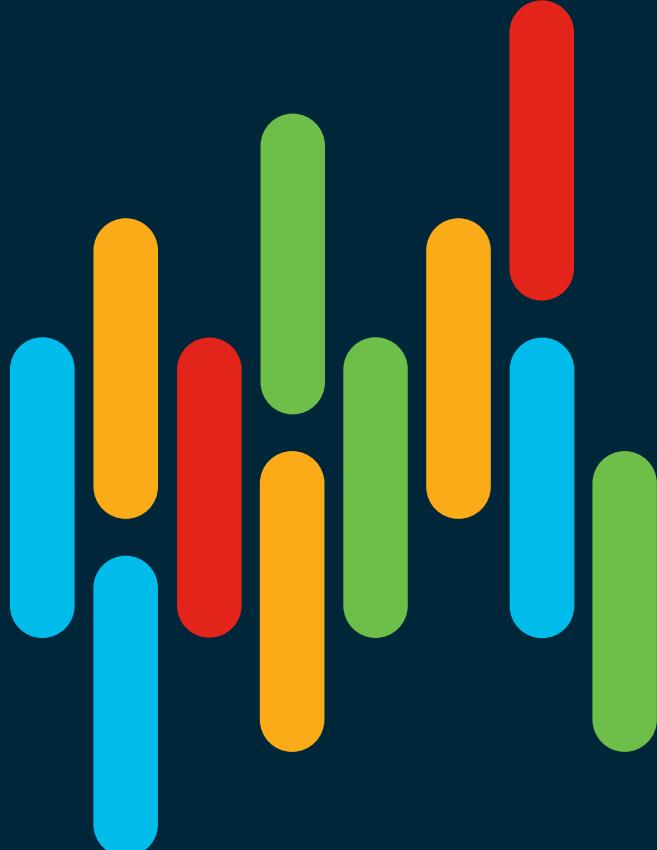




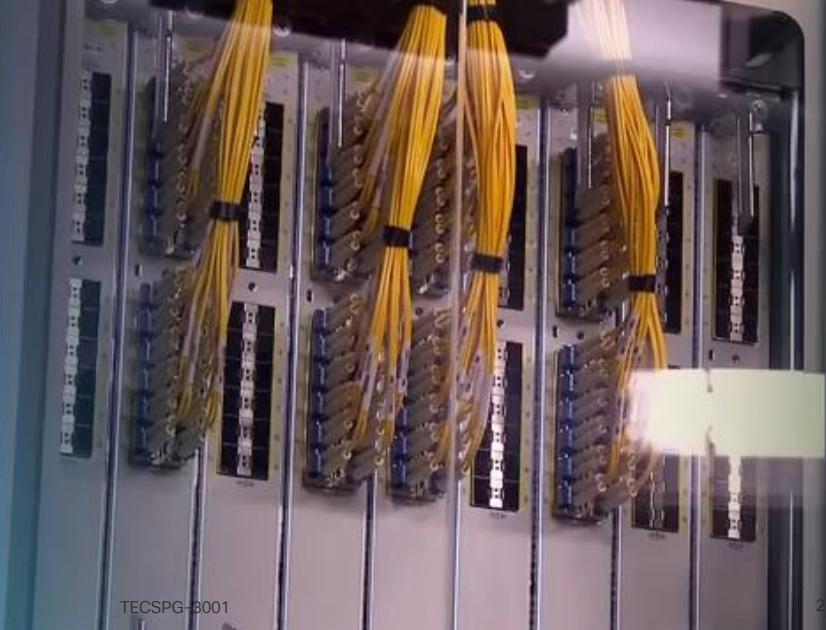
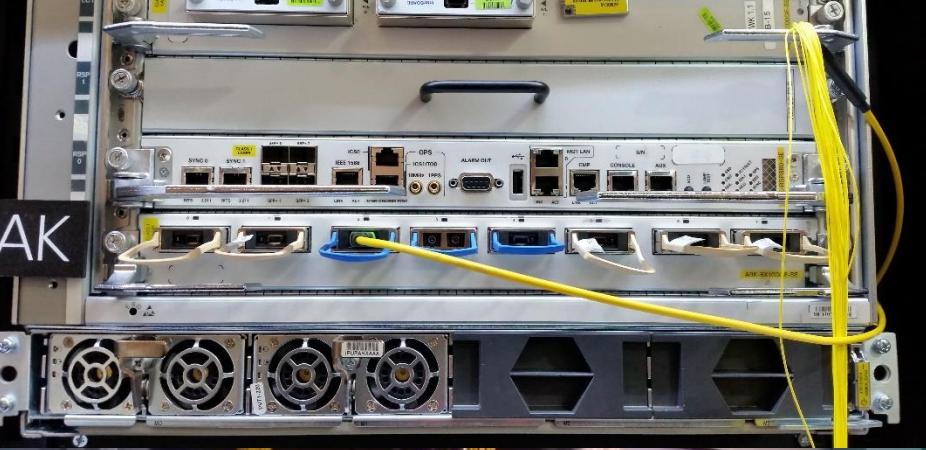
Advanced ASR 9000 Operation and Troubleshooting



Mike Mikhail, Solutions Architect mamikhai@cisco.com

David Pothier, Solutions Architect dpothier@cisco.com

TECSPG-3001



Acknowledgement

- Content
 - Jeff Byzek, Technical Marketing Engineer
 - Gawel Mikolajczyk, Technical Solutions Architect
 - David Pothier, Enterprise Architect
 - Santosh Sharma, Technical Leader
 - Xander Thuijs, Principal Engineer
 - Mei Zhang, Technical Leader
- Review
 - David Pothier, Enterprise Architect
 - Matt Breneisen, Solutions Integration Architect
 - Neel Shah
 - Xander Thuijs, Principal Engineer

Agenda

- **System Architecture:** System anatomy and health
- **Operating System & Configuration:** IOS-XR & configuration models
- **Control, Management, & Security:** Processing of control & exceptions
- **Transit Packet/Frame Journey:** Life of L3/L2 unicast/multicast
- **MPLS Operation:** Processing, forwarding and L3/L2 service operation
- **Troubleshooting:** Diagnostics, counters, drops, and packet capture

Cisco Webex Teams

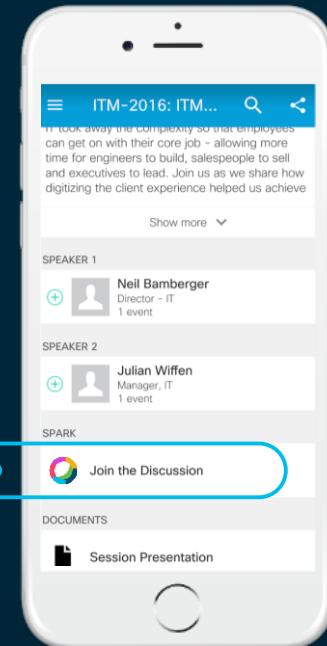
Questions?

Use Cisco Webex Teams to chat with the speaker after the session

How

- 1 Find this session in the Cisco Live Mobile App
- 2 Click “Join the Discussion”
- 3 Install Webex Teams or go directly to the team space
- 4 Enter messages/questions in the team space

Webex Teams will be moderated by the speaker until June 16, 2019.



cs.co/ciscolivebot#TECSPG-3001

Not covered

- We can have separate discussions about:
 - Clustering
 - Satellites [except briefly]
 - First generation hardware
 - SIP-700 and TDM
 - ISM & VSM
 - Technology and protocol troubleshooting [will focus on platform specifics]

Introduction

- About us
 - Mike Mikhail, Solutions Architect, mamikhai@cisco.com
 - David Pothier, Solutions Architect, dpothier@cisco.com
 - Available at “Meet the Engineer” for 1:1 discussions
 - Interests: SP platforms, SP technologies, SDN, NFV
- ASR 9000 today
 - Very popular SP/WAN edge router
 - High bandwidth Ethernet services platform
 - Hw forwarding, high density: ~2.5B pps per LC, >3Tbps/slot
 - Distributed processing and distributed forwarding
 - Continued dev, busy roadmap, a wealth of new features



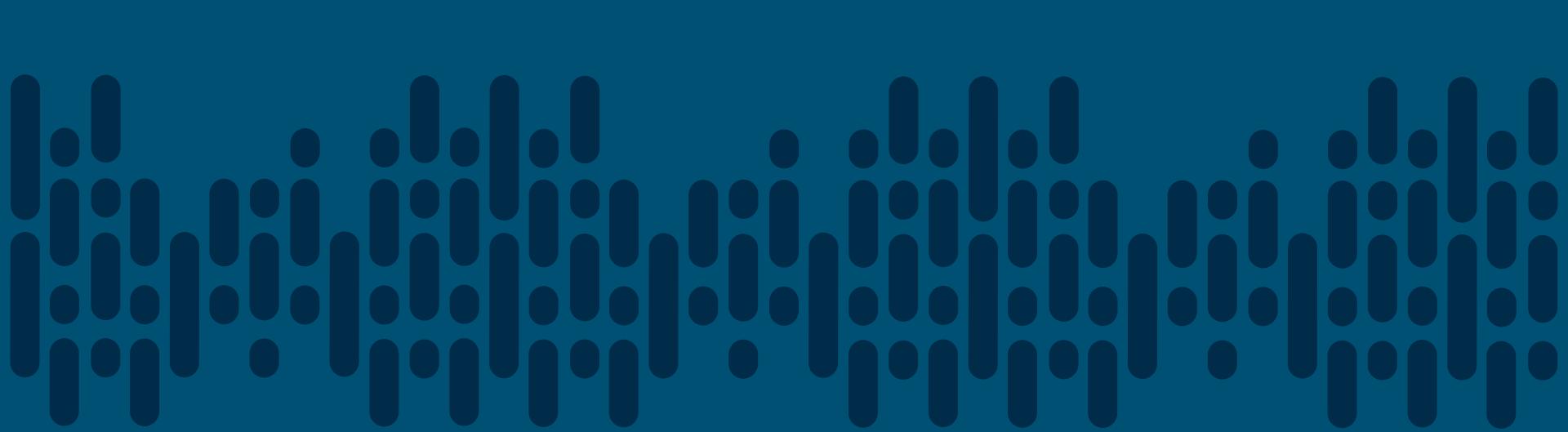
Agenda

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1 System Architecture



You make networking **possible**

A decorative header element consisting of a repeating pattern of dark blue vertical bars of varying heights, creating a visual effect similar to a sound wave or a digital signal.

System Components & Sub-Systems

ASR 9000 Family

Chassis, cards, power, air flow

“Fixed” hw:
RP+Fabric
+LC+ports



ASR 9901



ASR 9904



ASR 9906



ASR 9910



ASR 9912



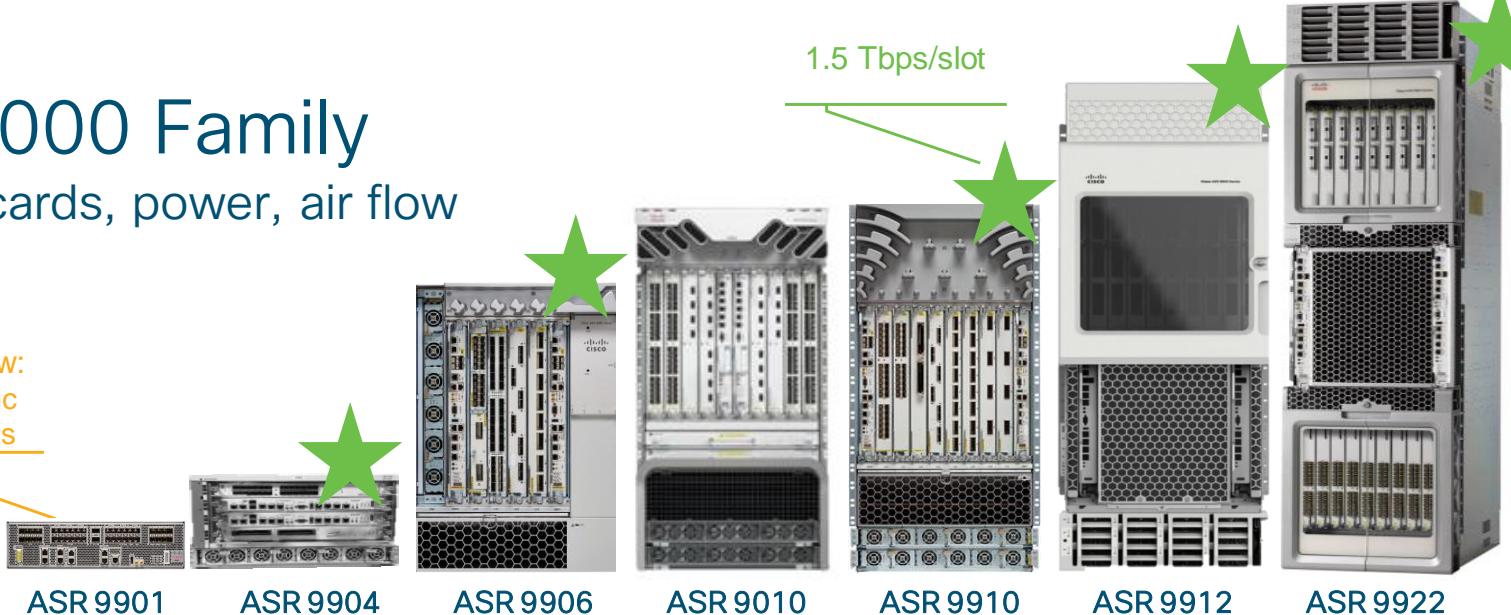
ASR 9922

	ASR 9901	ASR 9904	ASR 9906	ASR 9910	ASR 9912	ASR 9922
RP	Built-in	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RP	1+1 RP
Fabric	Built-in	2x RSP	6+1	6+1	6+1	6+1
Line cards or ports	16x1G + 24x1/10G + 2x100G	2	4	8	10	20
Rack units	2	6	14	21	30	44
Power modules	2x AC or 2x DC	4x AC or 4x DC	3x AC or 4x DC	8x AC or 8x DC	12x AC or 12x DC	16x AC or 16x DC
Air flow	Front to back	Right to left	Front to back	Front to back	Front to back	Front to back

