

EARL 8分类管理器：LOUs、L4Ops和Capmap表的一个性能上的考试

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简介

本文描述如何逻辑运算单元(LOUs)，并且Layer4操作(L4Ops)被编程到capmap表。它提供故障情景，在这些情况下您典型地遇到的这错误，并且什么您应该从这些错误推断。

分类管理器(CM)管理分类三重内容可编址存储器和相关资源例如标签、LOUs，capmap条目和其他。功能管理器(FM)和QoS管理器用于CM服务(QM)编程TCAM条目支持Cisco IOS访问控制表(ACL)和服务质量(QoS)功能。

背景信息

LOUs和L4Ops - LOUs代表逻辑运算单元，是硬件寄存器使用存储{操作员，操作数}在ACL和VLAN访问控制列表指定的TCP/UDP端口号的元组(VACL)。这些元组也呼叫作为L4Ops。例如，如果匹配主机x到主机Y gt 1023，然后元组变为{gt, 1023}。

L4Ops - Layer4操作。

Capmap表-以前描述的L4Ops被编程到由条目参考在capmap表里的LOU寄存器。每个capmap表有限制10个(一个人为方向保留，减少限制到九)条目(L4Ops)。TCAM标签标注Capmap表。

有两TCAMs、A和B;每TCAM有8K标签。对于每TCAM，有2K条目一个capmap表。因为每TCAM有8K标签，有4:1重叠在这里-四个标签地图对一个capmap条目。重叠是： $1=2049=4097=6145$ 。

基本上，这意味着TCAM标签1，2049，4097和6145使用同一个capmap索引。TCAM标签分配的因此思科的传统implementation导致问题交迭。思科分配了有差距的TCAM标签2K (是2048准确的)。这暗示分配将采取表1，2049，4097，6145，2，2050，4098，6146，等等。

因此，从开始，此TCAM分配是这样capmap表交迭。这是展示此的示例(采取从Cisco Bug ID [CSCuo02666](#))。这是两个ACL、a1和a2，定义和应用对interface VLAN 1和接口VLAN 2如显示此处：

```
Sup2T(config)#ip access-list extended a1
Sup2T(config-ext-nacl)# permit ip host 1.1.1.1 any dscp 1
```



```

- 0 0 0x0
I V 16369 2049 0 0 0 1.1.1.1 - 0.0.0.0
- 0 0 0 - ----- dscp=2; 0x0000000000000038
0
I M 16369 0x1FFF 0 0x00 0x000 255.255.255.255 - 0.0.0.0
- 0 0 0x0
I V 16370 2049 0 0 0 1.1.1.1 - 0.0.0.0
- 0 0 0 - ----- dscp=1; 0x0000000000000038
0
I M 16370 0x1FFF 0 0x00 0x000 255.255.255.255 - 0.0.0.0
- 0 0 0x0
I V 16371 2049 0 0 0 0.0.0.0 - 0.0.0.0
- 0 0 0 - ----- - 0x0000000040000038
0
I M 16371 0x1FFF 0 0x00 0x000 0.0.0.0 - 0.0.0.0
- 0 0 0x0

```

Sup2T#show platform hardware acl entry interface vlan 2 security in ip detail
mls_if_index:20000002 dir:0 feature:0 proto:0

pass#0 features

UAPRSF: U-urg, A-ack, P-psh, R-rst, S-syn, F-fin
MLGFI: M-mpls_plus_ip_pkt, L-L4_hdr_vld, G-gpid_present, F-global_fmt_match, I-ife/ofe
's' means set; 'u' means unset; '-' means don't care

```

-----
-----
-----
-----
I INDEX LABEL FS ACOS AS IP_SA SRC_PORT
IP_DA DST_PORT F FF L4PROT TCP-F:UAPRSF MLGFI OtherL4OPs
RSLT CNT
-----
-----
-----

```

fno:0

tcam:B, bank:1, prot:0 Aces

```

I V 32738 4097 0 0 0 1.1.1.2 - 0.0.0.0
- 0 0 0 - ----- dscp=9; 0x0000000000000038
0
I M 32738 0x1FFF 0 0x00 0x000 255.255.255.255 - 0.0.0.0
- 0 0 0x0
I V 32739 4097 0 0 0 1.1.1.2 - 0.0.0.0
- 0 0 0 - ----- dscp=8; 0x0000000000000038
0
I M 32739 0x1FFF 0 0x00 0x000 255.255.255.255 - 0.0.0.0
- 0 0 0x0
I V 32740 4097 0 0 0 1.1.1.2 - 0.0.0.0
- 0 0 0 - ----- dscp=7; 0x0000000000000038
0
I M 32740 0x1FFF 0 0x00 0x000 255.255.255.255 - 0.0.0.0
- 0 0 0x0
I V 32741 4097 0 0 0 1.1.1.2 - 0.0.0.0
- 0 0 0 - ----- dscp=6; 0x0000000000000038
0
I M 32741 0x1FFF 0 0x00 0x000 255.255.255.255 - 0.0.0.0
- 0 0 0x0
I V 32745 4097 0 0 0 0.0.0.0 - 0.0.0.0

```

```

- 0 0 0 - ----- - 0x0000000040000038
0
I M 32745 0x1FFF 0 0x00 0x000 0.0.0.0 - 0.0.0.0
- 0 0 0x0

```

为interface VLAN 1分配的TCAM标签是2049，并且分配的TCAM标签建立接口VLAN 2是4097。这意味着这两个接口使用同一个capmap表为了参考他们L4Op编程的LOU寄存器。

您能用此命令确认此(在ACL a1的五ACE和在ACL a2的四ACE暗示您应该参见capmap表如全双工)：

```

Sup2T#show platform hardware acl capmap tcam B label 4097
Hardware Capmap Table Entry For TCAM B. Free items are not shown

```

Index	Loc[9]	[8]	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
1	212	10	9	8	7	6	5	4	3	2

```

Sup2T#show platform hardware acl capmap tcam B label 2049
Hardware Capmap Table Entry For TCAM B. Free items are not shown

