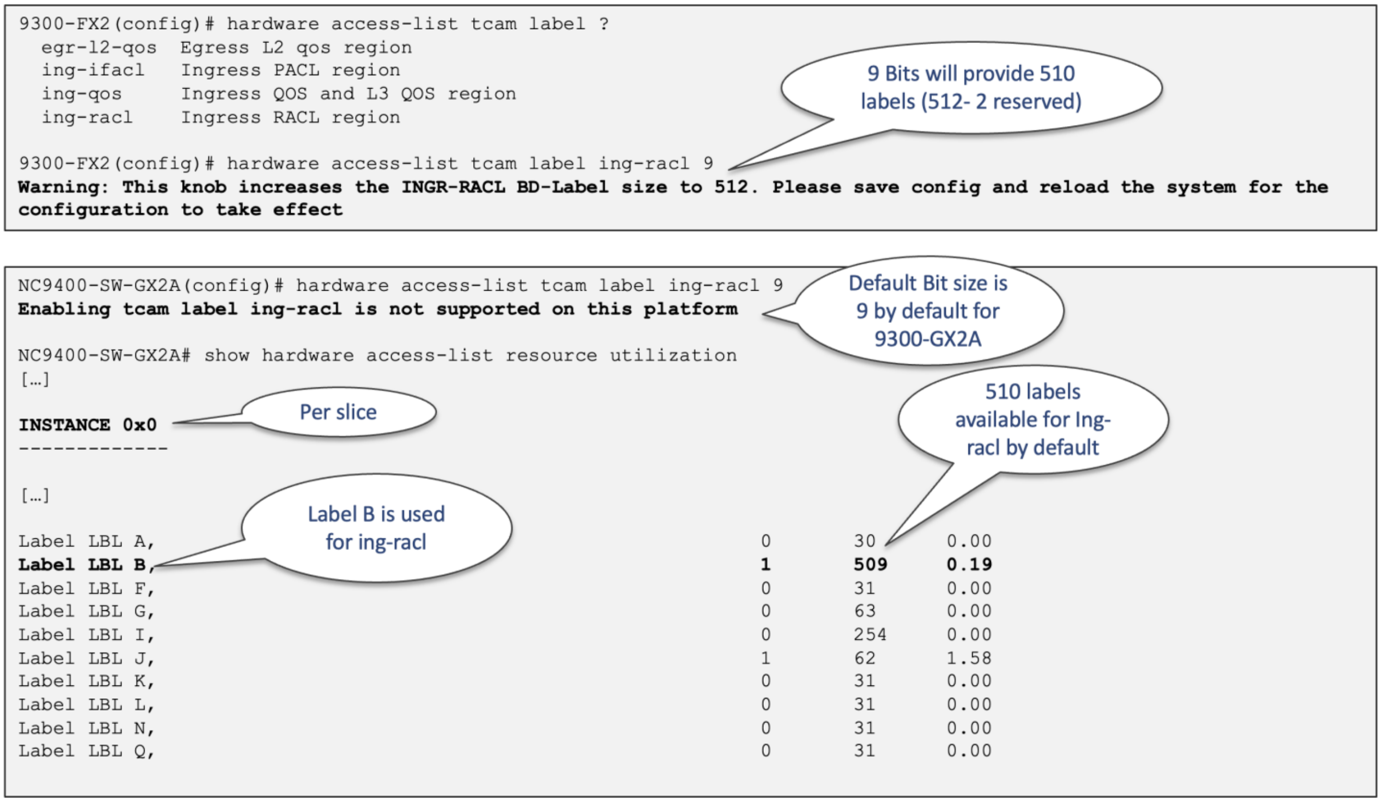
Maximum Label Sizes Supported for ACL Types

Table 8 presents the supported label sizes for various ACL types in Cisco NX-OS switches.

Table 8 Maximum label sizes supported for each ACL type

ACL Types	Platform	Direction	Max Label	Reserved Label	Size in Bits	Label Type
RACL/PBR/VACL/L3-VLAN QoS/L3-VLAN SPAN ACL	9300/9400	Ingress	510	2	9	BD
RACL/PBR/VACL/L3-VLAN QoS/L3-VLAN SPAN ACL	9500	Ingress	62	2	6	BD
PACL/L2 QoS/L2 SPAN ACL	9300/9400/9500	Ingress	62	2	6	IF
RACL/VACL/L3-VLAN QoS	9300/9400/9500	Egress	254	2	8	BD
L2 QoS	9300/9400/9500	Egress	62	2	6	IF

To enhance the default label size, users can utilize the " hardware access-list tcam label" command and subsequently reboot the switch. In Figure 42, there is a depiction of the process of augmenting the allocated ingress RACL region count to 512. This is achieved by adjusting the bit size from its initial value of 6 to 9. The default setting for the Ingress BD-Label size on Cisco Nexus 9300-GX, 9300-FX3, 9300-GX2A, 9408 and 9300-H2R/H1 is 512, requiring no further adjustments.



```
9300-FX2(config)# hardware access-list tcam label ?
  egr-l2-qos   Egress L2 qos region
  ing-ifacl    Ingress PACL region
  ing-qos      Ingress QOS and L3 QOS region
  ing-racl     Ingress RACL region

9300-FX2(config)# hardware access-list tcam label ing-racl 9
Warning: This knob increases the INGR-RACL BD-Label size to 512. Please save config and reload the system for the
configuration to take effect
```

```
NC9400-SW-GX2A(config)# hardware access-list tcam label ing-racl 9
Enabling tcam label ing-racl is not supported on this platform

NC9400-SW-GX2A# show hardware access-list resource utilization
[…]

INSTANCE 0x0
-------------

[…]

Label LBL A,                                                 0       30      0.00
Label LBL B,                                                 1       509     0.19
Label LBL F,                                                 0       31      0.00
Label LBL G,                                                 0       63      0.00
Label LBL I,                                                 0       254     0.00
Label LBL J,                                                 1       62      1.58
Label LBL K,                                                 0       31      0.00
Label LBL L,                                                 0       31      0.00
Label LBL N,                                                 0       31      0.00
Label LBL Q,                                                 0       31      0.00
```

9 Bits will provide 510 labels (512- 2 reserved)
Default Bit size is 9 by default for 9300-GX2A
Per slice
510 labels available for Ing-racl by default
Label B is used for ing-racl

Figure 42 The allocated label size for 9300-FX2 and 9300-GX2A

Classification ACL Design Considerations

Scaling TCAM Usage with Slices

The CloudScale ASIC Slice mapping section notes that users have the ability to enhance the overall TCAM scale by strategically distributing the ACL policies across various front panel ports. In Figure 43, you can observe the LS25600 GX2A ASIC slices of the Cisco Nexus 9364D-GX2A, each of which is equipped with 6K ingress and 3K egress TCAM, along with 62/254/510 labels.

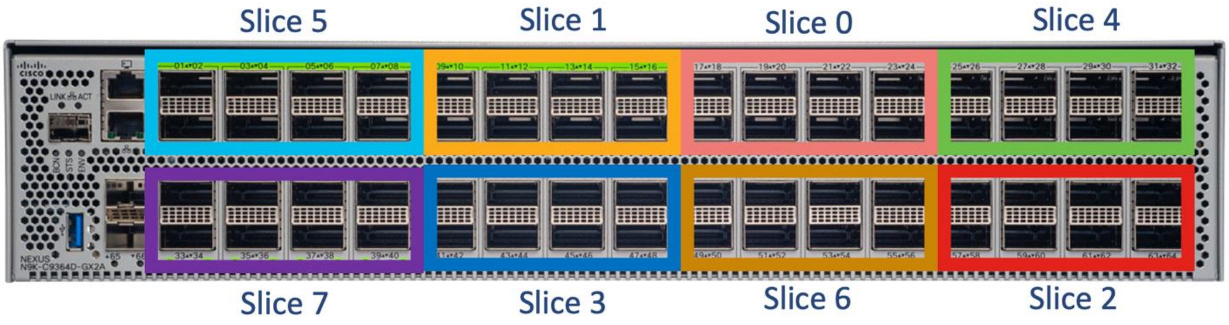
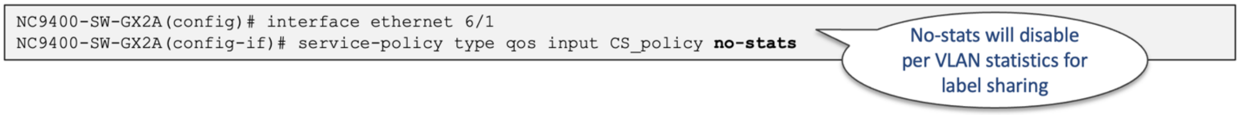