ASR 9000 Family

Chassis, cards, power, air flow

“Fixed” hw:
RP+Fabric
+LC+ports



	ASR 9901	ASR 9904	ASR 9906	ASR 9010	ASR 9910	ASR 9912	ASR 9922
RP	Built-in	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RP	1+1 RP
Fabric	Built-in	2x RSP	6+1	2x RSP	6+1	6+1	6+1
Line cards or ports	16x1G + 24x1/10G + 2x100G	2	4	8	8	10	20
Rack units	2	6	14	21	21	30	44
Power modules	2x AC or 2x DC	4x AC or 4x DC	3x AC or 4x DC	8x AC or 8x DC	8x AC or 8x DC	12x AC or 12x DC	16x AC or 16x DC
Air flow	Front to back	Right to left	Front to back	Front to back	Front to back	Front to back	Front to back

ASR 9000 Models

Chassis, cards, power, air flow

"Fixed" hw:
RP+SP+LC+
ports+bays



1.5 Tbps/slot

	ASR 9001	ASR 9904	ASR 9006	ASR 9010	ASR 9910	ASR 9912	ASR 9922
RP	Built-in	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RP	1+1 RP
Fabric	Built-in	2x RSP	2x RSP	2x RSP	6+1	6+1	6+1
Line cards & ports	4x SFP+ 2x MPA	2	4	8	8	10	20
Rack units	2	6	10	21	21	30	44
Power modules	2x AC or 2x DC	4x AC or 4x DC	4x AC or 4x DC	8x AC or 8x DC	8x AC or 8x DC	12x AC or 12x DC	16x AC or 16x DC
Air flow	Right to left	Right to left	Right to back	Front to back	Front to back	Front to back	Front to back

ASR 9000 Models

Chassis, cards, power, air flow

With optional
baffle

"Fixed" hw:
RP+SP+LC+
ports+bays



1.5 Tbps/slot



	ASR 9001	ASR 9904	ASR 9006	ASR 9010	ASR 9910	ASR 9912	ASR 9922
RP	Built-in	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RP	1+1 RP
Fabric	Built-in	2x RSP	2x RSP	2x RSP	6+1	6+1	6+1
Line cards & ports	4x SFP+ 2x MPA	2	4	8	8	10	20
Rack units	2	10U 2-post 23"	10	21	21	30	44
Power modules	2x AC or 2x DC	4x AC or 4x DC	4x AC or 4x DC	8x AC or 8x DC	8x AC or 8x DC	12x AC or 12x DC	16x AC or 16x DC
Air flow	Right to left	Front to back	Right to back	Front to back	Front to back	Front to back	Front to back

System Health: Inventory

System components and serial numbers

- Subscribe to Cisco notifications
 - www.cisco.com/cisco/support/notifications.html
- Field notices?
 - www.cisco.com/en/US/partner/support/td_products_field_notice_summary.html
- Test and approve
- Track and audit

```
RP/0/RSP0/CPU0:rusr9000-2w-b#admin show platform
Mon Dec  9 12:53:00.076 EST
Node          Type           State      Config State
-----
0/RSP0/CPU0   A9K-RSP440-SE(Active)  IOS XR RUN    PWR, NSHUT, MON
0/RSP1/CPU0   A9K-RSP440-SE(Standby) IOS XR RUN    PWR, NSHUT, MON
0/FT0/SP      FAN TRAY        READY
0/FT1/SP      FAN TRAY        READY
0/0/CPU0     A9K-24x10GE-SE   IOS XR RUN    PWR, NSHUT, MON
0/1/CPU0     A9K-MOD80-SE    IOS XR RUN    PWR, NSHUT, MON
0/1/0         A9K-MPA-20X1GE  OK
0/1/1         A9K-MPA-4X10GE  OK
0/PM0/SP      A9K-3KW-AC    READY
0/PM1/SP      A9K-3KW-AC    READY

RP/0/RSP0/CPU0:rusr9k-1y#admin show inventory
Thu Dec 20 06:47:24.375 UTC
NAME: "module 0/RSP0/CPU0", DESC: "ASR9K Route Switch Processor with 440G/slot Fabric and 12GB"
PID: A9K-RSP440-SE, VID: v01, SN: FOC161181CV
NAME: "module 0/RSP1/CPU0", DESC: "ASR9K Route Switch Processor with 440G/slot Fabric and 12GB"
PID: A9K-RSP440-SE, VID: v01, SN: FOC16038111
.
RP/0/RSP0/CPU0:rusr9k-1y#admin show inventory oid
Thu Dec 20 06:48:24.589 UTC
NAME: "module 0/RSP0/CPU0", DESC: "ASR9K Route Switch Processor with 440G/slot Fabric and 12GB"
PID: A9K-RSP440-SE, VID: v01, SN: FOC161181CV
OID: 1.3.6.1.4.1.9.12.3.1.9.74.25
```

System Health: Power

Installed power, status, consumption, and redundancy

```
RP/0/RSP0/CPU0:rasr9k-1y(admin)#show environment  
power-supply  
Wed Nov 21 06:48:41.443 UTC  


| R/S/I   | Modules | Capacity (W) | Status    |
|---------|---------|--------------|-----------|
| 0/PM0/* | host PM | 3000         | ok        |
| 0/PM3/* | host PM | 3000         | ok        |
| 0/PM4/* | host PM | 0            | Unpowered |


| R/S/I   | Power Supply (W) | Voltage (V) | Current (A) |
|---------|------------------|-------------|-------------|
| 0/PM0/* | 436.8            | 54.6        | 8.0         |
| 0/PM3/* | 459.0            | 54.0        | 8.5         |
| 0/PM4/* | 0.0              | 0.0         | 0.0         |


| Total: | 895.8 |
|--------|-------|
|--------|-------|


| R/S/I | Power Draw (W) | Voltage (V) | Current (A) |
|-------|----------------|-------------|-------------|
| 0/0/* | 348.1          | 54.4        | 6.4         |


| Total: | 348.1 |
|--------|-------|
|--------|-------|


```

Power Budget Summary for Rack 0		

Power Shelves Type: AC		
Total Power Capacity: 6000W		
Usable Power Capacity: 6000W		
Supply Failure Protected Capacity: 3000W		
Feed Failure Protected Capacity: 3000W		
Worst Case Power Used: 1700W		

Slot	Max Watts	
0/0/CPU0	400	
0/RSP0/CPU0	350	
0/RSP1/CPU0	350	
0/FT0/SP	300	
0/FT1/SP	300	

Worst Case Power Available: 4300W		
Supply Protected Capacity Available: 1300W		
Feed Protected Capacity Available: 1300W		

- Use Telemetry or SNMP to check on power population and status
- Use Power Calculator <http://tools.cisco.com/cpc/launch.jsp>. If changing chassis power version/type [v2/v1, AC/DC]: <http://www.cisco.com/en/US/docs/routers/asr9000/hardware/installation/guide/asr9kIGmaintaining.html#wp1323197>

System Health: Heat Dissipation & Alarms

Fans, temperature sensors, and alarms

RP/0/RSP0/CPU0:rasr9k-1y(admin)#show environment temperatures			
Wed Nov 21 07:04:54.506 UTC			
R/S/I	Modules	Sensor	(deg C)
0/0/*	ep0	Inlet0	31.0
	ep0	Hotspot0	41.4
	ep1	Inlet0	27.8
	ep1	Hotspot0	34.6
	host	Inlet0	29.5
	host	Hotspot0	41.5
0/RSP0/*	host	Inlet0	23.8
	host	Hotspot0	34.1
0/RSP1/*	host	Inlet0	25.2
	host	Hotspot0	39.3
0/FT0/*	host	Inlet0	-50.0

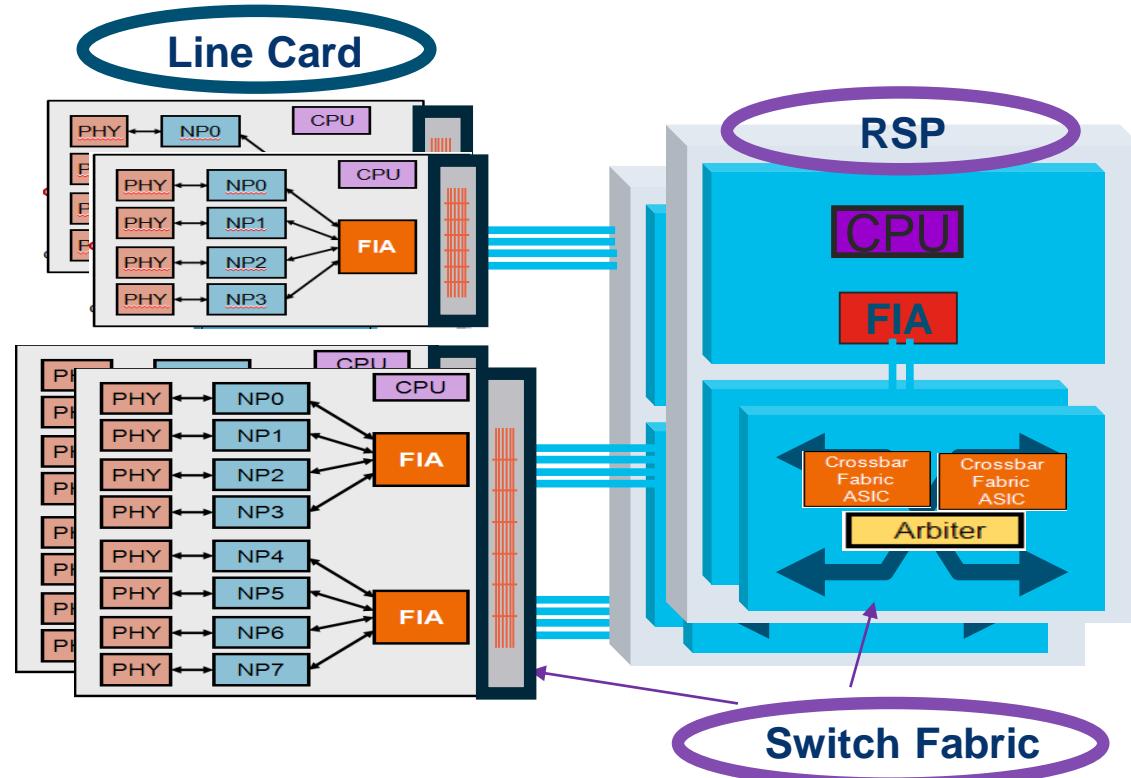
RP/0/RSP0/CPU0:rasr9k-1y(admin)#show environment fans						
wed Nov 21 07:08:51.674 UTC						
Fan speed (rpm):						
FAN6	FAN0	FAN1	FAN2	FAN3	FAN4	FAN5
0/FT0/*	3570	3570	3540	3510	3540	3570
3570	3570	3540	3600	3630	3600	
0/FT1/*	3510	3570	3570	3570	3540	3690
3600	3630	3630	3660	3630	3600	
RP/0/RSP0/CPU0:rasr9k-1y(admin)#show environment leds						
wed Nov 21 07:09:18.706 UTC						
R/S/I	Modules	LED	Status			
0/RSP0/*	host	Critical-Alarm	off			
	host	Major-Alarm	off			
	host	Minor-Alarm	off			
	host	ACO	off			
	host	Fail	off			
0/RSP1/*	host	Critical-Alarm	off			
	host	Major-Alarm	off			
	host	Minor-Alarm	off			
	host	ACO	off			
	host	Fail	off			

RP front
status LED

System Architecture

9904, 9006, 9010

- Distributed control plane
 - L2 protocols, ARP, BFD, CFM, Netflow run on LC CPU
- Distributed data plane
 - Forwarding distributed to NP's
- Active-active switch fabric
 - Each RSP houses "half" of the fabric



RSP5/RP3 Front Panel

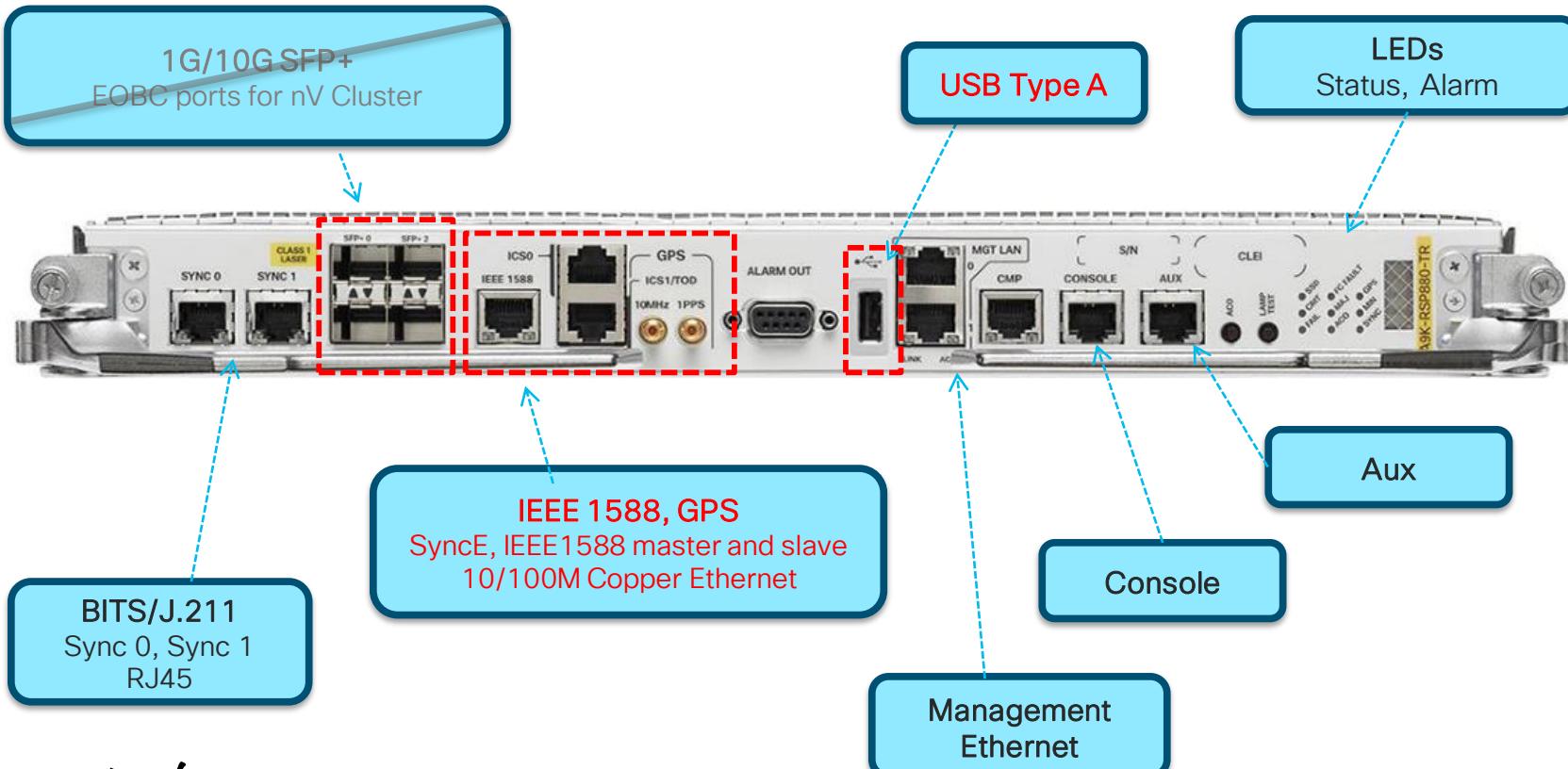
Fourth generation RP and fabric



- 2x BITS ports on RJ-45
- 100Mbps, 1588 port – RJ-45
- TOD – RJ-45
- 10Mhz on SMA
- 1x CMP
- 1PPS on SMA
- Alarm output serial port
- USB
- 2x OOB Management Ethernet
- AUX & Console on RJ-45 connectors
- LED's for major/critical and normal oper alarms or states