```

Index	Loc[9]	[8]	[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
1	212	10	9	8	7	6	5	4	3	2

那么当前，在此阶段，如果尝试安装另一个L4Op-based访问控制项(ACE)，不是可扩展的，对于任何这些接口，您不会收到自由capmap条目联机错误。

```

Sup2T(config)#ip access-list extended a2
Sup2T(config-ext-nacl)#permit ip host 1.1.1.2 any dscp 10
Sup2T(config-ext-nacl)#end

```

```

*Sep 16 14:57:55.983: %EARL_CM-5-NOCAPMAP: No free capmap entry available
*Sep 16 14:57:55.991: %FMCORE-4-RACL_REDUCED: Interface Vlan2 routed traffic
will be software switched in ingress direction. L2 features may not be applied
at the interface

```

这导致桥接潜在将引起更加缓慢的交换、高CPU利用率和其他相关问题的整个接口的软件。

Note: Cisco Bug ID [CSCuo02666](#)被上升解决此问题。引入在逻辑上的最大的变化是如何分配TCAM标签。现在思科不断地分配TCAM标签(2,3,4,5，等等) 2048而不是在2K差距。这意味着capmap表从开始不再共享。

切记LOUs，类似其他硬件资源，被限制。有总共104 LOUs联机为使用：

```

Sup2T#show platform software acl lou
LOUs Registers (shadow copies)

```

Index	Type	A_Op	A_Val	A_Cnt	B_Op	B_Val	B_Cnt
0	PKT_QOS_GI	A is free.			NEQ	0	1
1	DST_PORT	LT	81		2 B is free.		
2	B & A are free						
3	B & A are free						
4	B & A are free						
5	B & A are free						
6	B & A are free						

```
7 B & A are free
8 B & A are free
9 B & A are free
10 B & A are free
11 B & A are free
12 B & A are free
13 B & A are free
14 B & A are free
15 B & A are free
```

snip

```
95 B & A are free
96 B & A are free
97 B & A are free
98 B & A are free
99 B & A are free
100 B & A are free
101 B & A are free
102 B & A are free
103 B & A are free
```

程序Capmap表和LOU寄存器

Capmap表，只有当L4必须考虑到时，使用操作。注意匹配在差分服务代码点/业务类别(CoS)值也考虑作为L4Op。这是简单的示例(该使用包括修正Cisco Bug ID [CSCuo02666](#))本文递增建立的一个编码版本：

```
Sup2T#show ip access-lists a3
Extended IP access list a3
 10 permit ip host 192.168.1.1 host 192.168.1.2
```

I have this applied to interface VLAN 1.

```
Sup2T#show run int vlan 1
Building configuration...
```

Current configuration : 84 bytes

```
!
interface Vlan1
 ip address 192.168.1.1 255.255.255.0
 ip access-group a3 in
end
```

这正确地被编程到TCAM：

```
Sup2T#show platform hardware acl entry interface vlan 1 security in ip
mls_if_index:20000001 dir:0 feature:0 proto:0
```

pass#0 features

fno:0

tcam:B, bank:1, prot:0 Aces

```
Permit          ip host 192.168.1.1 host 192.168.1.2
L3_Deny         ip any any
```

```
Sup2t-MA1.7#show platform hardware acl entry interface vlan 1 security in ip detail
mls_if_index:20000001 dir:0 feature:0 proto:0
```

```
pass#0 features
UAPRSF: U-urg, A-ack, P-psh, R-rst, S-syn, F-fin
MLGFI: M-mpls_plus_ip_pkt, L-L4_hdr_vld, G-gpid_present, F-global_fmt_match, I-ife/ofe
's' means set; 'u' means unset; '-' means don't care
```

```
-----
-----
-----
-----
I      INDEX LABEL FS ACOS   AS          IP_SA          SRC_PORT
IP_DA  DST_PORT F FF L4PROT TCP-F:UAPRSF MLGFI OtherL4OPs
RSLT   CNT
```

```
fno:0
```

```
tcam:B, bank:1, prot:0 Aces
```

```
I V 32741 2 0 0 0 192.168.1.1 - 192.168.1.2
- 0 0 0 - ----- - 0x00000000000000038
0
I M 32741 0x1FFF 0 0x00 0x000 255.255.255.255 - 255.255.255.255
- 0 0 0x0
I V 32745 2 0 0 0 0.0.0.0 - 0.0.0.0
- 0 0 0 - ----- - 0x0000000040000038
0
I M 32745 0x1FFF 0 0x00 0x000 0.0.0.0 - 0.0.0.0
- 0 0 0x0
```

Capmap表通过TCAM标签被参考。您在显示平台软件[hardware] ACL capmap TCAM <>标签<>命令能使用TCAM标签为了查看对应的表(软件或硬件)此TCAM标签的。

```
Sup2T#show platform hardware acl capmap tcam B label 2
Hardware Capmap Table Entry For TCAM B. Free items are not shown
```

```
Index Loc[9] [8] [7] [6] [5] [4] [3] [2] [1] [0]
-----
1 212 0 0 0 0 0 0 0 0 0
```

什么都在此标签的capmap表里没有分配。定义ACL没有L4Ops;没有需求安装一个条目在capmap表里。

更改此ACE对此：

```
Sup2T#show ip access-lists a3
Extended IP access list a3
10 permit tcp host 192.168.1.1 host 192.168.1.2 eq www
```

再查看capmap表。

```
Sup2T#show platform software acl capmap tcam B label 2
Shadow Capmap Table Entry For TCAM B
```

```

-----
Output in a RST/INV/CNT format: RST - result value; INV - inverted;
                               CNT - aggregated reference account;

CBF - number of free cap bits (one per entry);
Free items are not shown
-----
Index   CBF      [9]          [8]          [7]          [6]
[5]     [4]     [3]          [2]          [1]
[0]
-----

```

```

-----
      1      9      Reserved      Free      Free      Free
Free      Free      Free      Free      Free      Free
Free