Figure 43 Nexus 9364D-GX2A front panel port and LS25600 GX2A ASIC slice allocations

TCAM Sharing for QoS Policy

By default, QoS TCAM sharing among interfaces or VLANs is not enabled to preserve per-policy stats. When multiple interfaces or VLANs have the same QoS policy, individual copies of the QoS policy are programmed for each interface or VLAN. However, TCAM sharing can be enabled by applying the QoS policy under interfaces or VLANs with the " no-stats" option using the configuration command " service-policy type qos input policy-name no-stats" . After you enable TCAM sharing, the per-interface or per-VLAN statistics is no longer available. Figure 44 illustrates how label sharing is enabled for VLAN QoS.



```
NC9400-SW-GX2A(config)# interface ethernet 6/1
NC9400-SW-GX2A(config-if)# service-policy type qos input CS_policy no-stats
```

No-stats will disable per VLAN statistics for label sharing

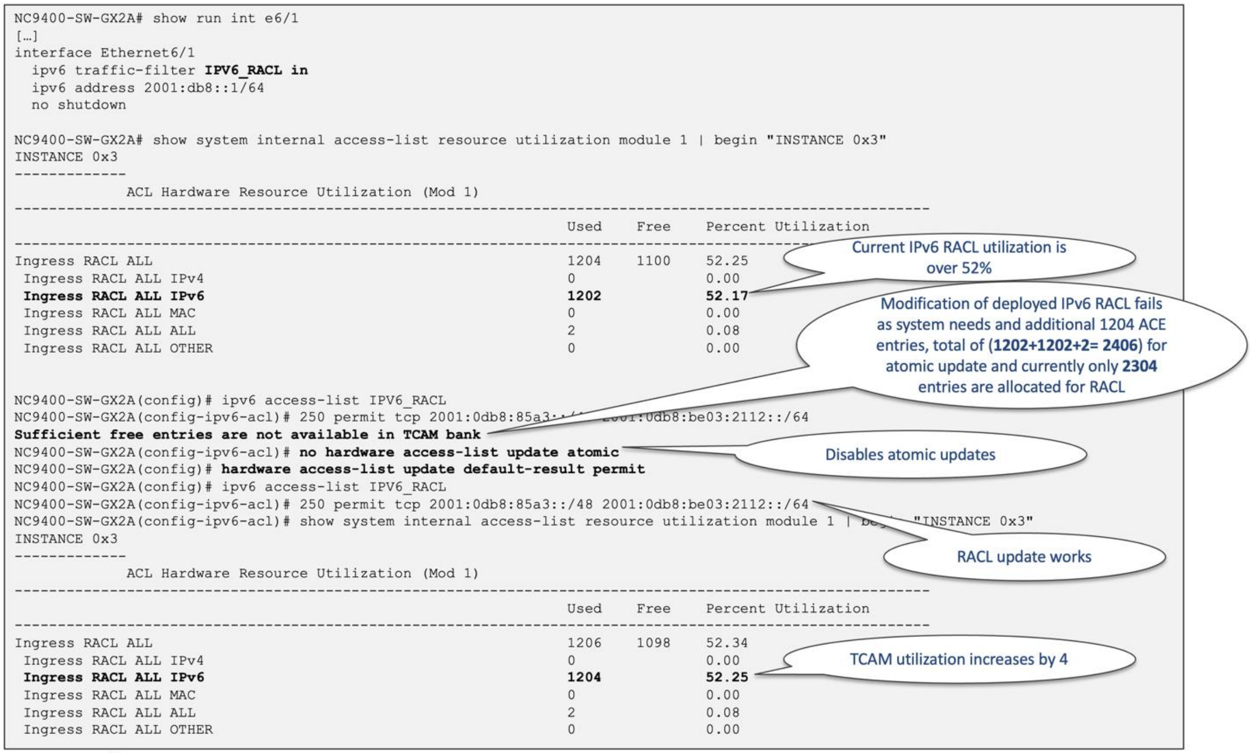
Figure 44 How to enable label sharing for VLAN QoS

Atomic ACL Programming

By default, when a Nexus 9000 switch equipped with the CloudScale ASIC updates an ACL, it performs an atomic ACL update. This type of update ensures that traffic traversing the interface where the change is being made is unaffected. However, an atomic update necessitates having enough available resources to store each updated ACL entry alongside all existing entries within the affected ACL. After the update completes, the additional resources utilized during the process are freed up.

In case there are insufficient free resources, an error is generated and no changes are applied to the hardware tables. You also have the option to disable atomic programming and perform the update non-atomically. You can do this by using the command " no hardware access-list update atomic" , as shown in Figure 45.

When performing non-atomic programming, there will be a brief impact on the traffic, and by default, the affected traffic is dropped. However, this behavior can be changed by issuing the command " hardware access-list update default-result permit" .



```
NC9400-SW-GX2A# show run int e6/1
[…]
interface Ethernet6/1
  ipv6 traffic-filter IPV6_RACL in
  ipv6 address 2001:db8::1/64
  no shutdown

NC9400-SW-GX2A# show system internal access-list resource utilization module 1 | begin "INSTANCE 0x3"
INSTANCE 0x3
-------------
             ACL Hardware Resource Utilization (Mod 1)
---------------------------------------------------------------------------------------------------------
                                                                Used    Free    Percent Utilization
---------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                                1204    1100    52.25
 Ingress RACL ALL IPv4                                          0               0.00
 Ingress RACL ALL IPv6                                          1202            52.17
 Ingress RACL ALL MAC                                           0               0.00
 Ingress RACL ALL ALL                                           2               0.08
 Ingress RACL ALL OTHER                                         0               0.00


NC9400-SW-GX2A(config)# ipv6 access-list IPV6_RACL
NC9400-SW-GX2A(config-ipv6-acl)# 250 permit tcp 2001:0db8:85a3::/48 2001:0db8:be03:2112::/64
Sufficient free entries are not available in TCAM bank
NC9400-SW-GX2A(config-ipv6-acl)# no hardware access-list update atomic
NC9400-SW-GX2A(config)# hardware access-list update default-result permit
NC9400-SW-GX2A(config)# ipv6 access-list IPV6_RACL
NC9400-SW-GX2A(config-ipv6-acl)# 250 permit tcp 2001:0db8:85a3::/48 2001:0db8:be03:2112::/64
NC9400-SW-GX2A(config-ipv6-acl)# show system internal access-list resource utilization module 1 | begin "INSTANCE 0x3"
INSTANCE 0x3
-------------
             ACL Hardware Resource Utilization (Mod 1)
---------------------------------------------------------------------------------------------------------
                                                                Used    Free    Percent Utilization
---------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                                1206    1098    52.34
 Ingress RACL ALL IPv4                                          0               0.00
 Ingress RACL ALL IPv6                                          1204            52.25
 Ingress RACL ALL MAC                                           0               0.00
 Ingress RACL ALL ALL                                           2               0.08
 Ingress RACL ALL OTHER                                         0               0.00
```

Current IPv6 RACL utilization is over 52%

Modification of deployed IPv6 RACL fails as system needs and additional 1204 ACE entries, total of (**1202+1202+2= 2406**) for atomic update and currently only **2304** entries are allocated for RACL

Disables atomic updates

RACL update works

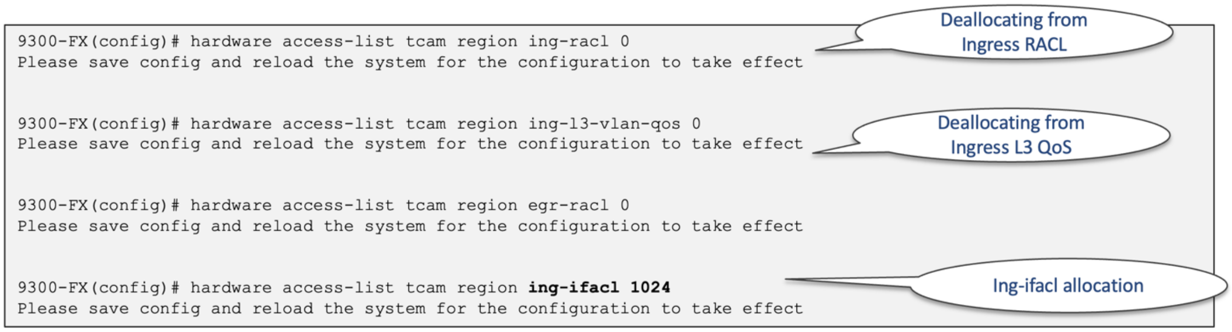
TCAM utilization increases by 4

Figure 45 How to disable atomic update with Cisco Nexus 9000

Cisco Nexus Dashboard Data Broker

Cisco Nexus Dashboard Data Broker (NDDB) offers a straightforward, flexible, and cost-efficient solution for monitoring high-volume and mission-critical traffic. It replaces conventional, purpose-specific matrix switches by utilizing one or multiple Cisco Nexus 9000 series switches that can be interconnected to form a scalable network Test Access Port (TAP) and Cisco Switched Port Analyzer (SPAN) aggregation infrastructure, supporting data rates of 1, 10, 25/40, 100, and 400 Gbps.