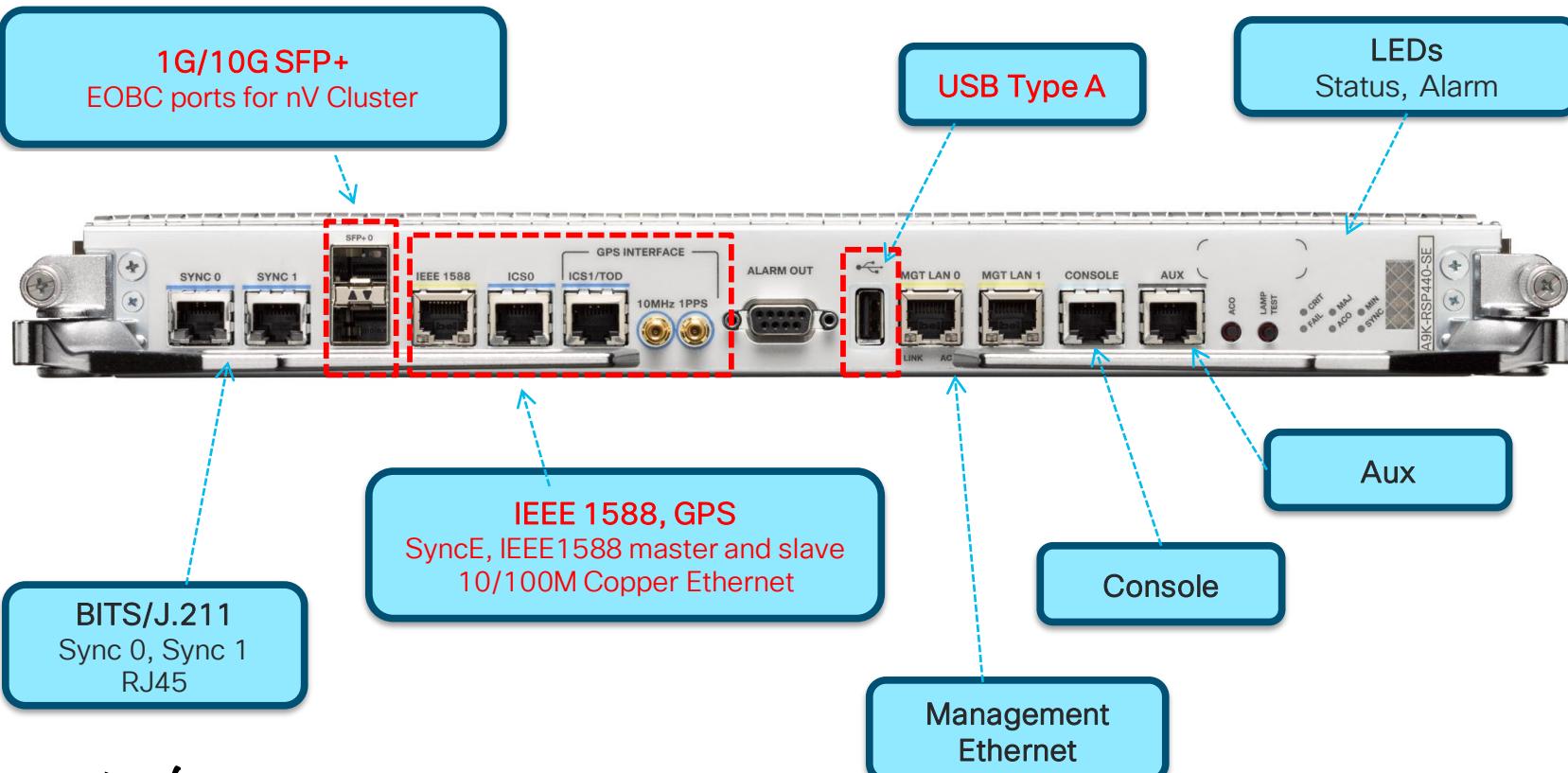
RSP880

Third generation RP and fabric



RSP440

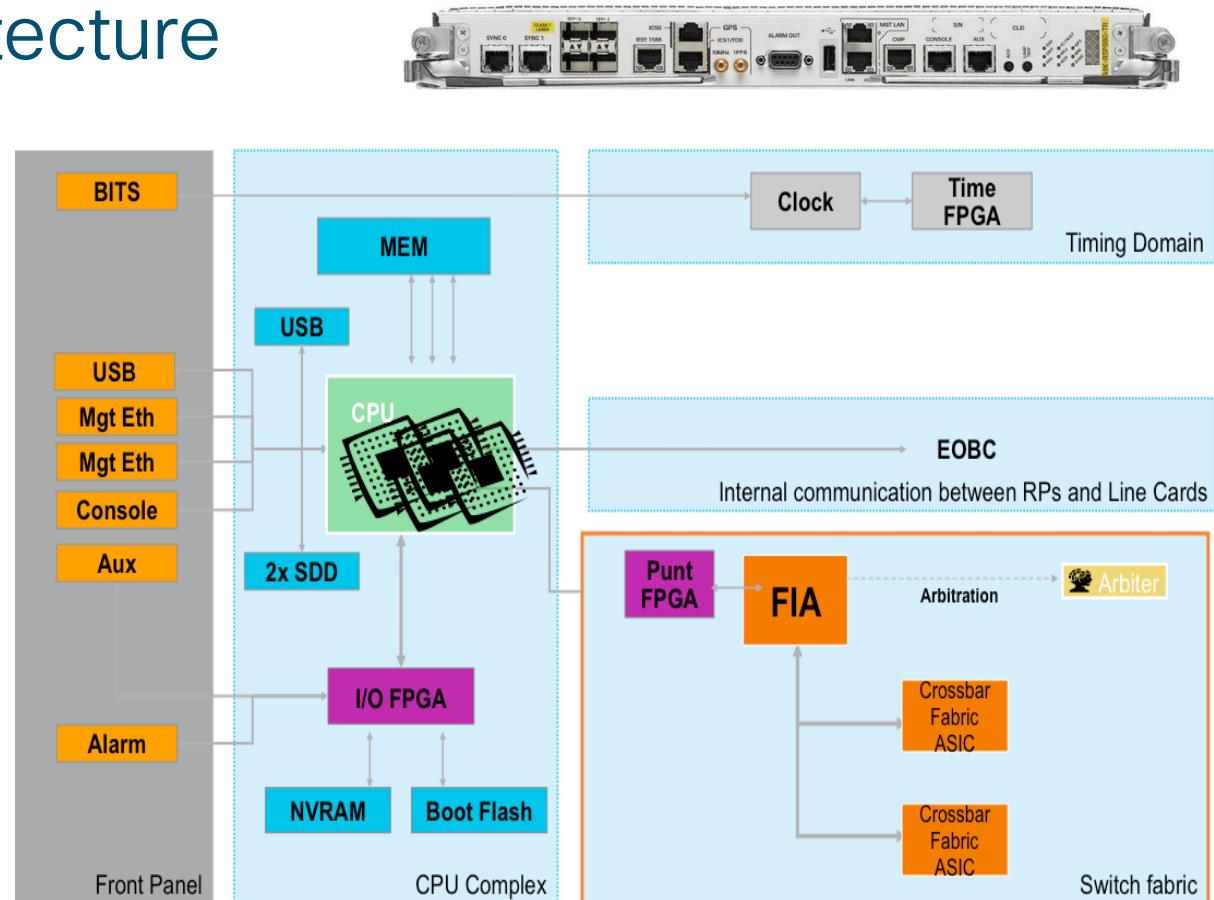
Second generation RP and fabric



RSP880 Architecture

The RP and fabric

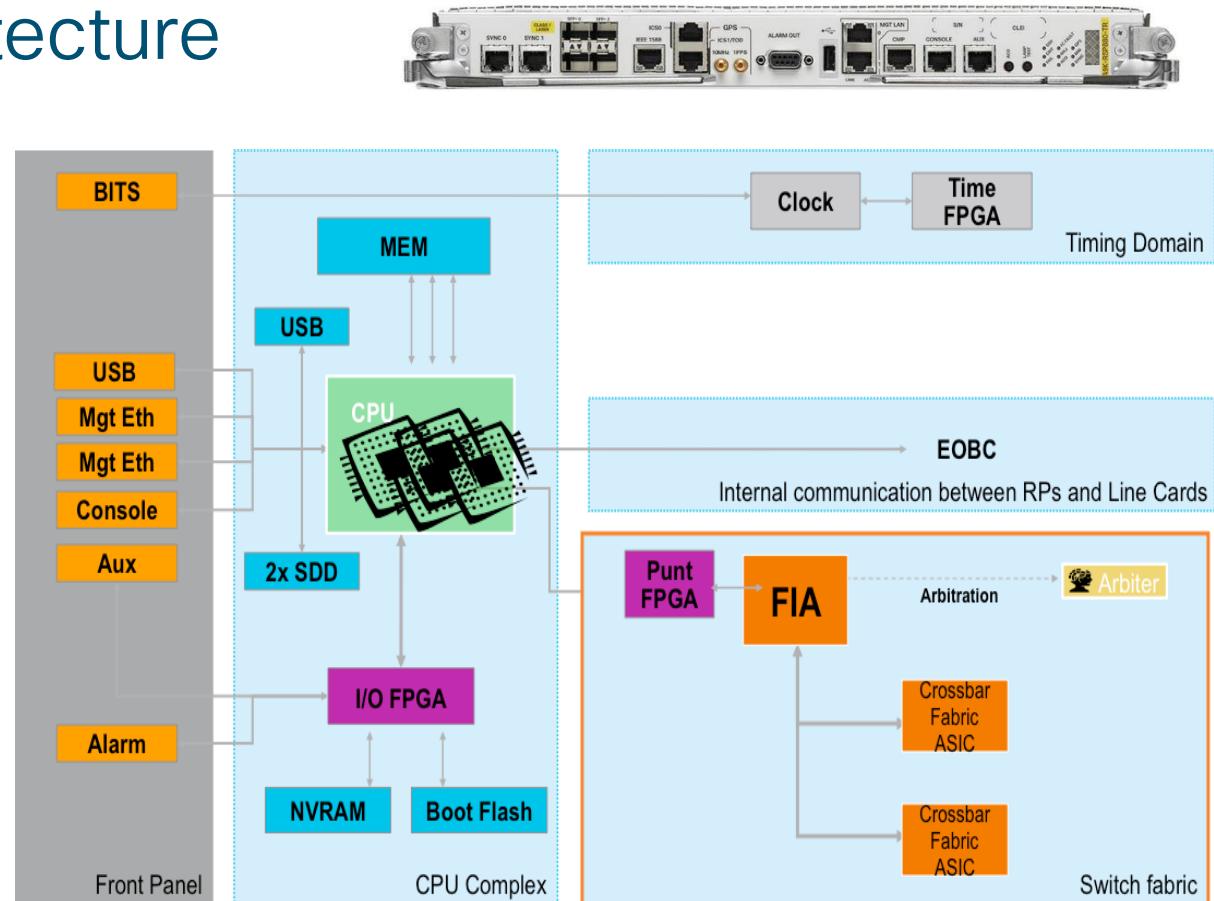
- Intel x86 8-core proc.
@2 GHz
- SE and TR versions
 - SE: 32 GB RAM
 - TR: 16 GB RAM
- Storage
 - 2x 32 GB SSD
 - 1x 8 GB USB
- EOBC on panel
 - 4 SFP+ EOBC ports for clustering
- Fabric on each RSP
 - 440 Gbps per slot per RSP
 - 0 packet loss switchover



RSP440 Architecture

The RP and fabric

- Intel x86 4-core proc.
@2 GHz
- SE and TR versions
 - SE: 12 GB RAM
 - TR: 6 GB RAM
- Storage
 - 2x 16 GB SSD
 - 1x 8 GB USB
- EOBC on panel
 - 2 SFP+ EOBC ports for clustering
- Fabric on each RSP
 - 220 Gbps per slot per RSP
 - 0 packet loss switchover



Route Switch Processors and Route Processors

RSP used in ASR9910/9906/9904/9006/9010, RP in ASR9922/9912

	RSP880 A99-RSP	RP2	RSP5	RP3
Description	3 rd Gen RP and Fabric ASIC		4 th Gen RP and Fabric ASIC	
Switch Fabric Bandwidth	400G + 400G (9006/9010) 700G + 700G (9904) 200G + 200G + 1.0T (9906/9910)	1.2Tb + 200G (separated fabric card)	900G + 900G (9006/9010) 1.8T + 1.8T (9904) 600G + 600G + 3.0T (9906/9910)	3.6Tb + 600G (separated fabric card)
Processor	Intel x86 (Ivy Bridge EP) 8 Core 2GHz		Intel x86 (Skylake EP) 8 Core 2GHz	
RAM	-TR: 16GB -SE: 32GB		-TR: 16GB -SE: 40GB	
SSD	2 x 32GB Slim SATA		2 x 128GB Slim SATA	
Punt BW	40GE		40GE	

RP

Processor and storage: RSP880

```
RP/0/RSP1/CPU0:ASR9006-2w-a.PE2_CE1#show version brief
Thu Feb 16 03:21:06.398 EST
```

Cisco IOS XR Software, Version 5.3.3[Default]
Copyright (c) 2016 by Cisco Systems, Inc.