```

如果直接地等同于对port-number，不算作是L4Op。

更改它对此：

```

Sup2T#show ip access-lists a3
Extended IP access list a3
 10 permit tcp host 192.168.1.1 host 192.168.1.2 gt www

```

更加检查capmap表：

```

Sup2T#show platform software acl capmap tcam B label 2
Shadow Capmap Table Entry For TCAM B

```

```

-----
Output in a RST/INV/CNT format: RST - result value; INV - inverted;
                               CNT - aggregated reference account;

CBF - number of free cap bits (one per entry);
Free items are not shown
-----
Index   CBF      [9]          [8]          [7]          [6]
[5]     [4]     [3]          [2]          [1]
[0]
-----

```

```

-----
      2      8 212/0/1      Free      Free      Free
Free      Free      Free      Free      Free      Free 3/1/1

```

当前有一个条目在capmap表里。ACE翻译到-3/1/1在capmap表里。这是格式RST/INV/CNT。LOU寄存器此L4Op安装此处的RST指定，并且CNT描述此LOU的(关于此以后的更多信息聚集的计数)。查看此输出为了知道如何标注RST值：

```

Sup2T#show platform software acl capmap mapping
L4op_sel value      Reference
=====
0      -----      LOU0 B register
1      -----      LOU0 A register
2      -----      LOU1 B register
3      -----      LOU1 A register
.....
.....

```

```

206 ----- LOU103 B register
207 ----- LOU103 A register
208 ----- Global format match for global acl
209 ----- Group id present
210 ----- L4_hdr_vld
211 ----- Mpls_plus_ip_pkt
212 ----- ife/ofe for direction
(213-223) ---- Reserved
(224-239) ---- 16 TCP flags map
(240-255) ---- 16 IPv6 ext header map

```

您能看到L4op_sel值为0指向LOU0变址寄存器，值为1指向LOU0 A寄存器，值对LOU1变址寄存器的2点，值对LOU1变址寄存器的3点，等等。A寄存器首先总是被编程。即然您看到此，输出的3/1/1有更多意义。

在此输出中，3意味着L4Op被编程了到LOU1 A寄存器。您能也验证L4Op被编程的地方，如果直接地调查LOU寄存器的内容：

```

Sup2T#show platform software acl lou
LOUs Registers (shadow copies)

```

Index	Type	A_Op	A_Val	A_Cnt	B_Op	B_Val	B_Cnt
0	PKT_QOS_GI	A is free.			NEQ	0	1
1	DST_PORT	LT	81	1	B is free.		
2	B & A are free						
3	B & A are free						
4	B & A are free						

snip

```

Sup2T#show platform hardware acl lou
Dumping h/w lou values

```

Index	lou_mux_sel	A_Opcode	A_Value	B_Opcode	B_Value
0	7	NEQ	0	NEQ	0
1	1	LT	81	NEQ	0
2	0	NEQ	0	NEQ	0
3	0	NEQ	0	NEQ	0

snip

正如你看到的a (gt, X)元组获得被编程作为(LT, X+1)在LOU寄存器。

Note:只有当他们应用对接口时，L4Ops获得编程到LOU寄存器。如果ACL创建与L4Ops (没有实际上应用对接口)的ACL，不编程可适用的L4Ops到LOU寄存器。

从interface VLAN 1删除ACL并且再查看LOU寄存器：

```

Sup2T(config)#int vlan 1
Sup2T(config-if)#no ip access-group a3 in

```

```

Sup2T#show platform software acl lou
LOUs Registers (shadow copies)

```

Index	Type	A_Op	A_Val	A_Cnt	B_Op	B_Val	B_Cnt
0	PKT_QOS_GI	A is free.			NEQ	0	1


```

1 B & A are free
2 B & A are free
3 B & A are free
4 B & A are free

```

snip

```

Sup2T#show platform hardware acl lou
Dumping h/w lou values

```

Index	lou_mux_sel	A_Opcode	A_Value	B_Opcode	B_Value
0	7	NEQ	0	NEQ	0
1	1	NEQ	0	NEQ	0
2	0	NEQ	0	NEQ	0
3	0	NEQ	0	NEQ	0

snip

案例研究#1 - ACL用TCP标志

TCP标志有在LOU寄存器范围内分配的特殊的寄存器。您能通过显示平台软件ACL capmap映射命令查看此范围如显示此处：

```

Sup2T#show platform software acl capmap mapping
L4op_sel value      Reference
=====
0      -----      LOU0 B register
1      -----      LOU0 A register
2      -----      LOU1 B register
3      -----      LOU1 A register
.....
.....
206    -----      LOU103 B register
207    -----      LOU103 A register
208    -----      Global format match for global acl
209    -----      Group id present
210    -----      L4_hdr_vld
211    -----      Mpls_plus_ip_pkt
212    -----      ife/ofe for direction
(213-223)  ----      Reserved
(224-239)  ----      16 TCP flags map
(240-255)  ----      16 IPv6 ext header map

```

L4op_sel值224-239是可用使用TCP标志，给您一套16个登记使用。这是简单的示例对demostrate这。此ACL定义：

```

Sup2T#show platform software acl capmap mapping
L4op_sel value      Reference
=====
0      -----      LOU0 B register
1      -----      LOU0 A register
2      -----      LOU1 B register
3      -----      LOU1 A register
.....
.....
206    -----      LOU103 B register
207    -----      LOU103 A register
208    -----      Global format match for global acl

```

```

209      -----      Group id present
210      -----      L4_hdr_vld
211      -----      Mpls_plus_ip_pkt
212      -----      ife/ofe for direction
(213-223)  -----      Reserved
(224-239)  -----      16 TCP flags map
(240-255)  -----      16 IPv6 ext header map

```

应用此入站在接口VLAN 13 :

```

Sup2T(config)#int vlan 13
Sup2T(config-if)#ip access-group a13 in
Sup2T(config-if)#end

```

```

Sup2T#show platform hardware acl entry interface vlan 13 security in ip detail
mls_if_index:2000000D dir:0 feature:0 proto:0