When deploying a Cisco Nexus 9000 as a NDDB switch, you must allocate the PACL TCAM region, which is not preallocated by default. To achieve this, you can deallocate resources from the ingress and egress RACL as well as Layer 3 QoS (Quality of Service). For a better understanding, see Figure 46, which illustrates an example of the ACL TCAM configuration for the NDDB switch.

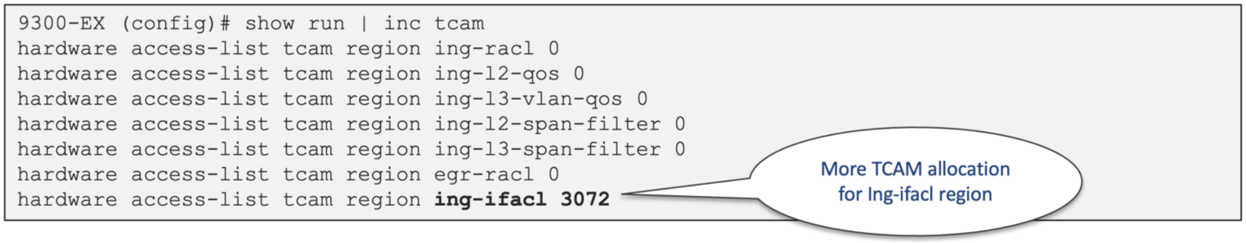


```
9300-FX(config)# hardware access-list tcam region ing-racl 0
Please save config and reload the system for the configuration to take effect

9300-FX(config)# hardware access-list tcam region ing-l3-vlan-qos 0
Please save config and reload the system for the configuration to take effect

9300-FX(config)# hardware access-list tcam region egr-racl 0
Please save config and reload the system for the configuration to take effect

9300-FX(config)# hardware access-list tcam region ing-ifacl 1024
Please save config and reload the system for the configuration to take effect
```

Deallocating from Ingress RACL
Deallocating from Ingress L3 QoS
Ing-ifacl allocation

Figure 46 Cisco Nexus Data Broker ACL TCAM configuration

In scenarios where additional ACL filtering is expected with the NDDB switch, you can assign even greater TCAM entries to the 'ing-ifacl' region. Figure 47 demonstrates a 3K allocation to the 'ing-ifacl' region.

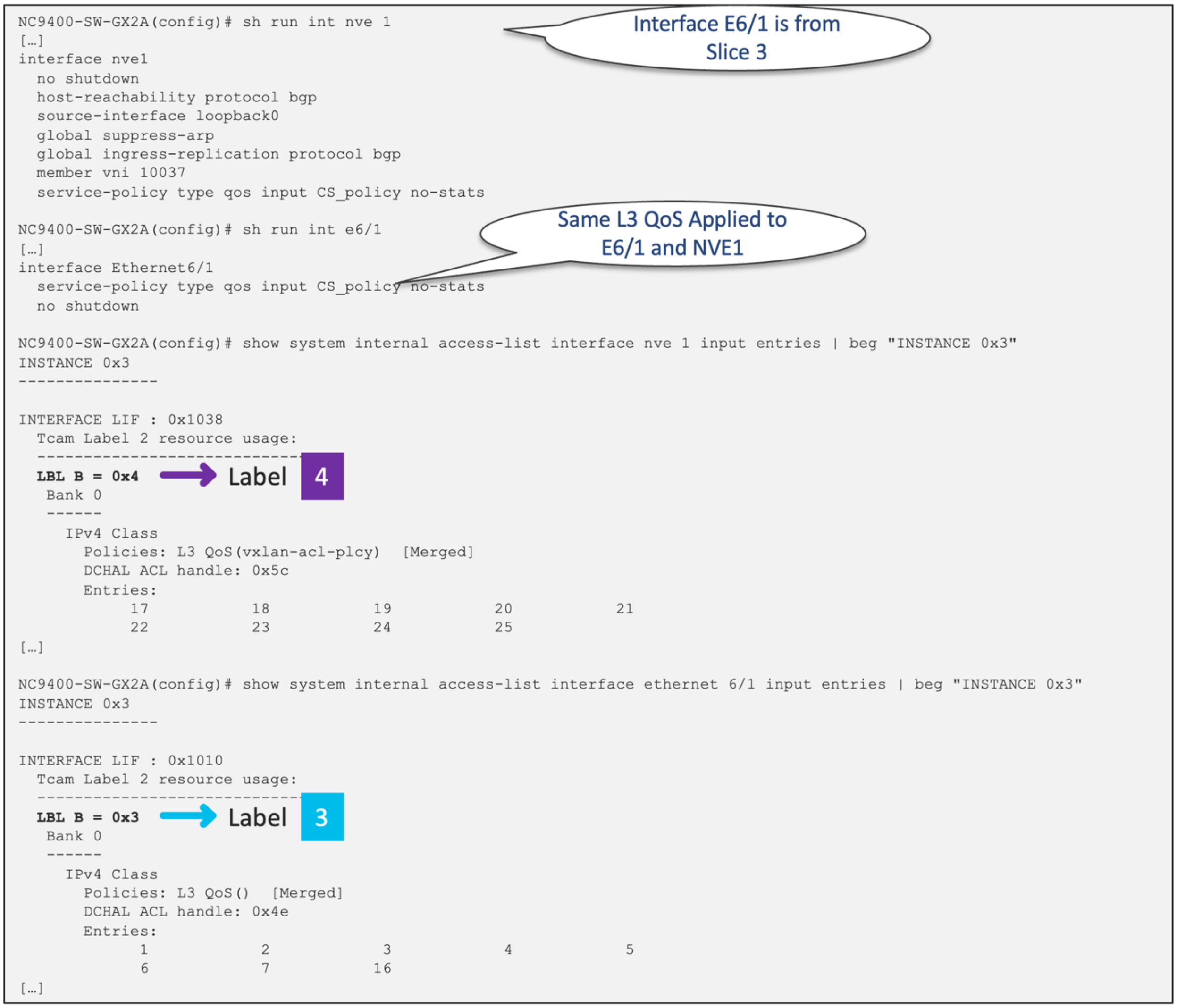


```
9300-EX (config)# show run | inc tcam
hardware access-list tcam region ing-racl 0
hardware access-list tcam region ing-l2-qos 0
hardware access-list tcam region ing-l3-vlan-qos 0
hardware access-list tcam region ing-l2-span-filter 0
hardware access-list tcam region ing-l3-span-filter 0
hardware access-list tcam region egr-racl 0
hardware access-list tcam region ing-ifacl 3072
```

Figure 47 Cisco Nexus Data Broker ACL TCAM config for additional filtering

ACL Label Sharing and VXLAN

A label cannot be shared between a Layer 3 interface and an NVE interface even if the same policies are configured on them. Figure 48 illustrates the distinct label allocations for NVE and Layer 3 interfaces from the same slice.