ROM: System Bootstrap, Version 10.45(c) 1994-2014 by
Cisco Systems, Inc.

ASR9006-2w-a.PE2_CE1 uptime is 5 weeks, 6 days, 7
hours, 38 minutes
System image file is "disk0:asr9k-os-mbi-
5.3.3/0x100305/mbiasr9k-rsp3.vm"

cisco ASR9K Series (Intel 686 F6M14S4) processor with
33554432K bytes of memory.
Intel 686 F6M14S4 processor at 1904MHz, Revision 2.174
ASR 9006 4 Line Card Slot Chassis with V1 AC PEM

2 FastEthernet
4 Management Ethernet
30 GigabitEthernet/IEEE 802.3 interface(s)
20 GigabitEthernet
38 TenGigE
45 DWDM controller(s)
38 WANPHY controller(s)

7 HundredGigE
375k bytes of non-volatile configuration memory.
6114M bytes of hard disk.
25012208k bytes of disk0: (Sector size 512 bytes).
25012208k bytes of disk1: (Sector size 512 bytes).

```
RP/0/RSP1/CPU0:ASR9006-2w-a.PE2_CE1#show filesystem
Thu Feb 16 03:28:29.679 EST
```

File Systems:

Size(b)	Free(b)	Type	Flags	Prefixes
-	-	network	rw	qsm/dev/fs/tftp:
-	-	network	rw	qsm/dev/fs/rcp:
-	-	network	rw	qsm/dev/fs/ftp:
5122293760	5120977408	dumper-lnk	rw	qsm/dumper_disk0a:
5122293760	5121016832	dumper-lnk	rw	qsm/dumper_disk1a:
6412025856	6399351808	dumper-		
lnk	rw	qsm/dumper_harddisk:		
767090688	767082496	dumper-		
lnk	rw	qsm/dumper_harddiskb:		
802160640	799895040	dumper-		
lnk	rw	qsm/dumper_harddiska:		
25612500992	24058017792	dumper-lnk	rw	qsm/dumper_disk1:
25612500992	24540718592	dumper-lnk	rw	qsm/dumper_disk0:
6412025856	6399351808	harddisk	rw	harddisk:
802160640	799895040	harddisk	rw	harddiska:
767090688	767082496	harddisk	rw	harddiskb:
25612500992	24540718592	flash-disk	rw	disk0:
25612500992	24058017792	flash-disk	rw	disk1:
5122293760	5120977408	flash-disk	rw	disk0a:
5122293760	5121016832	flash-disk	rw	disk1a:
384000	359424	nvram	rw	nvram:

USB

2x SSD

RP

Processor and storage: RSP440

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show version brief
Mon Nov 18 23:24:08.582 EST
Cisco IOS XR Software, Version 4.2.3[Default]
Copyright (c) 2013 by Cisco Systems, Inc.
ROM: System Bootstrap, Version 0.62(c) 1994-2012
by Cisco Systems, Inc.
rasr9000-2w-a uptime is 2 hours, 51 minutes
System image file is "disk0:asr9k-os-mbi-
4.2.3.CSCuf32158-1.0.0/0x100305/mbiasr9k-rsp3.vm"
cisco ASR9K Series (Intel 686 F6M14S4) processor
with 12582912K bytes of memory.
Intel 686 F6M14S4 processor at 2127MHz, Revision 2.174
ASR-9006 AC Chassis
4 Management Ethernet
28 TenGigE
28 DWDM controller(s)
28 WANPHY controller(s)
20 GigabitEthernet
503k bytes of non-volatile configuration memory.
6143M bytes of hard disk.
11817968k bytes of disk0: (Sector size 512
bytes).
11817968k bytes of disk1: (Sector size 512
bytes).
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show filesystem
Fri Jan 3 23:47:44.581 EST
File Systems:
  Size(b)   Free(b)    Type  Flags  Prefixes
  -          -        network  rw  qsm/dev/fs/tftp:
  -          -        network  rw  qsm/dev/fs/rcp:
  -          -        network  rw  qsm/dev/fs/ftp:
  2420113408 2417498112 dumper-lnk  rw  qsm/dumper_disk0a:
  2420113408 2419496448 dumper-lnk  rw  qsm/dumper_disk1a:
  6442434560 6176757248 dumper-lnk  rw
qsm/dumper_harddisk:
  771276800 771268608 dumper-lnk  rw
qsm/dumper_harddisksb:
  805306368 804222976 dumper-lnk  rw
qsm/dumper_harddisksa:
  12101599232 9732002816 dumper-lnk  rw  qsm/dumper_disk1:
  12101599232 9732002816 dumper-lnk  rw  qsm/dumper_disk0:
  6442434560 6176757248  harddisk  rw  harddisk:
  805306368 804222976  harddisk  rw  harddiska:
  771276800 771268608  harddisk  rw  harddiskb:
2x SSD 12101599232 9732002816 flash-disk  rw  disk1:
  12101599232 9732002816 flash-disk  rw  disk0:
  2420113408 2417498112 flash-disk  rw  disk0a:
  2420113408 2419496448 flash-disk  rw  disk1a:
  515072      486400    nvram   rw  nvram:
RP/0/RSP0/CPU0:rasr9000-2w-a#
```

RP

Redundancy

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show redundancy
Tue Nov 19 02:08:36.742 EST
Redundancy information for node 0/RSP0/CPU0:
=====
Node 0/RSP0/CPU0 is in ACTIVE role
Node Redundancy Partner (0/RSP1/CPU0) is in STANDBY role
Standby node in 0/RSP1/CPU0 is ready
Standby node in 0/RSP1/CPU0 is NSR-ready
Node 0/RSP0/CPU0 is in process group PRIMARY role
Process Redundancy Partner (0/RSP1/CPU0) is in BACKUP role
Backup node in 0/RSP1/CPU0 is ready
Backup node in 0/RSP1/CPU0 is NSR-ready

Group          Primary        Backup        Status
-----          -----        -----        -----
dsc            0/RSP0/CPU0    0/RSP1/CPU0    Ready
dlrsc          0/RSP0/CPU0    0/RSP1/CPU0    Ready
central-services 0/RSP0/CPU0  0/RSP1/CPU0    Ready
v4-routing      0/RSP0/CPU0    0/RSP1/CPU0    Ready
netmgmt         0/RSP0/CPU0    0/RSP1/CPU0    Ready
mcast-routing   0/RSP0/CPU0    0/RSP1/CPU0    Ready
v6-routing      0/RSP0/CPU0    0/RSP1/CPU0    Ready

Reload and boot info
-----
A9K-RSP440-SE reloaded Mon Nov 18 20:32:38 2013: 5 hours, 35 minutes ago
Active node booted Mon Nov 18 20:32:38 2013: 5 hours, 35 minutes ago
Standby node boot Mon Nov 18 20:32:40 2013: 5 hours, 35 minutes ago
Standby node last went not ready Mon Nov 18 20:36:29 2013: 5
```

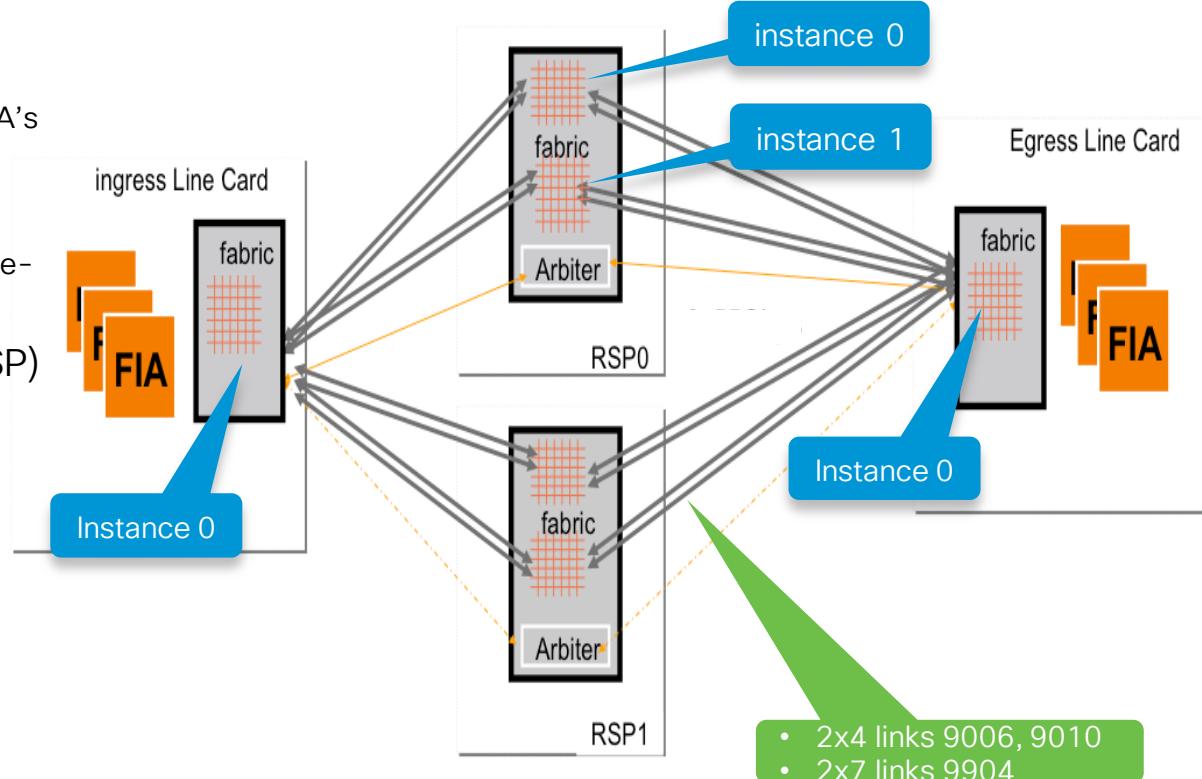
Redundancy failover example: RSP0 removed

```
RP/0/RSP1/CPU0:Dec 16 20:57:47.049 : ce_switch_srv[53]: %PLATFORM-CE_SWITCH-6-UPDN : Interface 8  
(Peer_RSP) is down  
RP/0/RSP1/CPU0:Dec 16 20:57:47.091 : sc_reddrv[392]: %PLATFORM-REDDRV-6-RESET_STANDBY : Active is  
going to reset standby peer node node0_RSP0_CPU0  
RP/0/RSP1/CPU0:Dec 16 20:57:47.093 : rmf_svr[386]: %HA-REDCON-6-GO_ACTIVE : this card going active  
RP/0/RSP1/CPU0:Dec 16 20:57:47.094 : sysmgr[93]: %OS-SYSMGR-5-NOTICE : This standby node is going  
active at Mon Dec 16 20:57:47 2013  
RP/0/RSP1/CPU0:Dec 16 20:57:47.400 : dao_tmp[56]: Card Removed 0/RSP0/CPU0  
RP/0/RSP1/CPU0:Dec 16 20:57:47.449 : sysmgr[93]: %OS-SYSMGR-5-NOTICE : This node is active now at  
Mon Dec 16 20:57:47 2013  
RP/0/RSP1/CPU0:Dec 16 20:57:47.450 : sysmgr[93]: %OS-SYSMGR-5-NOTICE : Critical failover elapsed  
time 0.353 seconds (86.080% idle)  
RP/0/RSP1/CPU0:Dec 16 20:57:47.457 : isis[1003]: %ROUTING-ISIS-6-INFO_STARTUP_START : Cold  
controlled start beginning  
RP/0/RSP1/CPU0:Dec 16 20:57:47.468 : ospf[1011]: %ROUTING-OSPF-5-HA_NOTICE : Process 100: Attempting  
Cisco NSF-enabled restart of vrf default  
RP/0/RSP1/CPU0:Dec 16 20:57:47.470 : ospf[1011]: %ROUTING-OSPF-5-HA_NOTICE : Process 100: Signaled  
PROC_AVAILABLE  
RP/0/RSP1/CPU0:Dec 16 20:57:47.784 : mpls_ldp[1043]: %ROUTING-LDP-3-ERR_LPTS_FILT : Failed to remove  
LPTS filter for local 10.101.111.1 remote=10.101.112.1: Host is down  
.
```