```

```

pass#0 features
UAPRSF: U-urg, A-ack, P-psh, R-rst, S-syn, F-fin
MLGFI: M-mpls_plus_ip_pkt, L-L4_hdr_vld, G-gpid_present, F-global_fmt_match, I-ife/ofe
's' means set; 'u' means unset; '-' means don't care

```

```

-----
-----
-----
-----
I      INDEX  LABEL FS ACOS   AS          IP_SA          SRC_PORT
IP_DA          DST_PORT F FF L4PROT TCP-F:UAPRSF MLGFI OtherL4OPs
RSLT                      CNT

```

fno:0

tcam:B, bank:1, prot:0 Aces

```

I  V  32545    13  0  0  0  192.168.13.10  -  192.168.13.20
-  0  0      1  ANY:-----s-  -----  -  0x00000000000000038
0
I  M  32545  0x1FFF  0  0x00  0x000  255.255.255.255  -  255.255.255.255
-  0  0    0xF
I  V  32546    13  0  0  0  192.168.13.10  -  192.168.13.20
-  1  0      1  -  -----  -  0x00000000000000038
0
I  M  32546  0x1FFF  0  0x00  0x000  255.255.255.255  -  255.255.255.255
-  1  0    0xF
I  V  32547    13  0  0  0  0.0.0.0  -  0.0.0.0
-  0  0      0  -  -----  -  0x00000000400000038
0
I  M  32547  0x1FFF  0  0x00  0x000  0.0.0.0  -  0.0.0.0
-  0  0    0x0

```

```

Sup2T#show platform software acl capmap tcam B label 13
Shadow Capmap Table Entry For TCAM B

```

```

-----
Output in a RST/INV/CNT format: RST - result value; INV - inverted;
CNT - aggregated reference account;

```


3	3%	7%	0%	1%	96%	100%	1%	0%	0%	0%
4	3%	7%	0%	1%	96%	100%	1%	0%	0%	0%
6	3%	7%	0%	1%	96%	100%	2%	0%	0%	0%

在此阶段，如果决定配置另一个ACL用一唯一TCP标志(或独创) TCP标志的组合和应用此到接口，然后您必须编程一新的TCP标志(或标志的组合)到TCP寄存器。然而，没有可用的硬件寄存器。在这种情况下，您桥接整个接口。

```
Sup2T(config)#ip access-list extended a29
Sup2T(config-ext-nacl)#permit tcp host 192.168.1.1 host 192.168.1.2 psh rst
```

```
Sup2T(config-if)#int vlan 29
Sup2T(config-if)#ip access-group a29 in
```

```
*Oct 6 13:57:47.612: %FMCORE-4-RACL_REDUCED: Interface Vlan29 routed traffic
will be software switched in ingress direction. L2 features may not be applied
at the interface
```

```
Sup2T#show platform hardware acl entry interface vlan 29 security in ip
mls_if_index:2000001D dir:0 feature:0 proto:0
```

```
pass#0 features
```

```
fno:0
```

```
tcam:B, bank:1, prot:0 Aces
```

```
Bridge ip any any
```

案例研究#2 - 100% LOU寄存器使用情况

切记LOUs是一种有限的资源-您能用尽那些的空间。您能监控LOU使用方法用此命令：

```
Sup2T#show platform hardware capacity acl
```

```
Classification Mgr Tcam Resources
```

```
Key: Ttlent - Total TCAM entries, QoSent - QoS TCAM entries, LOU - LOUs,
RBLent - RBACL TCAM entries, Lbl - Labels, TCP - TCP Flags,
Dsttbl - Destinfo Table, Ethcam - Ethertype Cam Table,
ACTtbl - Accounting Table, V6ext - V6 Extn Hdr Table
```

Module	Ttlent	QoSent	RBLent	Lbl	LOU	TCP	Dsttbl	Ethcam	ACTtbl	V6ext
1	2%	7%	0%	1%	1%	0%	1%	0%	0%	0%
3	2%	7%	0%	1%	1%	0%	1%	0%	0%	0%
4	2%	7%	0%	1%	1%	0%	1%	0%	0%	0%
6	2%	7%	0%	1%	1%	0%	2%	0%	0%	0%

扩展ACL为了使用更多LOUs。在采取两LOU寄存器，A和B)几个ACL的安装以后(用range命令，此示例显示96% LOU使用方法：

```
Sup2T#show platform hardware capacity acl
```

```
Classification Mgr Tcam Resources
```

```
Key: Ttlent - Total TCAM entries, QoSent - QoS TCAM entries, LOU - LOUs,
RBLent - RBACL TCAM entries, Lbl - Labels, TCP - TCP Flags,
Dsttbl - Destinfo Table, Ethcam - Ethertype Cam Table,
ACTtbl - Accounting Table, V6ext - V6 Extn Hdr Table
```

Module	Ttlent	QoSent	RBLent	Lbl	LOU	TCP	Dsttbl	Ethcam	ACTtbl	V6ext
1	3%	7%	0%	1%	96%	0%	1%	0%	0%	0%
3	3%	7%	0%	1%	96%	0%	1%	0%	0%	0%
4	3%	7%	0%	1%	96%	0%	1%	0%	0%	0%
6	3%	7%	0%	1%	96%	0%	2%	0%	0%	0%

创建另一个ACL并且应用那对将造成LOU使用方法超出100%范围的接口。

```
Sup2T(config)#ip access-list extended a12
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1401 1410
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1411 1420
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1421 1430
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1431 1440
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1441 1450
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1451 1460
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1461 1470
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1471 1480
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1481 1490
Sup2T(config-ext-nacl)#$68.14.1 host 192.168.14.2 range 1491 1500
```

```
Sup2T(config-ext-nacl)#exit
```

```
Sup2T(config)#int vlan 12
```

```
Sup2T(config-if)#ip access-group a12 in
```