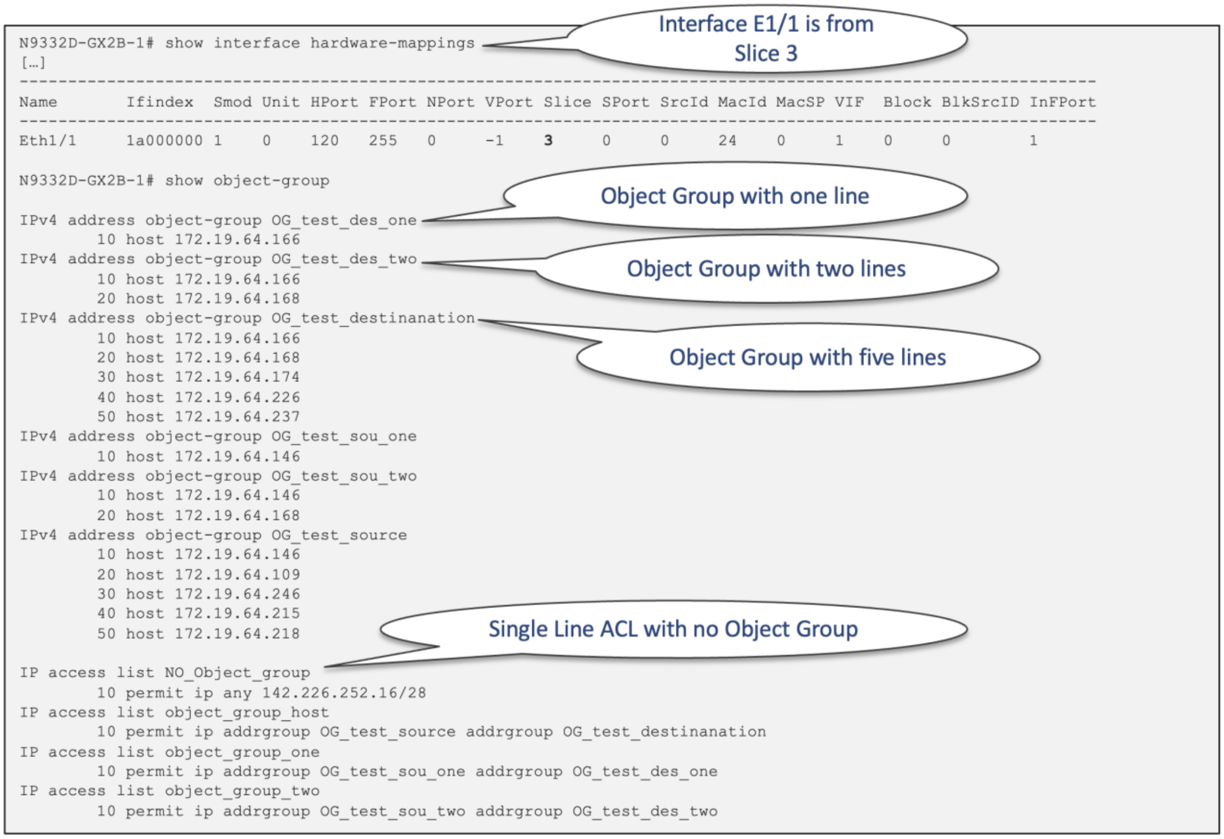
```
NC9400-SW-GX2A(config)# sh run int nve 1
[…]
interface nve1
  no shutdown
  host-reachability protocol bgp
  source-interface loopback0
  global suppress-arp
  global ingress-replication protocol bgp
  member vni 10037
  service-policy type qos input CS_policy no-stats

NC9400-SW-GX2A(config)# sh run int e6/1
[…]
interface Ethernet6/1
  service-policy type qos input CS_policy no-stats
  no shutdown

NC9400-SW-GX2A(config)# show system internal access-list interface nve 1 input entries | beg "INSTANCE 0x3"
INSTANCE 0x3
---------------

INTERFACE LIF : 0x1038
  Tcam Label 2 resource usage:
  -----------------------------
  LBL B = 0x4
   Bank 0
   ------
     IPv4 Class
       Policies: L3 QoS(vxlan-acl-plcy)  [Merged]
       DCHAL ACL handle: 0x5c
       Entries:
            17           18           19           20           21
            22           23           24           25
[…]

NC9400-SW-GX2A(config)# show system internal access-list interface ethernet 6/1 input entries | beg "INSTANCE 0x3"
INSTANCE 0x3
---------------

INTERFACE LIF : 0x1010
  Tcam Label 2 resource usage:
  -----------------------------
  LBL B = 0x3
   Bank 0
   ------
     IPv4 Class
       Policies: L3 QoS()  [Merged]
       DCHAL ACL handle: 0x4e
       Entries:
             1            2            3            4            5
             6            7           16
[…]
```

Interface E6/1 is from Slice 3
Same L3 QoS Applied to E6/1 and NVE1
Label 4
Label 3

Figure 48 Different label allocation for interface e6/1 and Nve1

ACL TCAM Space Utilization with Object Groups

Utilizing object groups does not result in a reduced TCAM space utilization. The extension of TCAM when using Object Groups in conjunction with ACLs depends on the number of lines present in each Object group. For a visual representation of this concept, see Figure 49, which illustrates the IPv4 RACL utilization with various object groups.



Interface E1/1 is from Slice 3

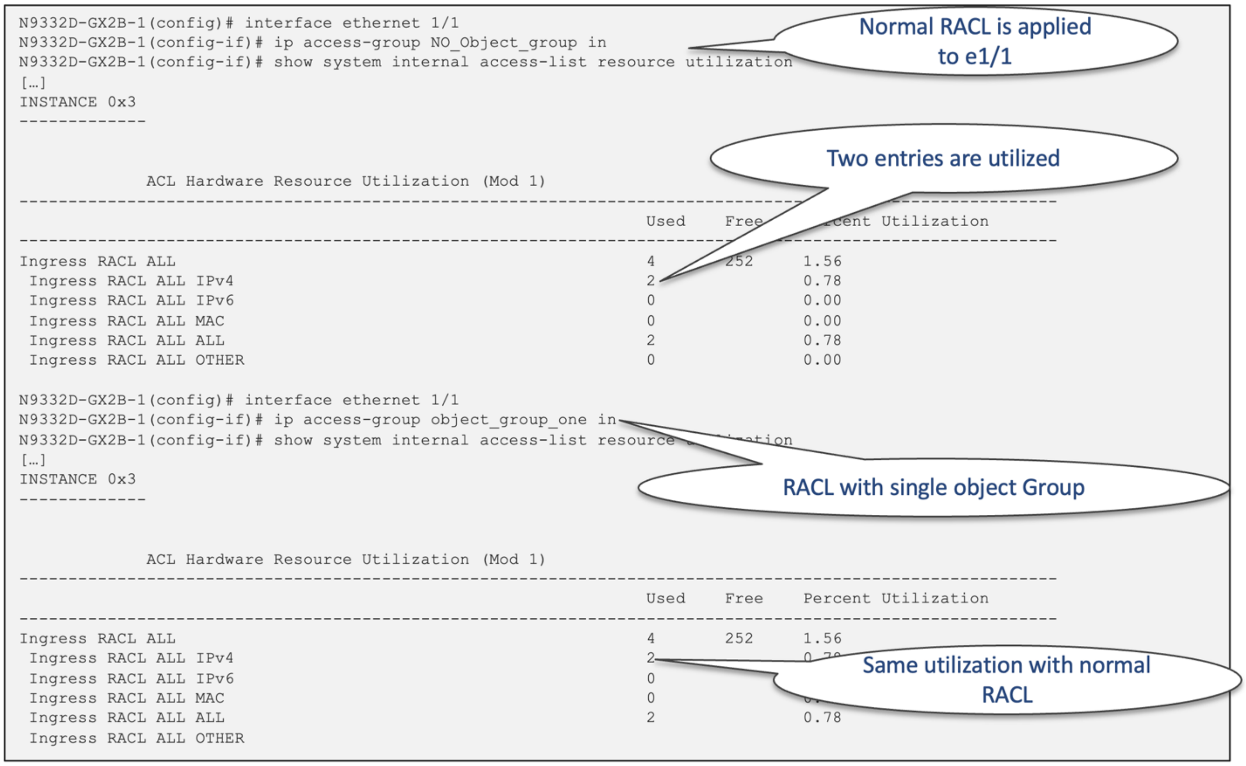
Object Group with one line

Object Group with two lines

Object Group with five lines

Single Line ACL with no Object Group

```
N9332D-GX2B-1# show interface hardware-mappings
[…]
--------------------------------------------------------------------------------------------------------------
Name       Ifindex   Smod Unit HPort FPort NPort VPort Slice SPort SrcId MacId MacSP VIF  Block BlkSrcID InFPort
--------------------------------------------------------------------------------------------------------------
Eth1/1     1a000000 1    0    120   255   0     -1    3     0     0     24    0     1     0     0        1

N9332D-GX2B-1# show object-group

IPv4 address object-group OG_test_des_one
        10 host 172.19.64.166
IPv4 address object-group OG_test_des_two
        10 host 172.19.64.166
        20 host 172.19.64.168
IPv4 address object-group OG_test_destinanation
        10 host 172.19.64.166
        20 host 172.19.64.168
        30 host 172.19.64.174
        40 host 172.19.64.226
        50 host 172.19.64.237
IPv4 address object-group OG_test_sou_one
        10 host 172.19.64.146
IPv4 address object-group OG_test_sou_two
        10 host 172.19.64.146
        20 host 172.19.64.168
IPv4 address object-group OG_test_source
        10 host 172.19.64.146
        20 host 172.19.64.109
        30 host 172.19.64.246
        40 host 172.19.64.215
        50 host 172.19.64.218

IP access list NO_Object_group
        10 permit ip any 142.226.252.16/28
IP access list object_group_host
        10 permit ip addrgroup OG_test_source addrgroup OG_test_destinanation
IP access list object_group_one
        10 permit ip addrgroup OG_test_sou_one addrgroup OG_test_des_one
IP access list object_group_two
        10 permit ip addrgroup OG_test_sou_two addrgroup OG_test_des_two
```