The Switch Fabric

9010, 9006, 9904

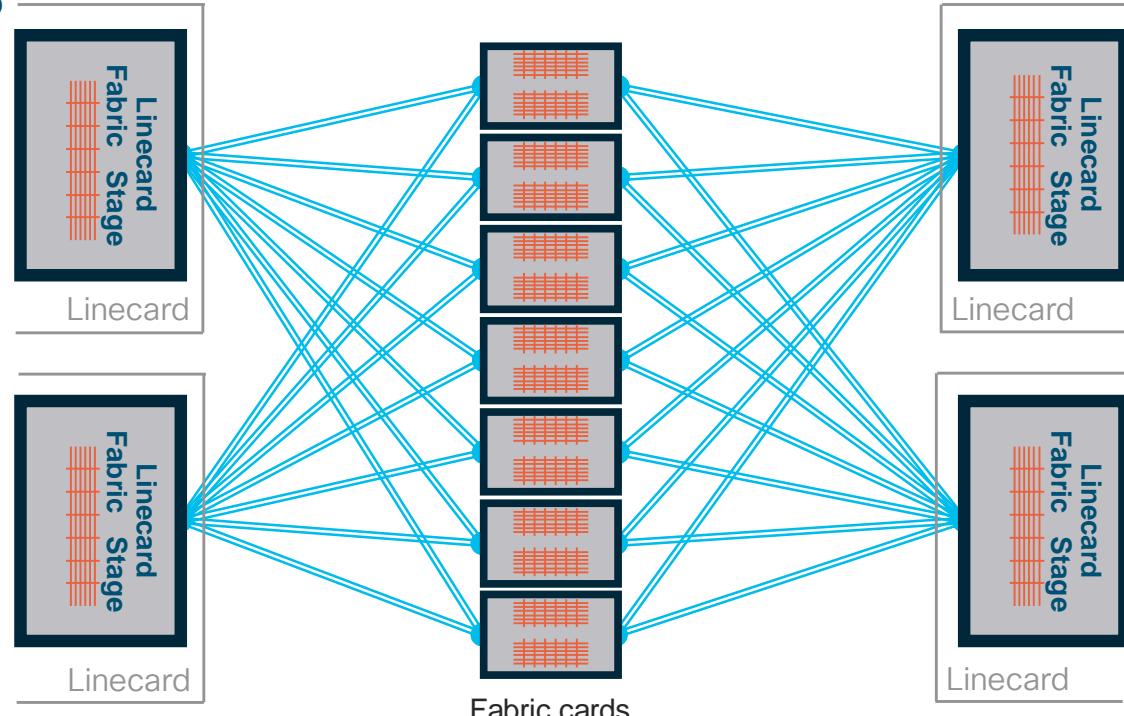
- 3-Stage fabric
 - Allows for variable number of FIA's and FIA links on LC
- Super-framing for unicast
 - Super-frame same-priority same-egress frames in a jumbo frame
- Bandwidth per slot (dual RSP)
 - RSP440: 440G
 - RSP880: 880G
 - asr9904: 1.5T
 - RSP5: 1.8T
 - asr9904: 3T
- Fabric load sharing
 - Unicast: per super-frame
 - Multicast: per flow



The Switch Fabric

9922, 9912, 9910, 9906

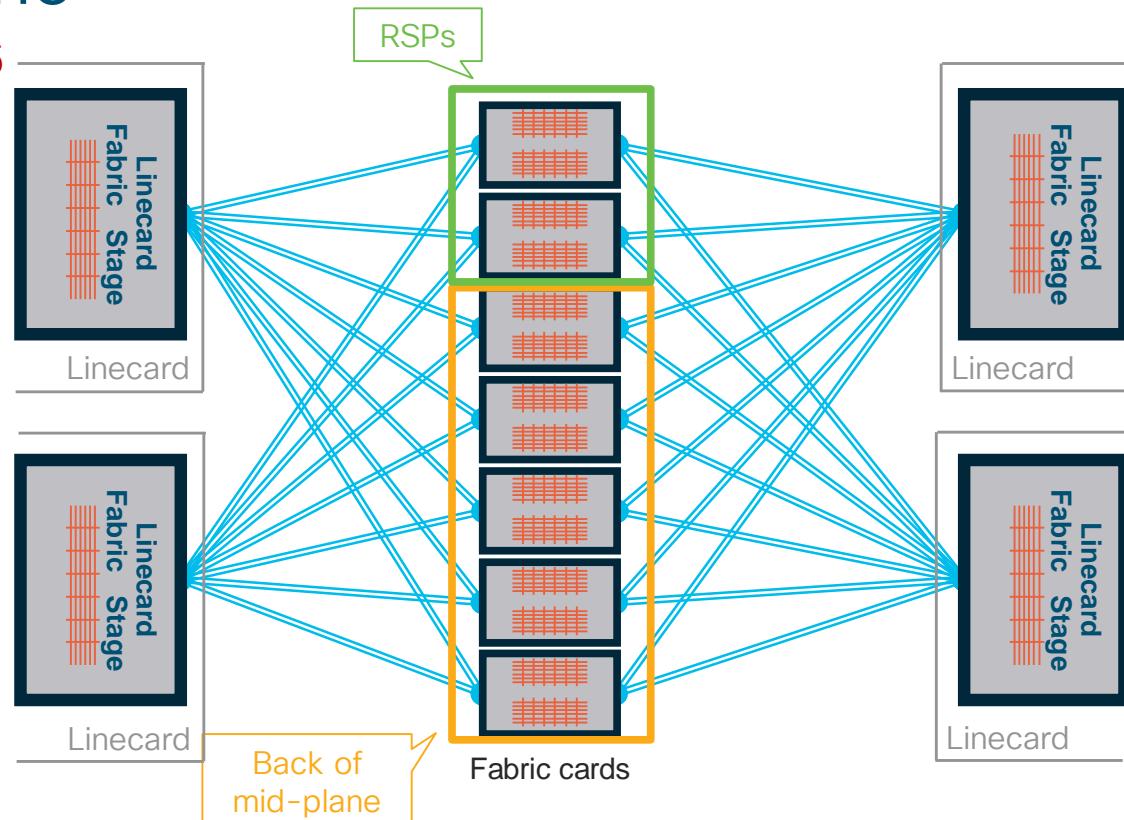
- 3-Stage fabric
 - Allows for variable number of FIA's and FIA links on LC
- Super-framing for unicast
 - Super-frame same-priority same-egress frames in a jumbo frame
- Bandwidth per slot:
 - SFC1: 110G [Typhoon gen]
 - SFC2: 230G [Tomahawk gen]
 - SFC3: 600G [Lightspeed gen]
- Fabric load sharing
 - Unicast: per super-frame
 - Multicast: per flow



The Switch Fabric

9922, 9912, 9910, 9906

- 3-Stage fabric
 - Allows for variable number of FIA's and FIA links on LC
- Super-framing for unicast
 - Super-frame same-priority same-egress frames in a jumbo frame
- Bandwidth per slot:
 - SFC1: 110G [Typhoon gen]
 - SFC2: 230G [Tomahawk gen]
 - SFC3: 600G [Lightspeed gen]
- Fabric load sharing
 - Unicast: per super-frame
 - Multicast: per flow



Slot Address

Internal slot address, slot mask, and fabric group ID

Slot		Slot Mask	
Logical	Physical	Binary	Hex
LC19	21	10 0000 0000 0000 0000 0000	0x10 0000
LC4-18	6-20		
LC3	5	00 0010 0000	0x0020
LC2	4	00 0001 0000	0x0010
LC1	3	00 0000 1000	0x0008
LC0	2	00 0000 0100	0x0004
RSP1	1	00 0000 0010	0x0002
RSP0	0	00 0000 0001	0x0001

- Follows the sequence of slots in chassis
- 4/6/12/22 RP slots: 000011 which is 0x0003, decimal 3
- Exception: 9010 RSP slots: 0000110000 which is 0x0030, decimal 48

Slot Address

Internal slot address, slot mask, and fabric group ID

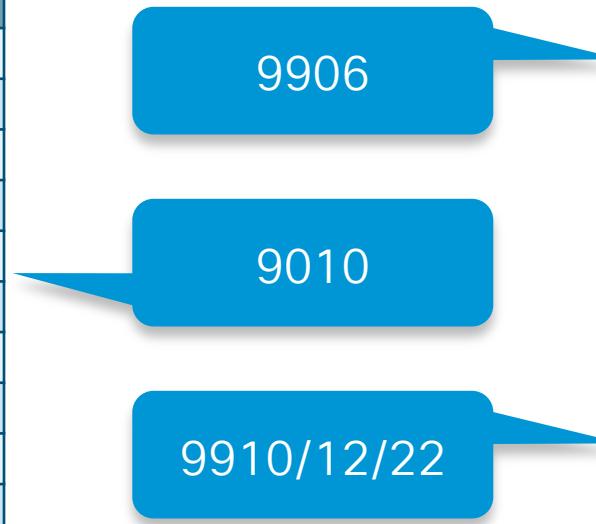
Location	Slot		Slot Mask	
	Logical	Physical	Binary	Hex
0/19/CPU0	LC19	21	10 0000 0000 0000 0000 0000	0x10 0000
0/4/CPU0 – 0/18/CPU0	LC4-18	6-20		
0/3/CPU0	LC3	5	00 0010 0000	0x0020
0/2/CPU0	LC2	4	00 0001 0000	0x0010
0/1/CPU0	LC1	3	00 0000 1000	0x0008
0/0/CPU0	LC0	2	00 0000 0100	0x0004
0/RSP1/CPU0	RSP1/RP1	1	00 0000 0010	0x0002
0/RSP0/CPU0	RSP0/RP0	0	00 0000 0001	0x0001

- Follows the sequence of slots in chassis
- 4/6/12/22 RP slots: 000011 which is 0x0003, decimal 3
- Exception: 9010 RSP slots: 0000110000 which is 0x0030, decimal 48

Slot Address

Internal slot address, slot mask, and fabric group ID

Slot		Slot Mask	
Logical	Physical	Binary	Hex
LC7	9	1000000000	0x0200
LC6	8	0100000000	0x0100
LC5	7	0010000000	0x0080
LC4	6	0001000000	0x0040
RSP0	5	0000100000	0x0020
RSP1	4	0000010000	0x0010
LC3	3	0000001000	0x0008
LC2	2	0000000100	0x0004
LC1	1	0000000010	0x0002
LC0	0	0000000001	0x0001



Slot		Slot Mask	
Logical	Physical	Binary	Hex
LC3	5	0000100000	0x0020
LC2	4	0000010000	0x0010
LC1	3	0000001000	0x0008
LC0	2	0000000100	0x0004
RSP1	1	0000000010	0x0002
RSP0	0	0000000001	0x0001

Slot		Slot Mask	
Logical	Physical	Binary	Hex
LC19	21	10000 00000000 00000000	0x10000
LC1-18	3-20		
LC0	2	0000000100	0x0004
RP1	1	0000000010	0x0002
RP0	0	0000000001	0x0001

- Follows the sequence of slots in chassis
- 4/6/12/22 RP slots: 000011 which is 0x0003, decimal 3
- 9010 RSP slots: 0000110000 which is 0x0030, decimal 48

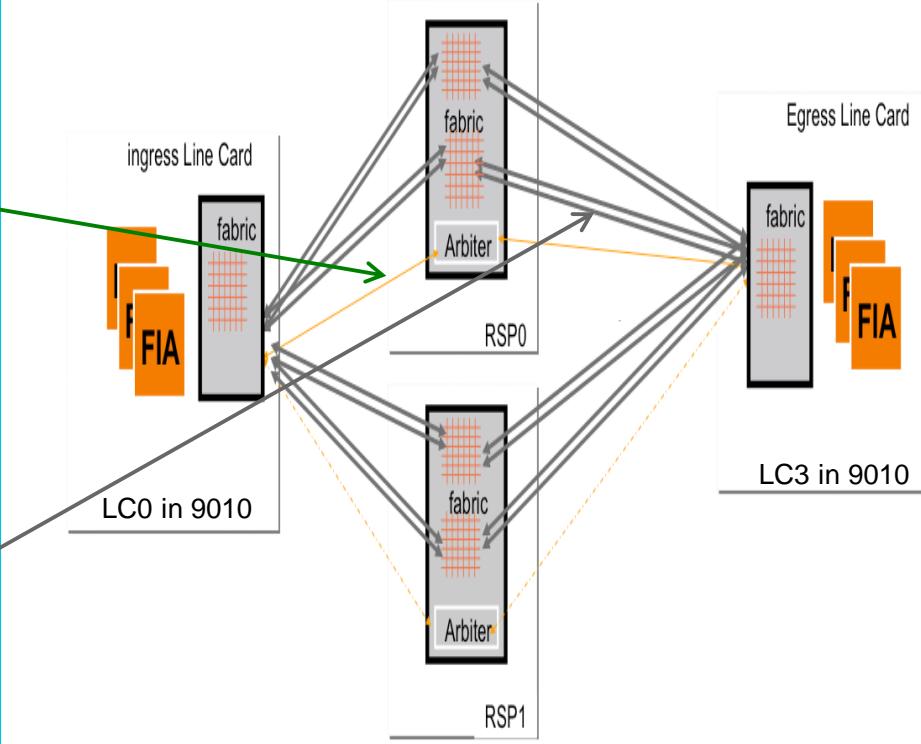
Fabric

Link status

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show controllers fabric
arbiter linkstatus 3 location 0/RSP0/CPU0
Wed Nov 20 20:44:29.615 EST
Slot 3      PG:9      up

RP/0/RSP0/CPU0:rasr9000-2w-a#show controllers fabric
arbiter linkstatus 0 location 0/RSP0/CPU0
Wed Nov 20 20:44:22.995 EST
Slot 0      PG:24     up