示例到达了100% LOU使用方法;然而，请注意错误消息未接收。

```
Sup2T#show platform hardware capacity acl
```

```
Classification Mgr Tcam Resources
```

```
Key: Ttlent - Total TCAM entries, QoSent - QoS TCAM entries, LOU - LOUs,
RBLent - RBACL TCAM entries, Lbl - Labels, TCP - TCP Flags,
Dsttbl - Destinfo Table, Ethcam - Ethertype Cam Table,
ACTtbl - Accounting Table, V6ext - V6 Extn Hdr Table
```

Module	Ttlent	QoSent	RBLent	Lbl	LOU	TCP	Dsttbl	Ethcam	ACTtbl	V6ext
1	3%	7%	0%	1%	100%	0%	1%	0%	0%	0%
3	3%	7%	0%	1%	100%	0%	1%	0%	0%	0%
4	3%	7%	0%	1%	100%	0%	1%	0%	0%	0%
6	3%	7%	0%	1%	100%	0%	2%	0%	0%	0%

这是另一测验。即然LOU在100%，请采取一非常简单L4Op并且设法为接口安装那。配置此ACL：

```
Sup2T#show ip access-lists a13
```

```
Extended IP access list a13
```

```
10 permit tcp host 192.168.14.1 host 192.168.14.2 range 1600 1650
```

应用入站的此建立接口VLAN 13。

```
Sup2T#show run int vlan 13
```

```
Building configuration...
```

```
Current configuration : 87 bytes
```

```
!
```

```
interface Vlan13
```

```
ip address 192.168.13.1 255.255.255.0
```

```
ip access-group a13 in
```

```
end
```

当前查看TCAM为此VLAN：

```
Sup2T#show platform hardware acl entry interface vlan 13 sec in ip
```

mls_if_index:2000000D dir:0 feature:0 proto:0

pass#0 features

fno:0

tcam:B, bank:0, prot:0 Aces

```

Permit          tcp host 192.168.14.1 host 192.168.14.2 eq 1650
Permit          tcp host 192.168.14.1 host 192.168.14.2 range 1648 1649
Permit          tcp host 192.168.14.1 host 192.168.14.2 range 1632 1647
Permit          tcp host 192.168.14.1 host 192.168.14.2 range 1600 1631
Permit          tcp host 192.168.14.1 host 192.168.14.2 fragments
L3_Deny         ip any any

```

L4Ops展开。如果查看capmap表为此TCAM标签，您看到什么都没有安装。

Sup2T#show platform hardware acl entry interface vlan 13 sec in ip detail

mls_if_index:2000000D dir:0 feature:0 proto:0

pass#0 features

UAPRSF: U-urg, A-ack, P-psh, R-rst, S-syn, F-fin
 MLGFI: M-mpls_plus_ip_pkt, L-L4_hdr_vld, G-gpid_present, F-global_fmt_match, I-ife/ofe
 's' means set; 'u' means unset; '-' means don't care

```

-----
-----
-----
-----
-----
I      INDEX LABEL FS ACOS  AS          IP_SA      SRC_PORT
IP_DA  DST_PORT F FF L4PROT TCP-F:UAPRSF MLGFI OtherL4OPs
RSLT   CNT
-----
-----
-----
-----
-----

```

fno:0

tcam:B, bank:0, prot:0 Aces

```

I V 16136 14 0 0 0 192.168.14.1 - 192.168.14.2
1650 0 0 1 - ----- - 0x0000000000000038
0
I M 16136 0x1FFF 0 0x00 0x000 255.255.255.255 - 255.255.255.255
0xFFFF 0 0 0xF
I V 16137 14 0 0 0 192.168.14.1 - 192.168.14.2
1648 0 0 1 - ----- - 0x0000000000000038
0
I M 16137 0x1FFF 0 0x00 0x000 255.255.255.255 - 255.255.255.255
0xFFFE 0 0 0xF
I V 16138 14 0 0 0 192.168.14.1 - 192.168.14.2
1632 0 0 1 - ----- - 0x0000000000000038
0
I M 16138 0x1FFF 0 0x00 0x000 255.255.255.255 - 255.255.255.255
0xFFF0 0 0 0xF
I V 16139 14 0 0 0 192.168.14.1 - 192.168.14.2
1600 0 0 1 - ----- - 0x0000000000000038
0

```

```

I M 16139 0x1FFF 0 0x00 0x000 255.255.255.255 - 255.255.255.255
0xF
I V 16140 14 0 0 0 192.168.14.1 - 192.168.14.2
- 1 0 1 - ----- - 0x00000000000000038
0

```

```

Sup2T#show platform software acl capmap tcam B label 14
Shadow Capmap Table Entry For TCAM B

```

```

-----
Output in a RST/INV/CNT format: RST - result value; INV - inverted;
CNT - aggregated reference account;

```

```

CBF - number of free cap bits (one per entry);
Free items are not shown

```

```

-----
Index   CBF      [9]          [8]          [7]          [6]
[5]     [4]          [3]          [2]          [1]
[0]

```

```

-----
-----
-----
14      9 212/0/1          Free          Free          Free
Free      Free          Free          Free          Free
Free

```

这是发生什么的说明。由于LOU寄存器全双工，您能不再安装其中任一新建的L4Ops那里，并且什么都在capmap表里不可以被参考。在此阶段，您仍然尝试通过展开他们安装在TCAM的L4Ops。如果L4Ops是非可扩展的，然后您软件交换机在给的方向的整个接口。

100% LOU寄存器使用情况暗示什么？您的TCAM开始迅速填满(由于L4Op扩展)。如果尝试安装非可扩展的L4Ops，然后与当前实施，您的整个接口获得软件桥接。

按照现在情况，当您尝试安装一非可扩展的L4Op在这种情况下时，当前，错误只生成。应用建立接口VLAN 13增加一非可扩展的L4Op的此示例修改了当前ACL a13。

```

Sup2T(config)#ip access-list extended a13
Sup2T(config-ext-nacl)#permit tcp host 192.168.14.1 host 192.168.14.2 dscp 40

```

```

Oct 5 04:50:13.104: %FMCORE-4-RACL_REDUCED: Interface Vlan13 routed traffic will
be software switched in ingress direction. L2 features may not be applied at the
interface