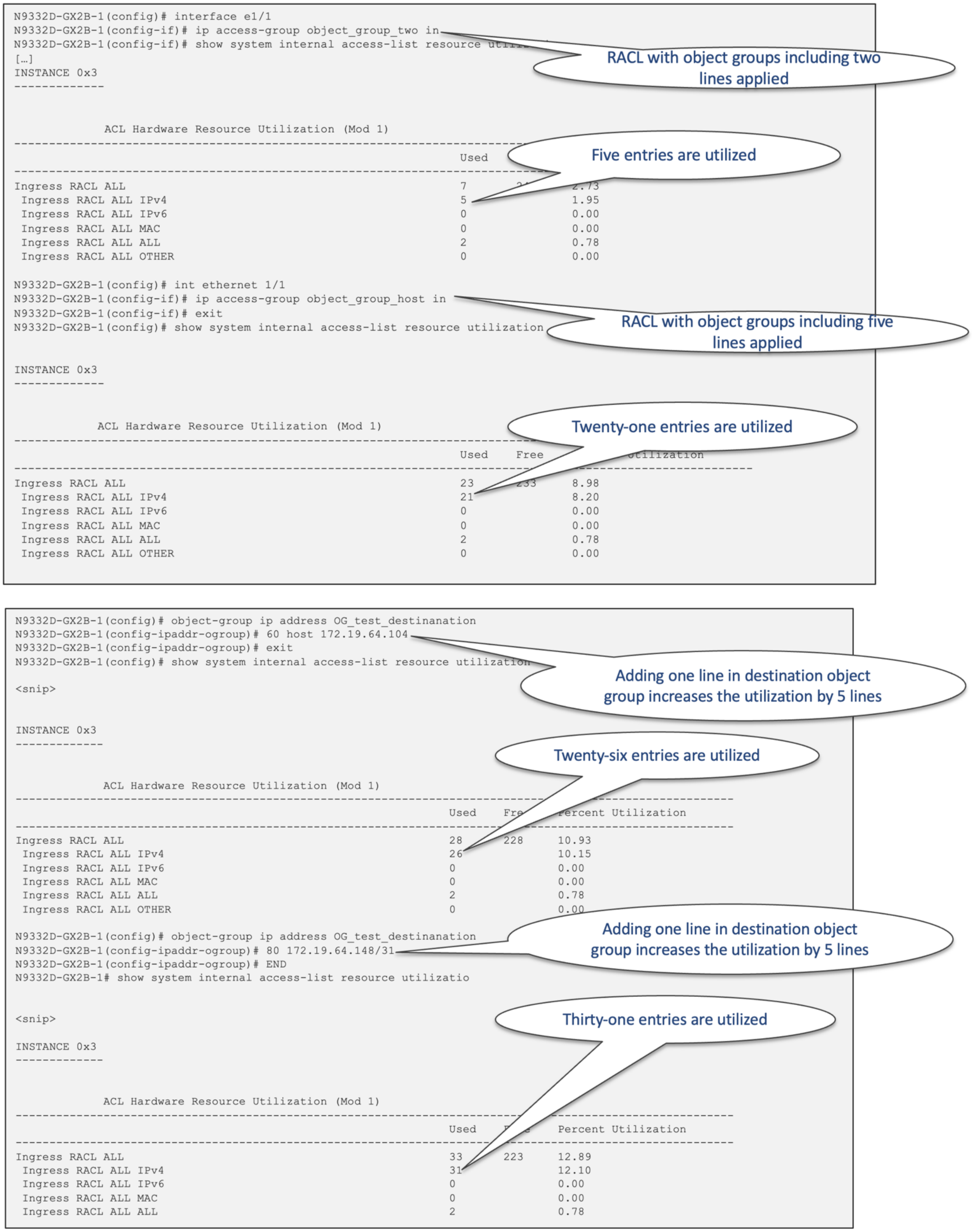
Normal RACL is applied to e1/1

Two entries are utilized

RACL with single object Group

Same utilization with normal RACL

```
N9332D-GX2B-1(config)# interface ethernet 1/1
N9332D-GX2B-1(config-if)# ip access-group NO_Object_group in
N9332D-GX2B-1(config-if)# show system internal access-list resource utilization
[…]
INSTANCE 0x3
-------------


             ACL Hardware Resource Utilization (Mod 1)
---------------------------------------------------------------------------------------------------------------
                                                                 Used     Free     Percent Utilization
---------------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                                 4        252      1.56
 Ingress RACL ALL IPv4                                           2                 0.78
 Ingress RACL ALL IPv6                                           0                 0.00
 Ingress RACL ALL MAC                                            0                 0.00
 Ingress RACL ALL ALL                                            2                 0.78
 Ingress RACL ALL OTHER                                          0                 0.00

N9332D-GX2B-1(config)# interface ethernet 1/1
N9332D-GX2B-1(config-if)# ip access-group object_group_one in
N9332D-GX2B-1(config-if)# show system internal access-list resource utilization
[…]
INSTANCE 0x3
-------------


             ACL Hardware Resource Utilization (Mod 1)
---------------------------------------------------------------------------------------------------------------
                                                                 Used     Free     Percent Utilization
---------------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                                 4        252      1.56
 Ingress RACL ALL IPv4                                           2                 0.78
 Ingress RACL ALL IPv6                                           0
 Ingress RACL ALL MAC                                            0                 0.00
 Ingress RACL ALL ALL                                            2                 0.78
 Ingress RACL ALL OTHER
```



```
N9332D-GX2B-1(config)# interface e1/1
N9332D-GX2B-1(config-if)# ip access-group object_group_two in
N9332D-GX2B-1(config-if)# show system internal access-list resource utili
[…]
INSTANCE 0x3
-------------


            ACL Hardware Resource Utilization (Mod 1)
--------------------------------------------------------------------------
                                                                Used
--------------------------------------------------------------------------
Ingress RACL ALL                                                7                2.73
 Ingress RACL ALL IPv4                                          5                1.95
 Ingress RACL ALL IPv6                                          0                0.00
 Ingress RACL ALL MAC                                           0                0.00
 Ingress RACL ALL ALL                                           2                0.78
 Ingress RACL ALL OTHER                                         0                0.00

N9332D-GX2B-1(config)# int ethernet 1/1
N9332D-GX2B-1(config-if)# ip access-group object_group_host in
N9332D-GX2B-1(config-if)# exit
N9332D-GX2B-1(config)# show system internal access-list resource utilization


INSTANCE 0x3
-------------


           ACL Hardware Resource Utilization (Mod 1)
--------------------------------------------------------------------------
                                                                Used    Free          tilization
------------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                                23      233      8.98
 Ingress RACL ALL IPv4                                          21               8.20
 Ingress RACL ALL IPv6                                          0                0.00
 Ingress RACL ALL MAC                                           0                0.00
 Ingress RACL ALL ALL                                           2                0.78
 Ingress RACL ALL OTHER                                         0                0.00
```

RACL with object groups including two lines applied

Five entries are utilized

RACL with object groups including five lines applied

Twenty-one entries are utilized

```
N9332D-GX2B-1(config)# object-group ip address OG_test_destinanation
N9332D-GX2B-1(config-ipaddr-ogroup)# 60 host 172.19.64.104
N9332D-GX2B-1(config-ipaddr-ogroup)# exit
N9332D-GX2B-1(config)# show system internal access-list resource utilization

<snip>


INSTANCE 0x3
-------------



            ACL Hardware Resource Utilization (Mod 1)
------------------------------------------------------------------------------------------------------
                                                              Used    Fre      ercent Utilization
------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                              28      228      10.93
 Ingress RACL ALL IPv4                                        26               10.15
 Ingress RACL ALL IPv6                                        0                0.00
 Ingress RACL ALL MAC                                         0                0.00
 Ingress RACL ALL ALL                                         2                0.78
 Ingress RACL ALL OTHER                                       0                0.00

N9332D-GX2B-1(config)# object-group ip address OG_test_destinanation
N9332D-GX2B-1(config-ipaddr-ogroup)# 80 172.19.64.148/31
N9332D-GX2B-1(config-ipaddr-ogroup)# END
N9332D-GX2B-1# show system internal access-list resource utilizatio


<snip>

INSTANCE 0x3
-------------



            ACL Hardware Resource Utilization (Mod 1)
------------------------------------------------------------------------------------------------------
                                                              Used             Percent Utilization
------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                              33      223      12.89
 Ingress RACL ALL IPv4                                        31               12.10
 Ingress RACL ALL IPv6                                        0                0.00
 Ingress RACL ALL MAC                                         0                0.00
 Ingress RACL ALL ALL                                         2                0.78
```