RP/0/RSP0/CPU0:rasr9000-2w-a#show controllers fabric
crossbar link-status instance 1 location 0/RSP0/CPU0
Tue Dec 17 02:59:30.110 EST
PORT      Remote Slot  Remote Inst   Logical ID Status
=====
02        0/3/CPU0    00            0       Up
16        0/0/CPU0    00            0       Up
18        0/2/CPU0    00            1       Up
20        0/2/CPU0    00            0       Up
24        0/3/CPU0    00            1       Up
```



Fabric

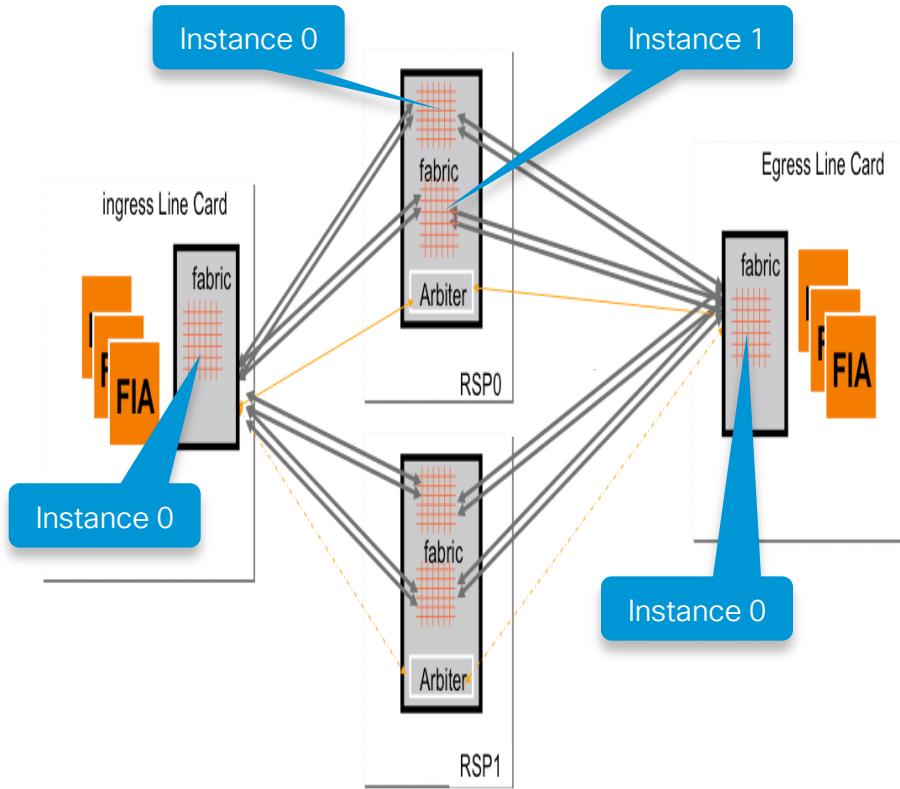
Link statistics

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show controllers fabric
crossbar statistics instance 1 location 0/RSP0/CPU0
Tue Dec 17 02:59:36.376 EST
Port statistics for xbar:1 port:2
=====
Hi priority stats (unicast)
=====
Ingress Packet Count Since Last Read : 17347357500
Ingress Channel Utilization Count : 5
Output Buffer Queued Packet Count : 1
Egress Packet Count Since Last Read : 19006087016
Egress Channel Utilization Count : 4

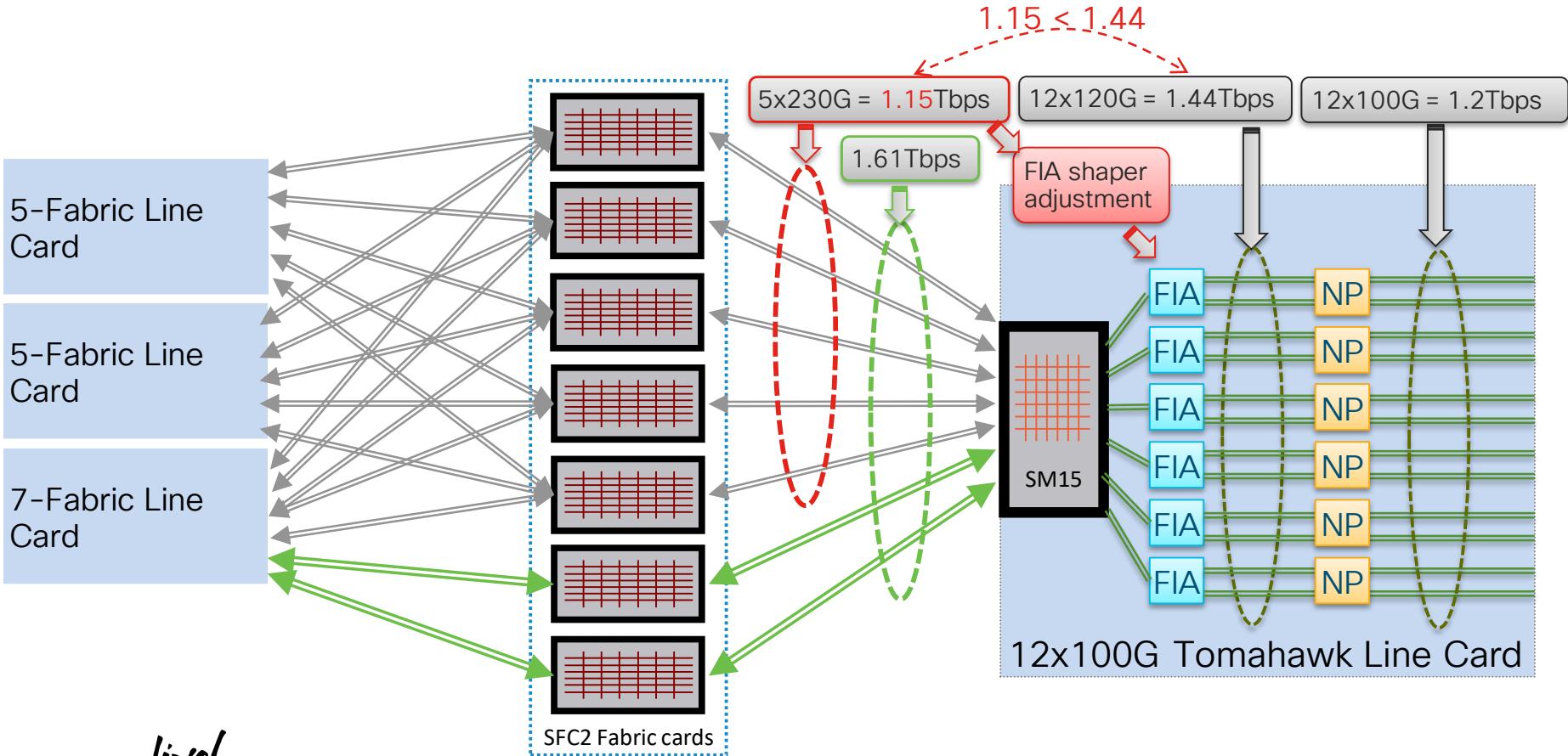
Port statistics for xbar:1 port:16
=====
Hi priority stats (unicast)
=====
Ingress Packet Count Since Last Read : 49365
Egress Packet Count Since Last Read : 323

Low priority stats (multicast)
=====
Ingress Packet Count Since Last Read : 1623
Egress Packet Count Since Last Read : 716

Total Unicast In: 63038489128
Total Unicast Out: 63038489275
Total Multicast In: 1625
Total Multicast Out: 1252
```



5-Fabric and 7-Fabric Interworking



Fabric Mode

High bandwidth, or mixed

- Default:
 - Max 1024 VQI per system
 - Multicast traffic uses the first 5 fabric cards
- highbandwidth:
 - Max 2048 VQI per system (➔ only Tomahawk/RP2 and later allowed)
 - Multicast traffic uses the first 5 fabric cards
- A99-highbandwidth:
 - Max 2048 VQI per system
 - Multicast traffic uses all 7 fabric cards (➔ only A99 Tomahawk /RP2 and later allowed)

```
RP/0/RSP1/CPU0:ASR9K-2(admin-config)#fabric enable mode ?
  A99-highbandwidth  A99 High bandwidth cards only
  highbandwidth      High bandwidth cards only
```

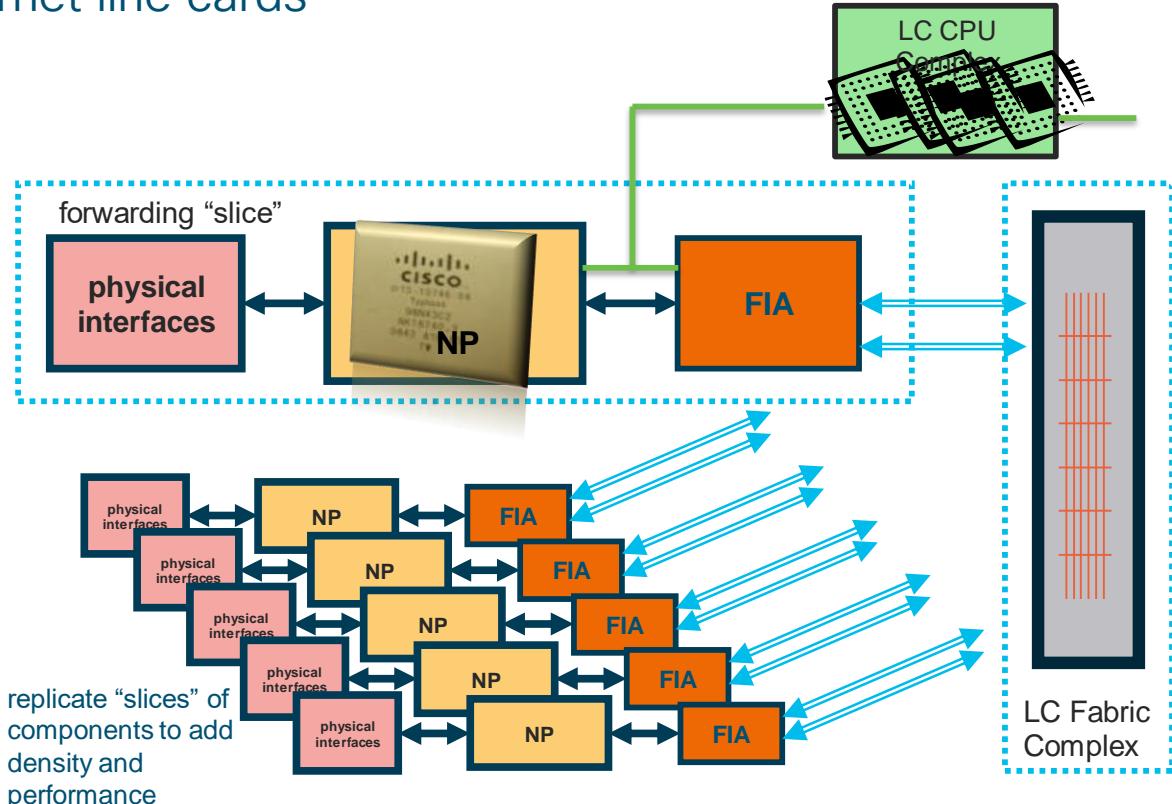
Fabric Interworking: 5-Fab LC to 12x100G LC

- FIA shaper is applied by default on 12x100G line cards
- A99 chassis with 5 fabric cards or more:
 - 83Gbps per 100G port (total of 996 Gbps; fabric conn 5x230Gbps = 1.15Tbps Gbps)
- Any chassis with 4 fabric cards (asr9010, asr9006 with dual RSP880):
 - 71Gbps per 100G port (total of 852 Gbps; fabric connection 4x230Gbps = 920 Gbps)
- Syslog:
 - LC/0/0/CPU0:Dec 27 12:05:16.429 EST: pfm_node_lc[299]: %FABRIC-FIA-1-RATE_LIMITER_ON : Set|fialc[163907]|0x1072000|Insufficient fabric capacity for card types in use - FIA egress rate limiter applied
- Checking the shaper rate:
 - `show controllers fabric fia information location <location>`
 - `show controller fabric fia trace location <location> | include "shape_RL"`

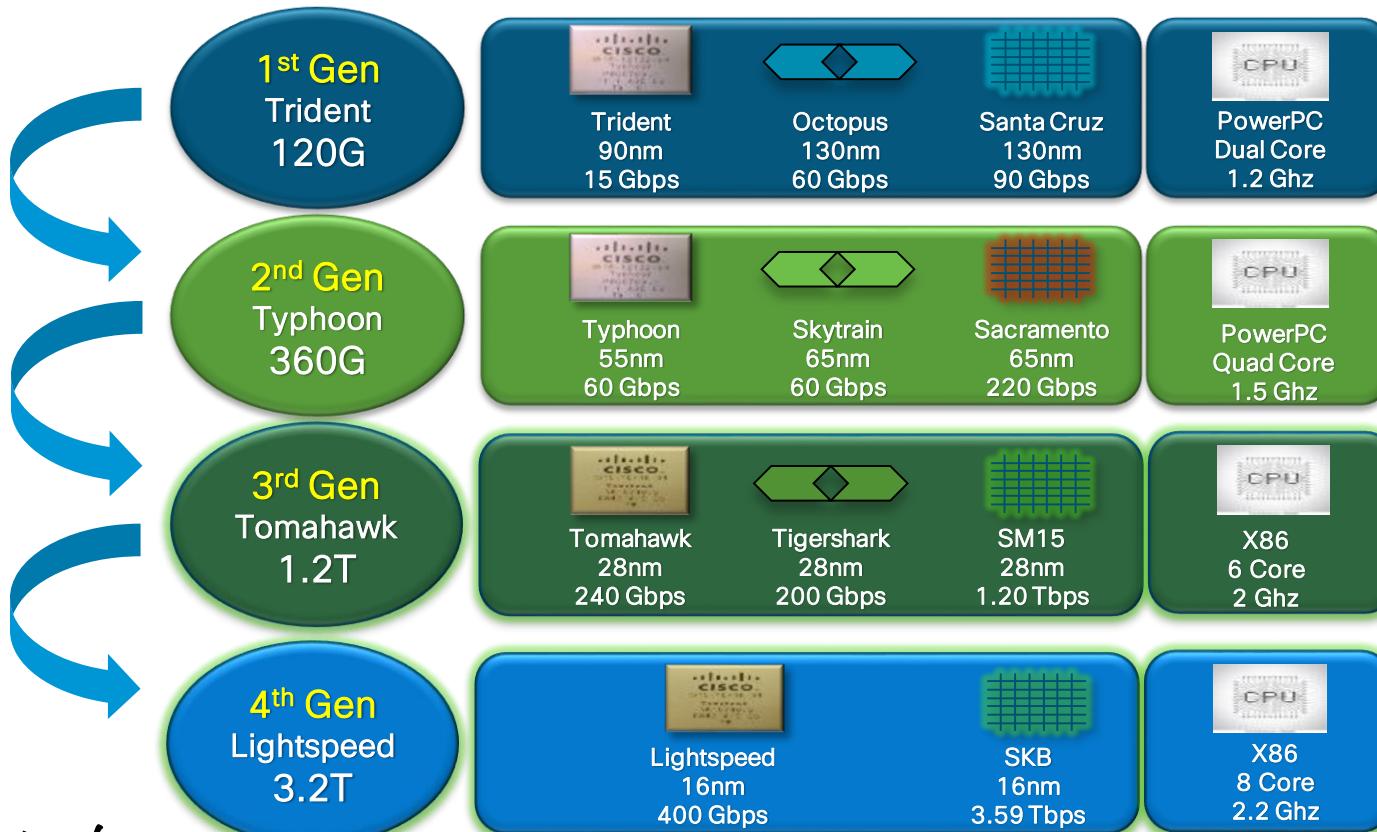
Line Card Architecture

3rd/2nd generation Ethernet line cards

- Physical 1/10/40/100 Gbps
 - No frame processing there
- Tomahawk [or Typhoon] NP
 - FIB, MAC, ACL, QoS, encap/decap, LPTS, all hw features, buffer, i/f stats
 - 240 [60] Gbps 150 [45] Mpps bidirectional
 - Or 480 [120] Gbps unidirectional
- Fabric Interface ASIC
 - 2PQ+1BE into fabric, VOQ
 - System priority queueing
 - Separate unicast and multicast queueing
 - Super-framing and buffering