```

```

Oct 5 04:50:13.096: %EARL_CM-DFC3-5-NOLOU: No free LOU entry available on the EARL
Oct 5 04:50:13.096: %EARL_CM-DFC1-5-NOLOU: No free LOU entry available on the EARL
Oct 5 04:50:13.096: %EARL_CM-DFC4-5-NOLOU: No free LOU entry available on the EARL

```

```

Sup2T#show platform hardware acl entry interface vlan 13 security in ip
mls_if_index:2000000D dir:0 feature:0 proto:0

```

```

pass#0 features

```

```

fno:0

```

```

tcam:B, bank:0, prot:0 Aces

```

```

Bridge ip any any

```

案例研究#3 -编程与L4Ops的QoS

QoS策略也许也参考L4Ops;必须安装这些L4Ops类似所有其他L4Op。这暗示每个接口,为您的QoS策略,您由capmap表和LOUs固有地有的限制限制。这是小规模地说明此的示例:

```
Sup2T#show ip access-lists a1
Extended IP access list a1
 10 permit tcp host 192.168.1.10 host 192.168.2.10 dscp ef
```

```
Sup2T#show class-map a1-class
Class Map match-all a1-class (id 37)
Match access-group name a1
```

```
Sup2T#show policy-map a1-policy
Policy Map a1-policy
Class a1-class
  police cir 80000 bc 2500
    conform-action transmit
    exceed-action drop
```

此示例有匹配呼叫access-list a1匹配从192.168.1.10的流量到192.168.2.10用紧急转发(EF)标记的类映射的一策略映射。匹配在DSCP值是一非可扩展的L4Op;这要求被编程到LOU寄存器和通过条目被参考在capmap表里。此策略映射当前安装的入站对gig3/23。

```
Sup2T#show run int gig3/23
Building configuration...
```

```
Current configuration : 176 bytes
!
interface GigabitEthernet3/23
 switchport
 switchport trunk allowed vlan 1-30
 switchport mode trunk
 service-policy input a1-policy
end
```

为了查看编程的QoS为接口,请使用此命令:

```
Sup2T#show platform hardware acl entry interface gig3/23 qos in ip module 3
mls_if_index:8096000 dir:0 feature:1 proto:0
```

```
pass#0 features
```

```
fno:0
```

```
tcam:A, bank:0, prot:0 Aces
```

```
0x0000E0100000D00B tcp host 192.168.1.10 host 192.168.2.10 dscp eq 46
0x0000000000080D00B ip any any
```

选派此命令给您什么TCAM标签使用在此接口。

```
Sup2T#show platform hardware acl entry interface gig3/23 qos in ip detail module 3
mls_if_index:8096000 dir:0 feature:1 proto:0
```



```

pass#0 features
UAPRSF: U-urg, A-ack, P-psh, R-rst, S-syn, F-fin
MLGFI: M-mpls_plus_ip_pkt, L-L4_hdr_vld, G-gpid_present, F-global_fmt_match, I-ife/ofe
's' means set; 'u' means unset; '-' means don't care

```

```

-----
-----
-----
I      INDEX LABEL FS ACOS   AS          IP_SA          SRC_PORT
IP_DA          DST_PORT F FF L4PROT TCP-F:UAPRSF MLGFI OtherL4OPs
RSLT                                CNT
-----
-----
-----

```

fno:0

tcam:A, bank:0, prot:0 Aces

```

I V 16238      2 0 0 0 192.168.1.10 - 192.168.2.10
- 0 0 1 - ----- dscp=46; 0x0000E0100000D00B
0
I M 16238 0x1FFF 0 0x00 0x000 255.255.255.255 - 255.255.255.255
- 0 0 0xF
I V 16239      2 0 0 0 0.0.0.0 - 0.0.0.0
- 0 0 0 - ----- - 0x0000000000080D00B
0
I M 16239 0x1FFF 0 0x00 0x000 0.0.0.0 - 0.0.0.0
- 0 0 0x0

```

使用的TCAM标签当前是2.查看在此的capmap表：

```

Sup2T#show platform software acl capmap tcam A label 2 module 3
Shadow Capmap Table Entry For TCAM A

```

```

-----
Output in a RST/INV/CNT format: RST - result value; INV - inverted;
CNT - aggregated reference account;

```

```

CBF - number of free cap bits (one per entry);
Free items are not shown

```

```

-----
-----
-----
Index   CBF      [9]          [8]          [7]          [6]
[5]     [4]      [3]          [2]          [1]
[0]
-----
-----
-----
2      8 212/0/1          Free          Free          Free
Free          Free          Free          Free          Free 2/1/1

```

Note:对于QoS TCAM，您必须指定模块号。没有此，输出不产生任何结果。

```

Sup2T#show platform software acl capmap mapping
L4op_sel value Reference
=====
0      ----- LOU0 B register
1      ----- LOU0 A register
2      ----- LOU1 B register

```

snip

LOU值对LOU1的2点，寄存器B。您能确认编程用此命令的此：

```
Sup2T#show platform hardware acl lou
Dumping h/w lou values
```

Index	lou_mux_sel	A_Opcode	A_Value	B_Opcode	B_Value
0	7	NEQ	0	NEQ	0
1	4	NEQ	0	NEQ	46
2	1	NEQ	0	NEQ	0

snip

按比例提高配置。

```
Sup2T#show ip access-lists a1
```

```
Extended IP access list a1
 10 permit tcp host 192.168.1.10 host 192.168.2.10 dscp ef
 20 permit tcp host 192.168.2.11 host 192.168.2.11 dscp ef
 30 permit tcp host 192.168.3.11 host 192.168.3.11 dscp ef
 40 permit tcp host 192.168.4.11 host 192.168.4.11 dscp ef
 50 permit tcp host 192.168.5.11 host 192.168.5.11 dscp ef
 60 permit tcp host 192.168.6.11 host 192.168.6.11 dscp ef
 70 permit tcp host 192.168.7.11 host 192.168.7.11 dscp ef
 80 permit tcp host 192.168.8.11 host 192.168.8.11 dscp ef
```

```
Sup2T#show platform software acl capmap tcam A label 2 module 3
```

```
Shadow Capmap Table Entry For TCAM A
```

```
-----
Output in a RST/INV/CNT format: RST - result value; INV - inverted;
                               CNT - aggregated reference account;
```

```
CBF - number of free cap bits (one per entry);
```

```
Free items are not shown
```

```
-----
Index   CBF      [9]          [8]          [7]          [6]
[5]     [4]          [3]          [2]          [1]
[0]
```

```
-----
      2      8 212/0/1          Free          Free          Free
Free          Free          Free          Free          Free          Free  2/1/8
```