Adding one line in destination object group increases the utilization by 5 lines

Twenty-six entries are utilized

Adding one line in destination object group increases the utilization by 5 lines

Thirty-one entries are utilized

Figure 49 Object group impact on RACL TCAM utilization

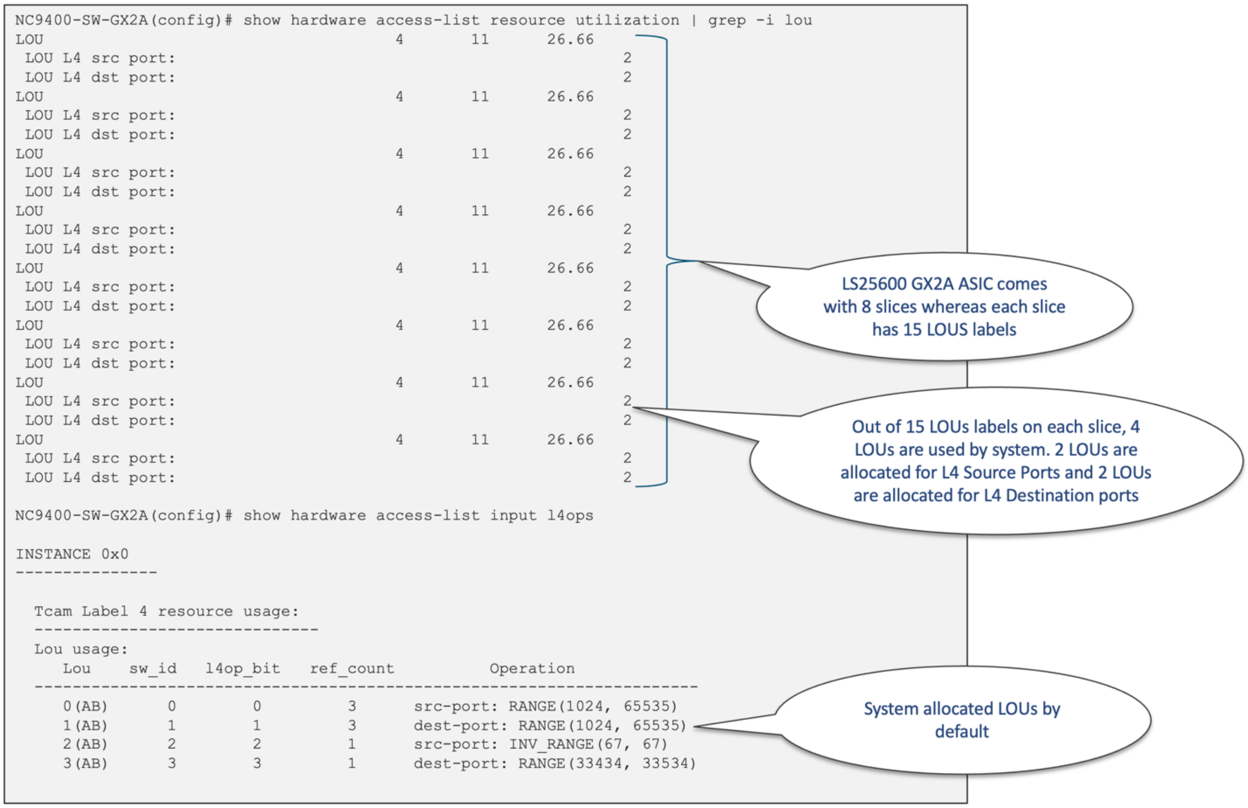
Logical Operators and Logical Operation Units (LOUs)

IP ACL rules for TCP and UDP traffic can use logical operators to filter traffic based on port numbers in the ingress direction. Cisco Nexus 9000 stores operator-operand couples in registers called logical operator units (LOUs). Table 9 displays the LOU usage for each type of operator.

Table 9 LOU usage for each type of operator

LOU Operator	Direction
EQ (equal to)	Is never stored in an LOU
GT (greater than)	Uses 1 LOU
LT (less than)	Uses 1 LOU
NEG (not equal to)	Uses 1 LOU
Range	Uses 1 LOU

Within each CloudScale ASIC slice, there are a total of 15 LOU labels available, with 4 of them allocated for the default CoPP policy. Figure 50 exhibits the default LOU allocation for the NC9400-SW-GX2A model featuring the LS25600 GX2A ASIC.



```
NC9400-SW-GX2A(config)# show hardware access-list resource utilization | grep -i lou
LOU                                     4       11      26.66
 LOU L4 src port:                                               2
 LOU L4 dst port:                                               2
LOU                                     4       11      26.66
 LOU L4 src port:                                               2
 LOU L4 dst port:                                               2
LOU                                     4       11      26.66
 LOU L4 src port:                                               2
 LOU L4 dst port:                                               2
LOU                                     4       11      26.66
 LOU L4 src port:                                               2
 LOU L4 dst port:                                               2
LOU                                     4       11      26.66
 LOU L4 src port:                                               2
 LOU L4 dst port:                                               2
LOU                                     4       11      26.66
 LOU L4 src port:                                               2
 LOU L4 dst port:                                               2
LOU                                     4       11      26.66
 LOU L4 src port:                                               2
 LOU L4 dst port:                                               2
LOU                                     4       11      26.66
 LOU L4 src port:                                               2
 LOU L4 dst port:                                               2

NC9400-SW-GX2A(config)# show hardware access-list input l4ops

INSTANCE 0x0
---------------

  Tcam Label 4 resource usage:
  ------------------------------
  Lou usage:
     Lou     sw_id   l4op_bit   ref_count          Operation
  ----------------------------------------------------------------------
     0(AB)      0        0          3      src-port: RANGE(1024, 65535)
     1(AB)      1        1          3      dest-port: RANGE(1024, 65535)
     2(AB)      2        2          1      src-port: INV_RANGE(67, 67)
     3(AB)      3        3          1      dest-port: RANGE(33434, 33534)
```

LS25600 GX2A ASIC comes with 8 slices whereas each slice has 15 LOUS labels

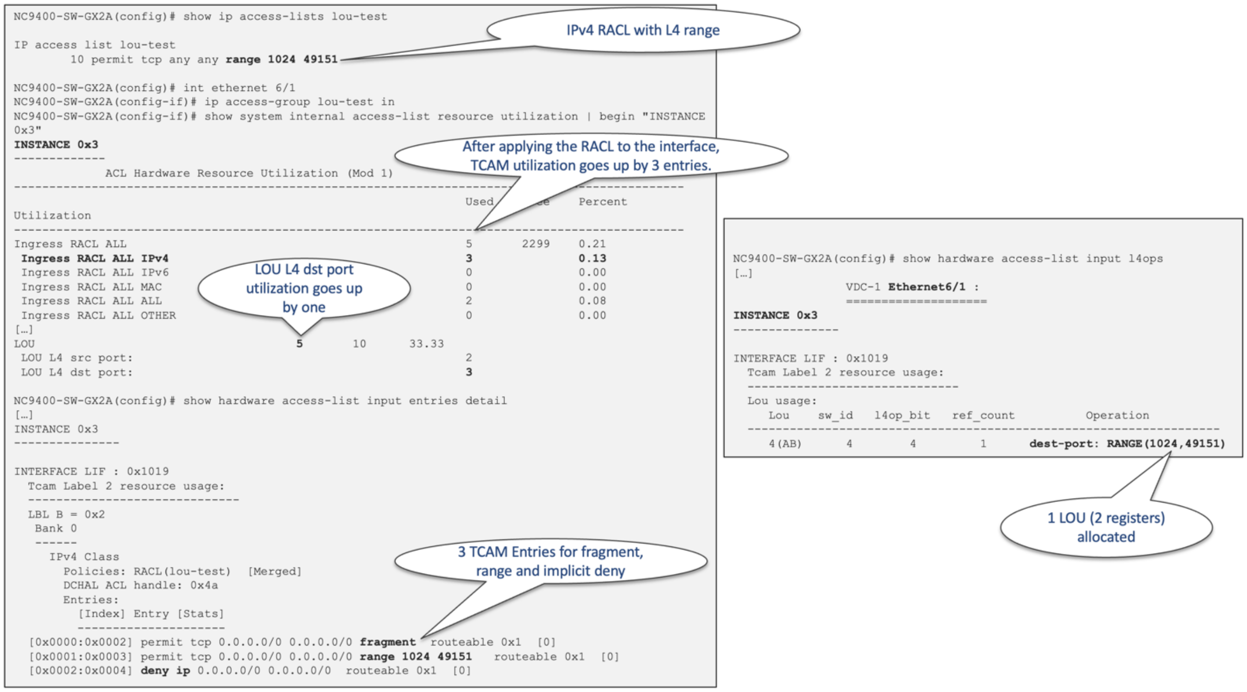
Out of 15 LOUs labels on each slice, 4 LOUs are used by system. 2 LOUs are allocated for L4 Source Ports and 2 LOUs are allocated for L4 Destination ports

System allocated LOUs by default

Figure 50 The default LOU allocation for the NC9400-SW-GX2A

The " ACE Expansion Threshold" plays a pivotal role in determining how ACEs utilizing Layer 4 operators such as " range" , " gt" , " lt" , and " neq" are managed. There are two distinct methods by which software handles these Layer 4 operators. The first approach involves the allocation of L4op, a hardware resource, alongside programming the LOU register, which is another hardware resource. Alternatively, ACEs can be expanded into multiple " eq" entries, effectively utilizing multiple ACL TCAM entries. The command " global hardware access-list lou resource threshold" governs the decision between these two options for each ACE. The expansion threshold, a key factor in this decision-making process, governs when ACE expansion occurs. By default, the threshold is set at 5. When an ACE can be expanded into 5 or fewer ACL TCAM entries, no L4op is allocated. You must weigh the pros and cons of these approaches. While expansion conserves L4op resources, it does consume more TCAM entries. Additionally, the utilization of L4op and LOU is constrained by their respective limits which is 15 labels per slice. Figure 51 and Figure 52 provide an illustrative example of a straightforward ACE extension, showcasing the impact of modifying the default threshold.