ASR9000 Edge Linecard Silicon Evolution



Line Cards: 3rd Generation [Tomahawk NP]

12x 100G QSFP Line Card



QSFP-100G-LR4-S



QSFP-100G-SR4-S



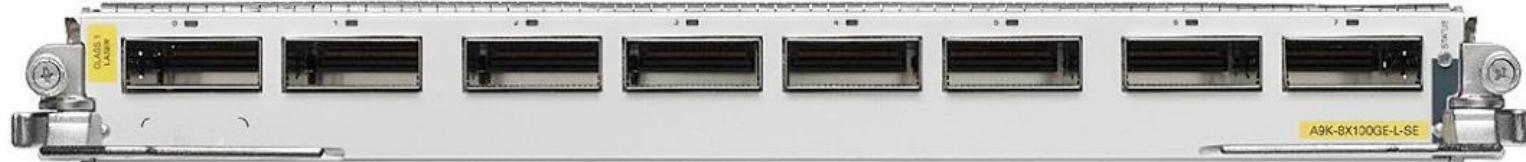
QSFP-100G-CWDM4-S



QSFP-100G-PSM4-S

Line Cards: 3rd Generation [Tomahawk NP]

8x & 4x 100G CPAK Line Cards



A9K-8X100G



A9K-4X100G



CPAK



MPO24 TO 10X DUPLEX LC SM



MPO24 TO 10X DUPLEX LC MM

Tomahawk Line Card

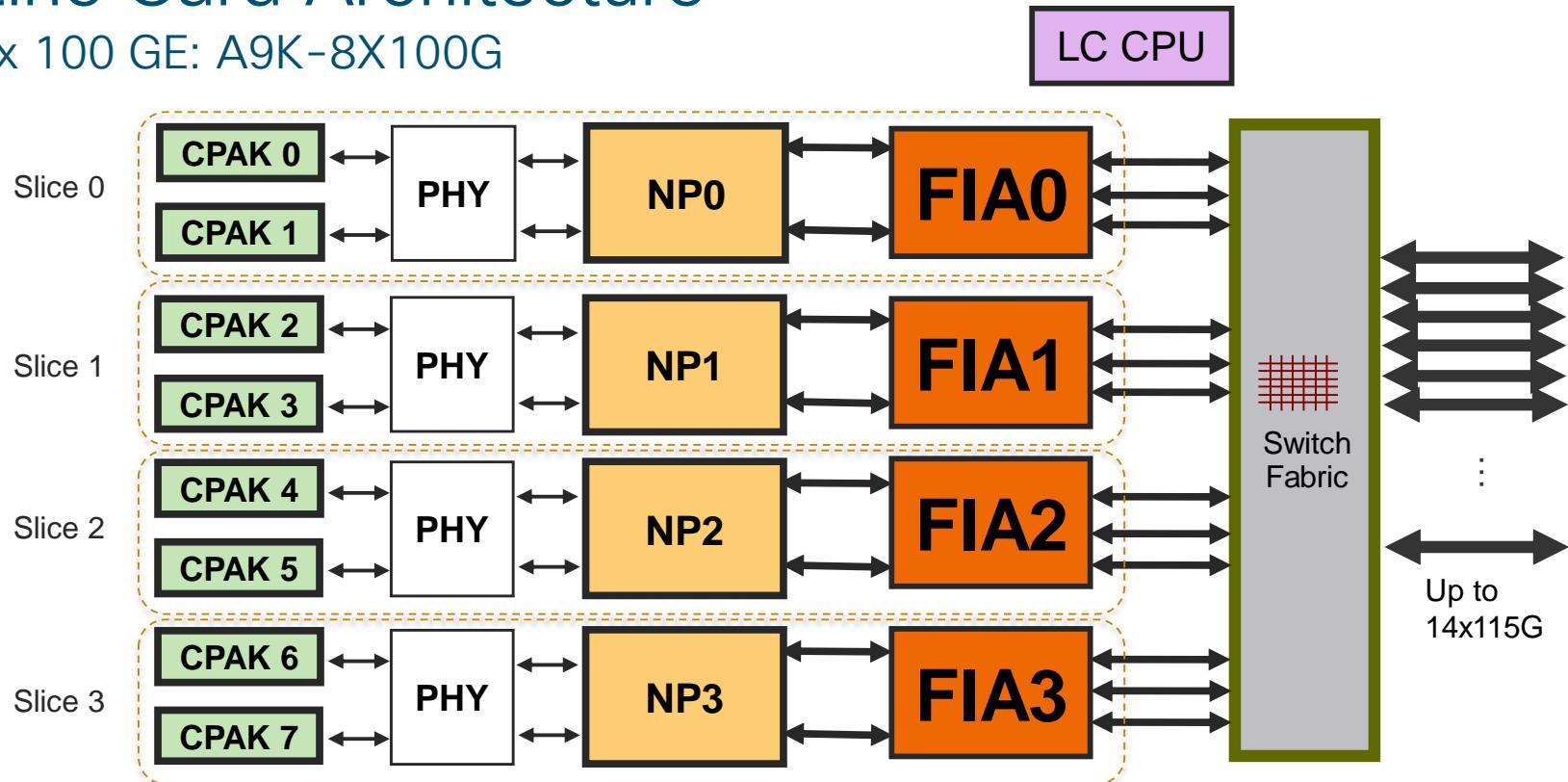
Notes on 8x 100G line card

- SE and TR versions
 - SE System Edge: More memory, scalable QoS
 - TR Transport: Basic QoS, mostly sufficient for Transport or core-facing
- CPU and memory
 - Processor: Six core processor
 - RAM: SE 24 GB – TR 12 GB
- Port breakout
 - 1x 100G or 2x 40G or 10x 10G with breakout cables (or passive panel)
`Router(config)#hw-module 0/2/cpu0 port 3 breakout 10xTenGigE`
- Power control per slice [110W/slice]
`Router(config)#hw-module power saving slice 3 location 0/2/cpu0`
- Consumption Model [CM]: Pay as you go per slice



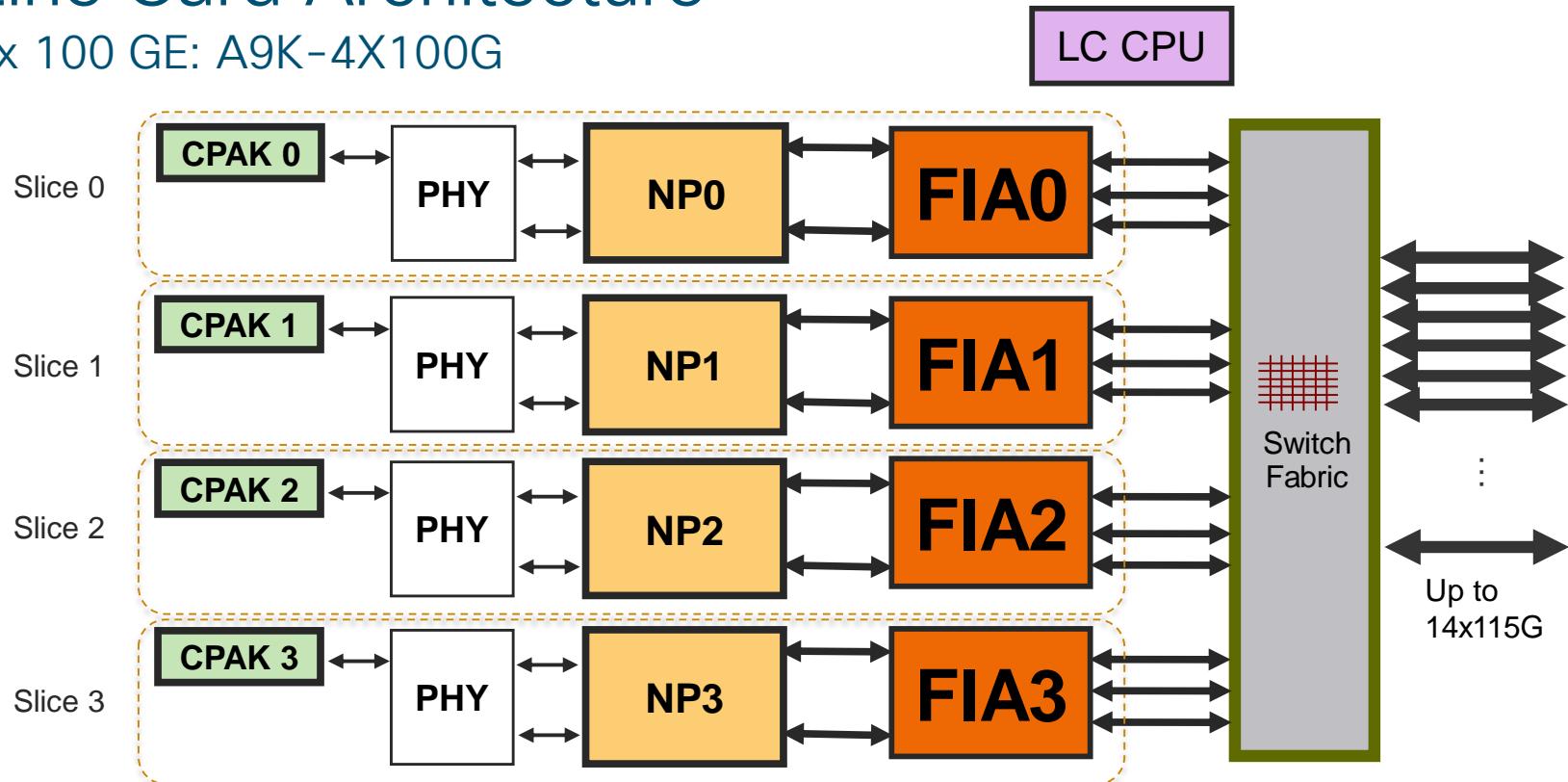
Line Card Architecture

8x 100 GE: A9K-8X100G



Line Card Architecture

4x 100 GE: A9K-4X100G



Tomahawk Interface Flexibility

Single CPAK Product ID → Three SW selectable Options

Configurable 100GE Interconnect Options for 10GE interfaces:

Interface HunGigE 0/x/y/z

Breakout Interface Convention:
Rack/Slot/Bay/Port (phy)/Breakout#

10GE Interconnect Options

hw-module 0/x/cpu0 port z breakout 10xTenGigE

Interface TenGigE 0/x/y/z/0

Interface TenGigE 0/x/y/z/1

...

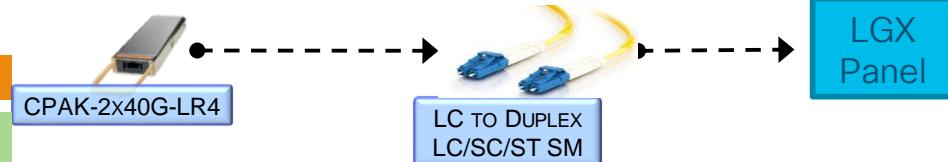
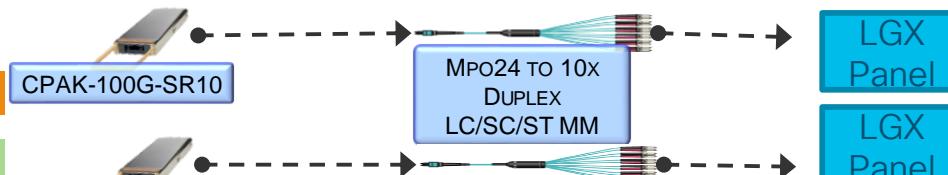
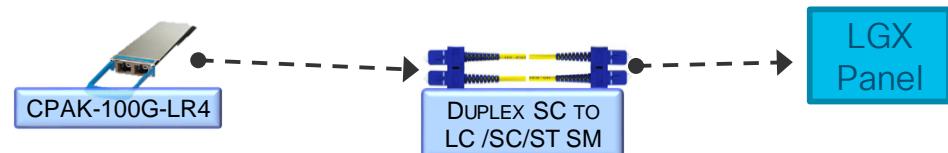
Interface TenGigE 0/x/y/z/9

40GE Interconnect Options

hw-module 0/x/cpu0 port z breakout 2xFortyGigE

Interface FortyGigE 0/x/y/z/0

Interface FortyGigE 0/x/y/z/1



Line Cards: 3rd Generation [Tomahawk NP]

Modular Line Card [2 MPA Bays]