这不使用条目;反而，它增加聚集参考计数首先进入，有意义。从capmap表和LOU寄存器方面，没有关于来源和目的地的不安。这存储L4Op信息。因为它配比在所有ACE的同一个DSCP值，您只需要该DSCP值的一个条目。

修改此，以便您使用九个不同的DSCP值。

```
Sup2T#show ip access-lists a1
```

```
Extended IP access list a1
 10 permit tcp host 192.168.1.10 host 192.168.2.10 dscp af11
 20 permit tcp host 192.168.2.11 host 192.168.2.11 dscp af12
```

```

30 permit tcp host 192.168.3.11 host 192.168.3.11 dscp af13
40 permit tcp host 192.168.4.11 host 192.168.4.11 dscp af21
50 permit tcp host 192.168.5.11 host 192.168.5.11 dscp af22
60 permit tcp host 192.168.6.11 host 192.168.6.11 dscp af23
70 permit tcp host 192.168.7.11 host 192.168.7.11 dscp af31
80 permit tcp host 192.168.8.11 host 192.168.8.11 dscp af32
90 permit tcp host 192.168.9.11 host 192.168.9.11 dscp af33

```

现在，如果查看capmap表，您看到全双工：

```

Sup2T#show platform software acl capmap tcam A label 2 module 3
Shadow Capmap Table Entry For TCAM A

```

```

-----
Output in a RST/INV/CNT format: RST - result value; INV - inverted;
                               CNT - aggregated reference account;

```

```

CBF - number of free cap bits (one per entry);
Free items are not shown

```

```

-----
Index   CBF      [9]                [8]                [7]                [6]
[5]     [4]                [3]                [2]
[1]     [0]
-----
-----
      2      0 212/0/1      10/1/1      9/1/1      8/1/1
7/1/1      6/1/1      5/1/1      4/1/1      3/1/1
2/1/1

```

这是发生了什么，如果尝试并且安装另一个非可扩展的L4Op-based条目：

```

Sup2T(config-ext-nacl)#permit tcp host 192.168.10.11 host 192.168.10.11 dscp 2
Sup2T(config-ext-nacl)#end

```

```

%QM-4-TCAM_ENTRY: Hardware TCAM entry programming failed for slot 3 intf Gi3/23
dir IN: <CONFIG_UPDATE_REQ> TCAM Req Error: FAIL (4): Low TCAM Entries (1)
%QM-4-TCAM_ENTRY: Hardware TCAM entry programming failed for slot 3 intf Gi3/23
dir IN: <CONFIG_UPDATE_REQ> TCAM Req Error: FAIL (4): Low TCAM Entries (1)
%QM-4-TCAM_ENTRY: Hardware TCAM entry programming failed for slot 3 intf Gi3/23
dir IN: <CONFIG_UPDATE_REQ> TCAM Req Error: FAIL (4): Low TCAM Entries (1)
%QM-4-TCAM_ENTRY: Hardware TCAM entry programming failed for slot 3 intf Gi3/23
dir IN: <CONFIG_UPDATE_REQ> TCAM Req Error: FAIL (4): Low TCAM Entries (1)
%QM-4-TCAM_ENTRY: Hardware TCAM entry programming failed for slot 3 intf Gi3/23
dir IN: <CONFIG_UPDATE_REQ> TCAM Req Error: FAIL (4): Low TCAM Entries (1)
%FMCORE-6-RACL_ENABLED: Interface GigabitEthernet3/23 routed traffic is hardware
switched in ingress direction

```

```

Oct 20 17:12:54.304: %EARL_CM-DFC3-5-NOCAPMAP: No free capmap entry available

```

当前查看TCAM为此接口：

```

Sup2T#show platform hardware acl entry interface gig3/23 qos in ip module 3

```

```

mls_if_index:8096000 dir:0 feature:1 proto:0

```

```

Couldnt find feature for mls_if_index 0x8096000, dir 0

```

QoS功能都在此接口的TCAM不再安装。

注意标记不消耗任何L4Ops。因此，如果不让L4Ops和您设置在匹配的一个DSCP值的有简单


```

I V 16239      3 0 0 0      0.0.0.0      -      0.0.0.0
- 0 0 0      0 -      -      -      -      0x000000000080D00B
0
I M 16239 0x1FFF 0 0x00 0x000      0.0.0.0      -      0.0.0.0
- 0 0 0x0

```

```

Sup2T#show platform software acl capmap tcam A label 3 module 3
Shadow Capmap Table Entry For TCAM A

```

```

-----
Output in a RST/INV/CNT format: RST - result value; INV - inverted;
                               CNT - aggregated reference account;

```

```

CBF - number of free cap bits (one per entry);
Free items are not shown
-----

```

```

Index   CBF      [9]          [8]          [7]          [6]
[5]     [4]          [3]          [2]          [1]
[0]
-----
-----
-----

```

```

      3      9 212/0/1          Free          Free          Free
Free          Free          Free          Free          Free
Free

```

案例研究#4 -双协议栈ACL原因CAPMAP耗尽

在本例中，有创建这些错误配置的接口使用IPv4和IPv6 ACL，当接口启动时：

```

Sup2T#show run interface gig3/23
Building configuration...