Starting from NX-OS 10.4(1)F, Layer 3 ePBR solutions will also support Layer 4 port operators such as port-range, " gt" , " lt" , and " neq" . You can use these operators for selective redirection, load balancing, and service chaining based on the your specifications, aligning with the intended traffic filtering. Additionally, if you use ePBR you can modify the platform behavior for Layer 4 port operations by utilizing the " global hardware access-list lou resource threshold" command.

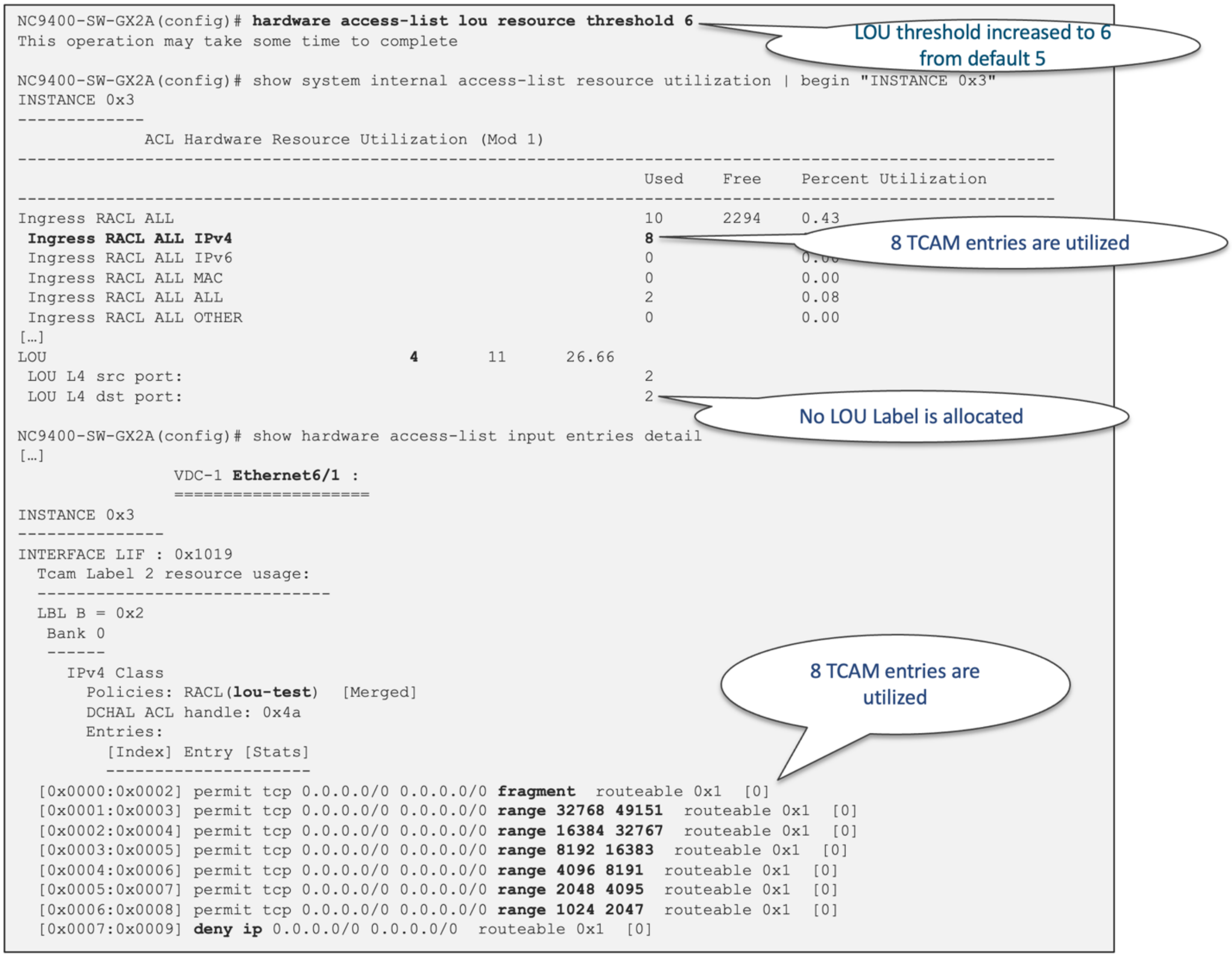


```
NC9400-SW-GX2A(config)# show ip access-lists lou-test

IP access list lou-test
        10 permit tcp any any range 1024 49151

NC9400-SW-GX2A(config)# int ethernet 6/1
NC9400-SW-GX2A(config-if)# ip access-group lou-test in
NC9400-SW-GX2A(config-if)# show system internal access-list resource utilization | begin "INSTANCE
0x3"
INSTANCE 0x3
-------------
             ACL Hardware Resource Utilization (Mod 1)
-----------------------------------------------------------------------------------------------
                                                                 Used        e     Percent
Utilization
-----------------------------------------------------------------------------------------------
Ingress RACL ALL                                                 5       2299    0.21
 Ingress RACL ALL IPv4                                           3               0.13
 Ingress RACL ALL IPv6                                           0               0.00
 Ingress RACL ALL MAC                                            0               0.00
 Ingress RACL ALL ALL                                            2               0.08
 Ingress RACL ALL OTHER                                          0               0.00
[…]
LOU                                          5         10       33.33
 LOU L4 src port:                                                2
 LOU L4 dst port:                                                3

NC9400-SW-GX2A(config)# show hardware access-list input entries detail
[…]
INSTANCE 0x3
---------------

INTERFACE LIF : 0x1019
  Tcam Label 2 resource usage:
  ------------------------------
  LBL B = 0x2
   Bank 0
   ------
     IPv4 Class
       Policies: RACL(lou-test)  [Merged]
       DCHAL ACL handle: 0x4a
       Entries:
         [Index] Entry [Stats]
         ---------------------
  [0x0000:0x0002] permit tcp 0.0.0.0/0 0.0.0.0/0 fragment  routeable 0x1  [0]
  [0x0001:0x0003] permit tcp 0.0.0.0/0 0.0.0.0/0 range 1024 49151   routeable 0x1  [0]
  [0x0002:0x0004] deny ip 0.0.0.0/0 0.0.0.0/0  routeable 0x1  [0]
```

```
NC9400-SW-GX2A(config)# show hardware access-list input l4ops
[…]
                VDC-1 Ethernet6/1 :
                ====================
INSTANCE 0x3
---------------

INTERFACE LIF : 0x1019
  Tcam Label 2 resource usage:
  ------------------------------
  Lou usage:
     Lou     sw_id    l4op_bit    ref_count          Operation
  -------------------------------------------------------------------
     4(AB)      4         4           1       dest-port: RANGE(1024,49151)
```

IPv4 RACL with L4 range
After applying the RACL to the interface, TCAM utilization goes up by 3 entries.
LOU L4 dst port utilization goes up by one
3 TCAM Entries for fragment, range and implicit deny
1 LOU (2 registers) allocated

Figure 51 ACE extension example with default threshold of 5



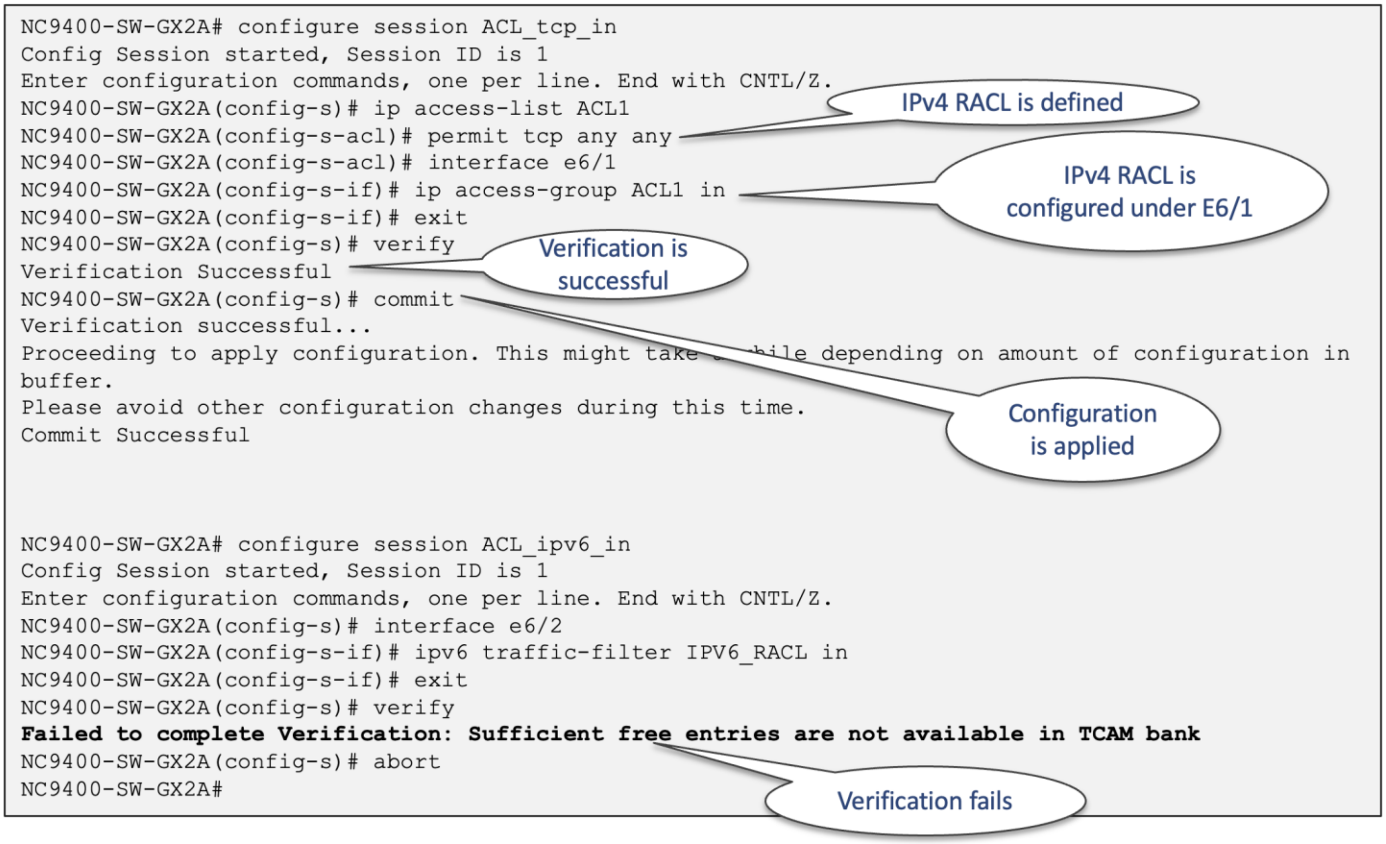
```
NC9400-SW-GX2A(config)# hardware access-list lou resource threshold 6
This operation may take some time to complete

NC9400-SW-GX2A(config)# show system internal access-list resource utilization | begin "INSTANCE 0x3"
INSTANCE 0x3
-------------
             ACL Hardware Resource Utilization (Mod 1)
----------------------------------------------------------------------------------------------------------
                                                                Used    Free    Percent Utilization
----------------------------------------------------------------------------------------------------------
Ingress RACL ALL                                                10      2294    0.43
 Ingress RACL ALL IPv4                                          8               0.00
 Ingress RACL ALL IPv6                                          0               0.00
 Ingress RACL ALL MAC                                           0               0.00
 Ingress RACL ALL ALL                                           2               0.08
 Ingress RACL ALL OTHER                                         0               0.00
[…]
LOU                                      4       11      26.66
 LOU L4 src port:                                               2
 LOU L4 dst port:                                               2

NC9400-SW-GX2A(config)# show hardware access-list input entries detail
[…]
                VDC-1 Ethernet6/1 :
                ====================

INSTANCE 0x3
---------------

INTERFACE LIF : 0x1019
  Tcam Label 2 resource usage:
  ------------------------------
  LBL B = 0x2
   Bank 0
   ------
     IPv4 Class
       Policies: RACL(lou-test)  [Merged]
       DCHAL ACL handle: 0x4a
       Entries:
         [Index] Entry [Stats]
         ---------------------
  [0x0000:0x0002] permit tcp 0.0.0.0/0 0.0.0.0/0 fragment  routeable 0x1  [0]
  [0x0001:0x0003] permit tcp 0.0.0.0/0 0.0.0.0/0 range 32768 49151  routeable 0x1  [0]
  [0x0002:0x0004] permit tcp 0.0.0.0/0 0.0.0.0/0 range 16384 32767  routeable 0x1  [0]
  [0x0003:0x0005] permit tcp 0.0.0.0/0 0.0.0.0/0 range 8192 16383  routeable 0x1  [0]
  [0x0004:0x0006] permit tcp 0.0.0.0/0 0.0.0.0/0 range 4096 8191  routeable 0x1  [0]
  [0x0005:0x0007] permit tcp 0.0.0.0/0 0.0.0.0/0 range 2048 4095  routeable 0x1  [0]
  [0x0006:0x0008] permit tcp 0.0.0.0/0 0.0.0.0/0 range 1024 2047  routeable 0x1  [0]
  [0x0007:0x0009] deny ip 0.0.0.0/0 0.0.0.0/0  routeable 0x1  [0]
```

LOU threshold increased to 6 from default 5
8 TCAM entries are utilized
No LOU Label is allocated
8 TCAM entries are utilized

Figure 52 ACE extension example with modified threshold of 6

Configuring Session Manager

To ascertain the sufficiency of hardware resources (TCAM entries) prior to implementing an ACL or a QoS policy, employing a " Configuration Session" proves effective. During this process, users can set up ACLs and assign them to a designated interface. In instances where TCAM space is inadequate, the verification process will yield a failure. Referencing Figure 53 illustrates both a successful configuration session and an unsuccessful verification due to insufficient resources.



```
NC9400-SW-GX2A# configure session ACL_tcp_in
Config Session started, Session ID is 1
Enter configuration commands, one per line. End with CNTL/Z.
NC9400-SW-GX2A(config-s)# ip access-list ACL1
NC9400-SW-GX2A(config-s-acl)# permit tcp any any
NC9400-SW-GX2A(config-s-acl)# interface e6/1
NC9400-SW-GX2A(config-s-if)# ip access-group ACL1 in
NC9400-SW-GX2A(config-s-if)# exit
NC9400-SW-GX2A(config-s)# verify
Verification Successful
NC9400-SW-GX2A(config-s)# commit
Verification successful...
Proceeding to apply configuration. This might take a while depending on amount of configuration in
buffer.
Please avoid other configuration changes during this time.
Commit Successful



NC9400-SW-GX2A# configure session ACL_ipv6_in
Config Session started, Session ID is 1
Enter configuration commands, one per line. End with CNTL/Z.
NC9400-SW-GX2A(config-s)# interface e6/2
NC9400-SW-GX2A(config-s-if)# ipv6 traffic-filter IPV6_RACL in
NC9400-SW-GX2A(config-s-if)# exit
NC9400-SW-GX2A(config-s)# verify
Failed to complete Verification: Sufficient free entries are not available in TCAM bank
NC9400-SW-GX2A(config-s)# abort
NC9400-SW-GX2A#
```

Figure 53 Configuration session examples

Conclusion

The Cisco Nexus 9000 platform switches incorporate Cisco's cutting edge CloudScale ASICs, which establish the benchmark for contemporary data center switching solutions. With simplified ACL TCAM regions and a versatile TCAM carving approach using multi-slice architecture, you can harness the full potential of classification table regions. This optimization strategy allows Nexus 9000 to leverage its TCAM space capabilities to the fullest, enabling you to achieve exceptional performance and efficiency in your data center operations.

Additional Resources

- Cisco Nexus 9500 Cloud Scale Line Cards and Fabric Modules White Paper
- Cisco IP Fabric for Media White Paper
- Flexible Forwarding Table on Nexus 9000
- Layer 4 to Layer 7 Service Redirection with Enhanced Policy-Based Redirect White Paper