```

```

Current configuration : 176 bytes

```

```

!
interface GigabitEthernet3/23
 switchport
 switchport trunk allowed vlan 1-30
 switchport mode trunk
 service-policy input a1-policy
end

```

```

Sup2T#show platform hardware acl entry interface gig3/23 qos in ip detail module 3

```

```

mls_if_index:8096000 dir:0 feature:1 proto:0

```

```

pass#0 features
UAPRSF: U-urg, A-ack, P-psh, R-rst, S-syn, F-fin
MLGFI: M-mpls_plus_ip_pkt, L-L4_hdr_vld, G-gpid_present, F-global_fmt_match, I-ife/ofe
's' means set; 'u' means unset; '-' means don't care
-----
-----
-----

```

```

-----
I      INDEX LABEL FS ACOS   AS      IP_SA      SRC_PORT
IP_DA      DST_PORT F FF L4PROT TCP-F:UAPRSF MLGFI OtherL4OPs
RSLT      CNT
-----

```


fno:0

tcam:A, bank:0, prot:0 Aces

```
I V 16238      3 0 0 0 192.168.1.1 - 192.168.2.1
- 0 0 1 - ----- - 0x0000E010005D100B
0
I M 16238 0x1FFF 0 0x00 0x000 255.255.255.255 - 255.255.255.255
- 0 0 0xF
I V 16239      3 0 0 0 0.0.0.0 - 0.0.0.0
- 0 0 0 - ----- - 0x0000000000080D00B
0
I M 16239 0x1FFF 0 0x00 0x000 0.0.0.0 - 0.0.0.0
- 0 0 0x0
```

Sup2T#show platform software acl capmap tcam A label 3 module 3
Shadow Capmap Table Entry For TCAM A

Output in a RST/INV/CNT format: RST - result value; INV - inverted;
CNT - aggregated reference account;

CBF - number of free cap bits (one per entry);
Free items are not shown

Index	CBF	[9]	[8]	[7]	[6]
[5]		[4]	[3]	[2]	[1]
[0]					

3	9	212/0/1	Free	Free	Free
Free		Free	Free	Free	Free
Free					

然而，如果仅IPv4ACL删除，然后再追加对同样接口硬件编程成功地完成，并且错误不再生成。

对于此示例，这些ACL配置在SVI下：

Sup2T#show run interface gig3/23
Building configuration...

```
Current configuration : 176 bytes
!
interface GigabitEthernet3/23
 switchport
 switchport trunk allowed vlan 1-30
 switchport mode trunk
 service-policy input a1-policy
end
```

Sup2T#show platform hardware acl entry interface gig3/23 qos in ip detail module 3

mls_if_index:8096000 dir:0 feature:1 proto:0

```

pass#0 features
UAPRSF: U-urg, A-ack, P-psh, R-rst, S-syn, F-fin
MLGFI: M-mpls_plus_ip_pkt, L-L4_hdr_vld, G-gpid_present, F-global_fmt_match, I-ife/ofe
's' means set; 'u' means unset; '-' means don't care

```

```

-----
-----
-----
-----
I      INDEX  LABEL FS ACOS   AS           IP_SA       SRC_PORT
IP_DA   DST_PORT F FF L4PROT TCP-F:UAPRSF MLGFI OtherL4OPs
RSLT                               CNT
-----
-----
-----
-----

```

```
fno:0
```

```
tcam:A, bank:0, prot:0 Aces
```

```

I V 16238      3 0 0 0 192.168.1.1 - 192.168.2.1
- 0 0 1 - ----- - 0x0000E010005D100B
0
I M 16238 0x1FFF 0 0x00 0x000 255.255.255.255 - 255.255.255.255
- 0 0 0xF
I V 16239      3 0 0 0 0.0.0.0 - 0.0.0.0
- 0 0 0 - ----- - 0x0000000000080D00B
0
I M 16239 0x1FFF 0 0x00 0x000 0.0.0.0 - 0.0.0.0
- 0 0 0x0

```

```
Sup2T#show platform software acl capmap tcam A label 3 module 3
```

```
Shadow Capmap Table Entry For TCAM A
```

```

-----
Output in a RST/INV/CNT format: RST - result value; INV - inverted;
CNT - aggregated reference account;

```

```
CBF - number of free cap bits (one per entry);
```

```
Free items are not shown
```

```

-----
-----
-----
Index  CBF      [9]          [8]          [7]          [6]
[5]    [4]          [3]          [2]          [1]
[0]

```

```

-----
-----
-----
3      9 212/0/1          Free          Free          Free
Free          Free          Free          Free          Free
Free

```

如在前一个示例中看到，IPv4ACL有超过九唯一可扩展的L4Ops。在接口下配置与仅IPv4这些将展开当必要时为了不用尽capmap表。

当编程这些到在双协议栈环境时的TCAM硬件，交换机从IPv4ACL首先启动。使用不足的自由输入在capmap表里，交换机展开某些可扩展的L4Ops为了填满capmap表，无需超出它。结果是当前自由输入数量在表里是0，含义当前没有可用的条目编程要求的非可扩展的L4Op，当您去其次时编程IPv6 ACL。

当您删除仅IPv4ACL时，自由输入数量在capmap表里增加，并且IPv6 ACL适当地当前被编程到硬件并且使用其中一个最近被释放的capmap条目。当IPv4ACL重新应用对接口配置时，同一扩展再发

生。用完一个自由capmap值仅的一个其他IPv4条目当前展开由于IPv6 ACL。因为所有L4Ops是可扩展的在编程成功的此ACL。

为了防止IPv4ACL的手动移除和新增内容允许条目合并硬件方面，增强创建更改在这样方案的TCAM合并的算法。欲知更多信息，请参阅Cisco Bug ID [CSCuq24924](#)。

由于此增强，“软件固定”版本在更改方式L4Ops在实例被编程例如双协议栈IPv4/v6 ACL部署的全局配置里当前将有一个可配置选项。这是可以做的配置更改

```
Switch(config)#platform hardware acl tcam-exp-logic enable
```

Note:由于扩展，由于由于此增强介绍的更改，可扩展的L4Ops比正常展开在速率极大，并且也许导致在TCAM利用率的一个显著提高。