CFP2-DCO optics

A9K-MOD400



IPoDWDM A9K-MPA-1X200GE



A9K-MPA-2X100GE



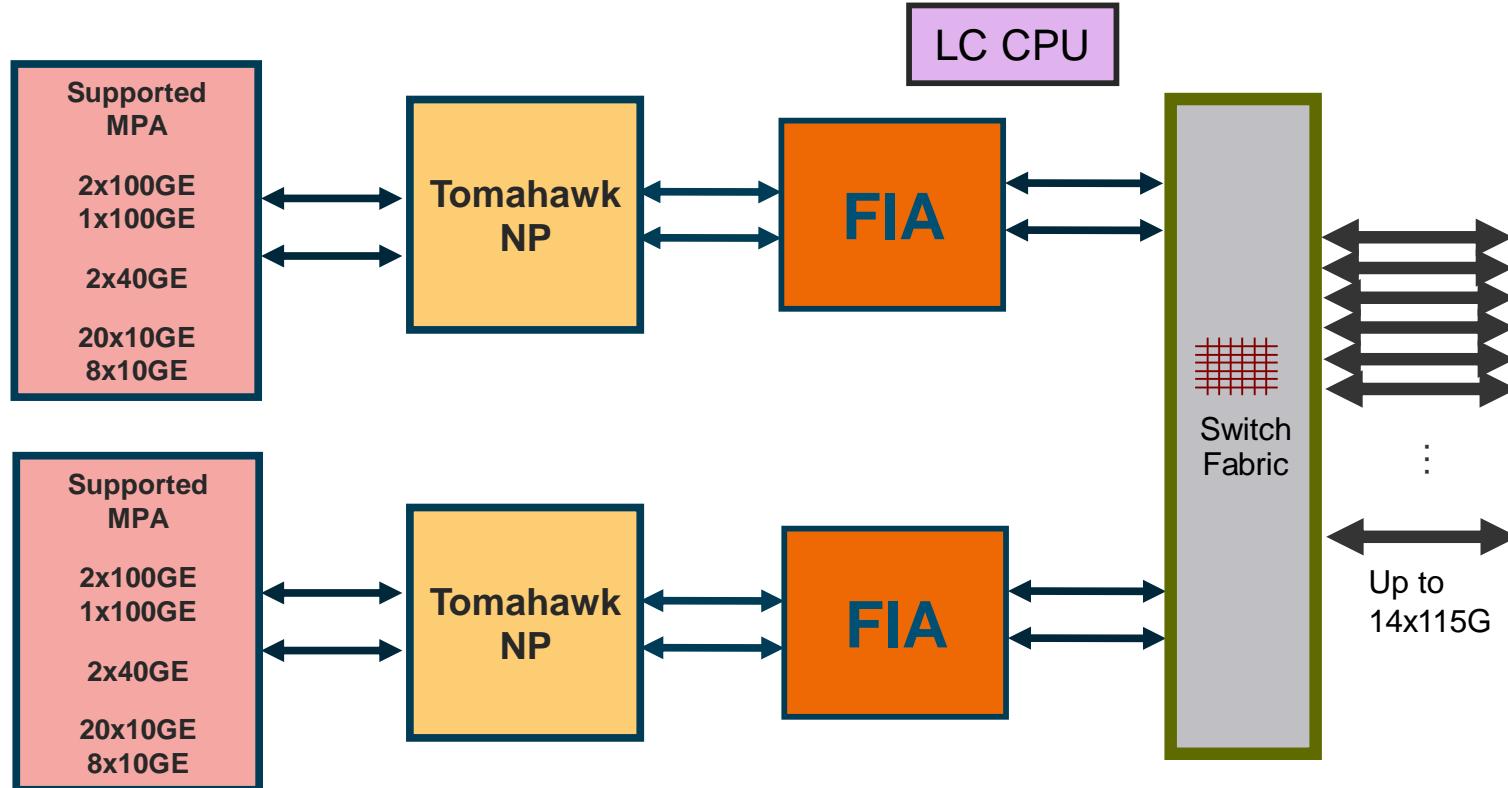
A9K-MPA-20X10GE



MPAs
20x1GE
2x10GE
4x10GE
8x10GE
1x40GE
2x40GE

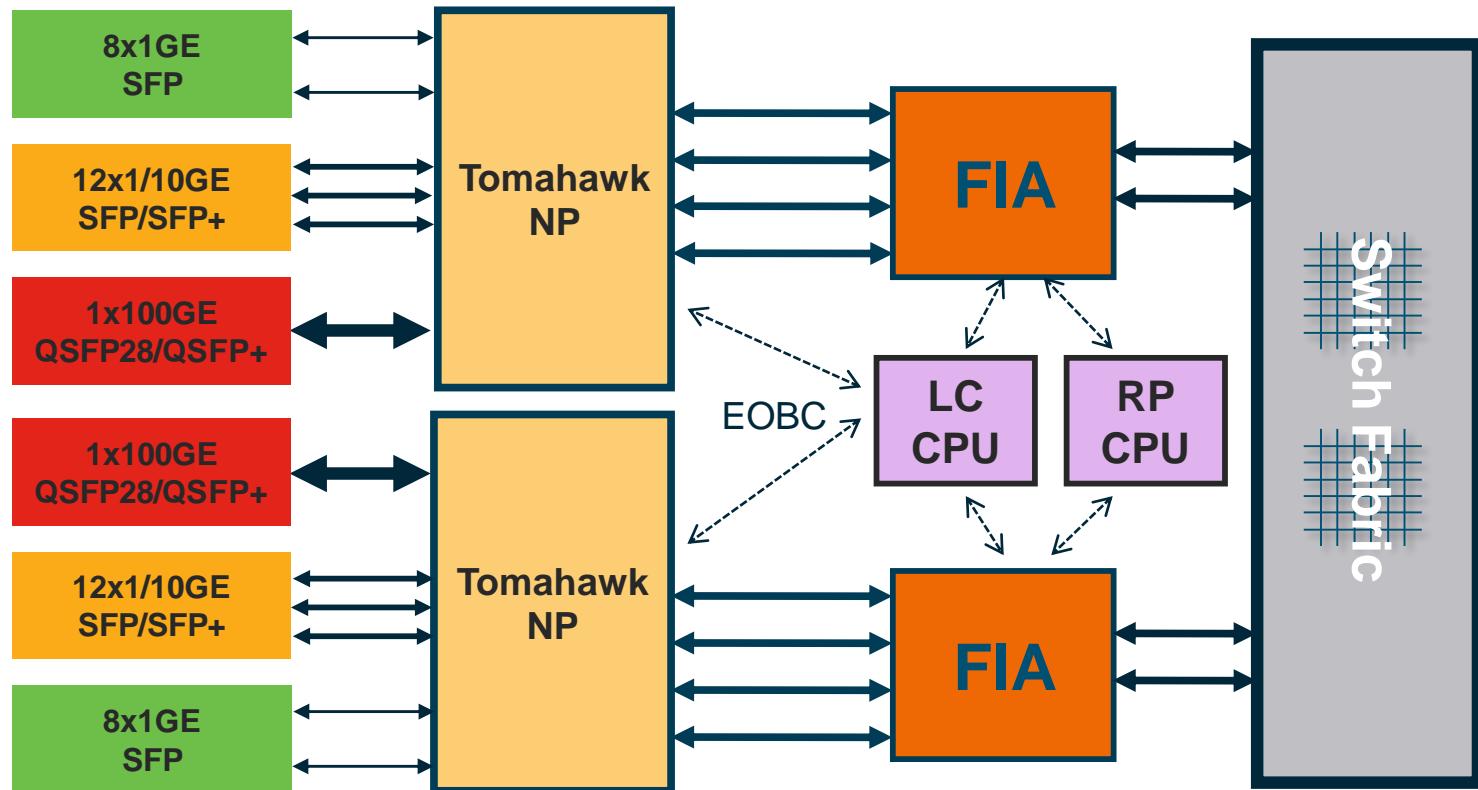
Line Card Architecture

Modular line card: A9K-MOD400-SE and A9K-MOD400-TR



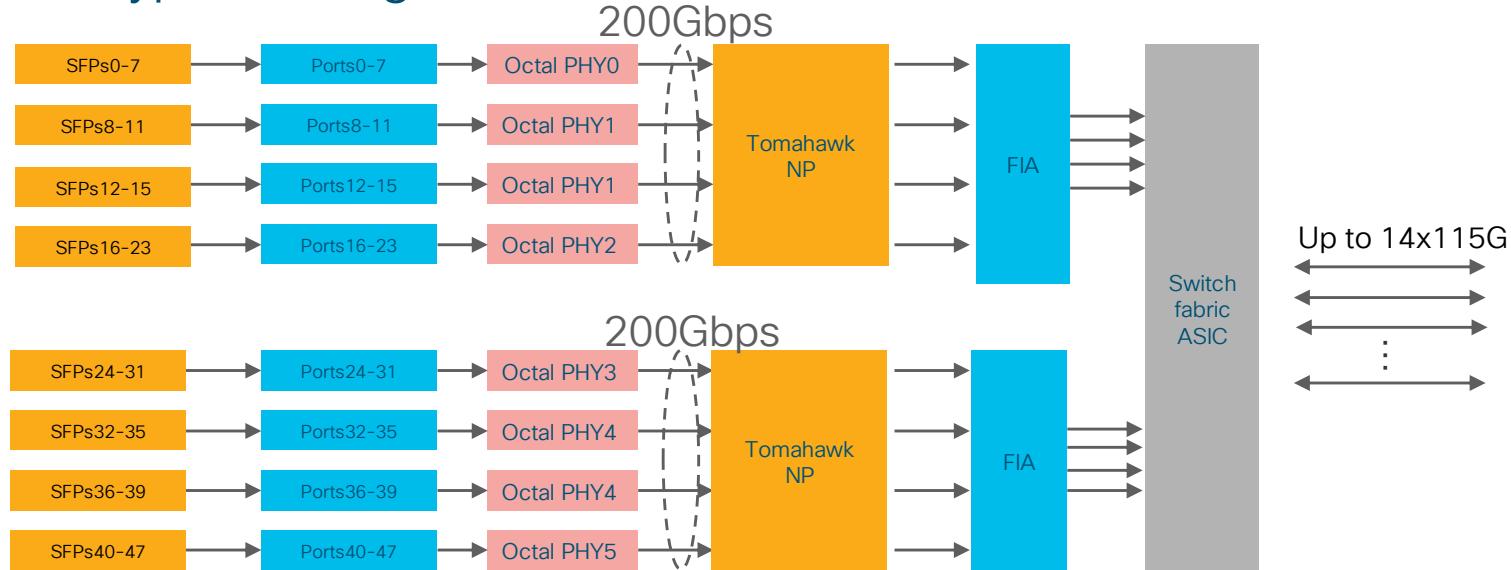
ASR 9901 Architecture

A router + LC in 2 RU



Dense 1G/10GE Dual Rate Tomahawk LCs

Trident/Typhoon migration to Tomahawk



- 24-port has a single NPU; 48-port card has two NPUs
- 200G per NPU equally across 24 ports
- Graceful capacity re-distribution across ports in case of oversubscription (Support from 6.2.2)
- No MacSec/OTN PHY features
- Equivalent TCAM size compared to Typhoon → scale parity with Typhoon

48x and 24x10G/1G Port Configuration Rules

- By default all ports are 10G
- Set of 12 ports are grouped together as follows {P0 to P11}, {P12 to P23}, {P24 to P35}, {P36 to P47}.
- 1G port configuration rule: If the first port in any set of 12 ports is configured as 1GE, then the entire group of 12 ports have to be configured as 1GE
- 10G Ports have to be configured in sets of four. Starting ports could be P0, P4, P8, P12 and so on
 - Valid examples: {P0, P1, P2, P3}, {P4, P5, P6,P7}, {P8,P9,P10,P11}.
 - Invalid examples: (P1, P2, P3, P4), {P2, P3, P4, P5} and so on.
- Port configuration command: `hw-module location <location> port-mode <string>`
 - Example: `hw-module location 0/5/CPU0 port-mode 24x10,24x1`

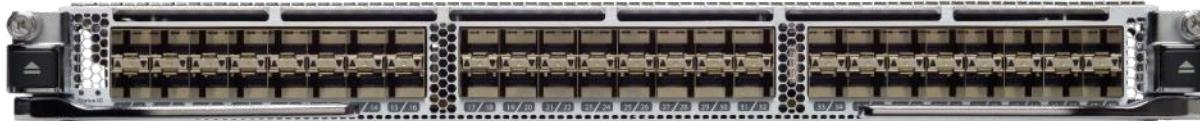
48x/24x 1G/10G Port Configuration Examples

24-port Line card

P0	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	CLI to configure ports as shown
1G	12X1,12X10																							
10G	10G	10G	10G	1G	4X10,8X1,8X10,4X1																			
10G	1G	8X10,16X1																						
10G	1G	1G	1G	1G	10G	10G	10G	10G	16X10,4X1,4X10															
10G	24X10																							

48-port Line card

P0	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P24	P25	P26	P27	P28	P29	P30	P31	P32	P33	P34	P35	P36	P37	P38	P39	P40	P41	P42	P43	P44	P45	P46	P47	CLI to configure ports as shown
1G	1G	1G	1G	1G	1G	12X1,12X10,12X1,12X10																																										
10G	10G	10G	10G	1G	1G	1G	1G	1G	1G	10G	4X10,8X1,8X10,4X1,4X1,4X10,8X1,8X10,4X1																																					
10G	24X10,24X1																																															
10G	36X1,12X10																																															
10G	48X10																																															



A99-32x100G-TR – Preparing for Zettabyte Era

Innovation

Cisco NPU 4 in 1 (16nm): Integrated NPU, PHY, FIA, Memory

Native support for 10/25/40/100/400G

Integrated 100GE FEC

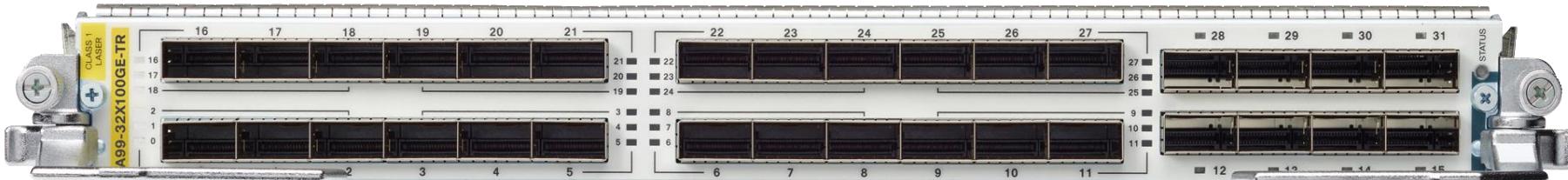
Leading the Market

4 x capacity increase per system

10GE, 40GE, 100GE and 400GE densities w/ rich features

Hitless FPD upgrade possible (no LC reload)

Sub Sec ISSU



Lower TCO

Low OPEX:

Drastically lower power profile: ~ .5W/GE

Improvement over Tomahawk w/ power down capability of the complete slice path including NP

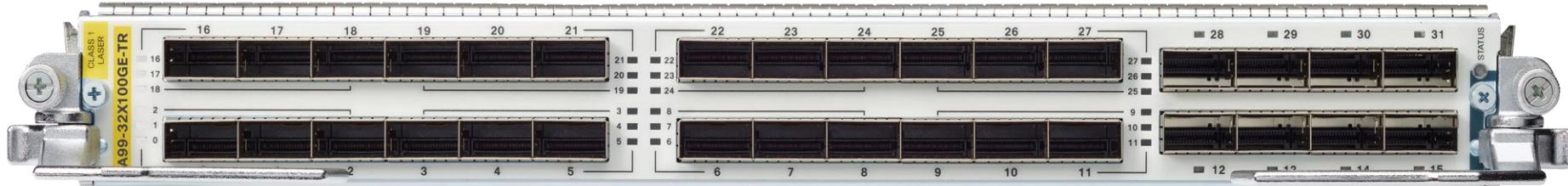
Low CAPEX - Vortex and PAYG

Scale

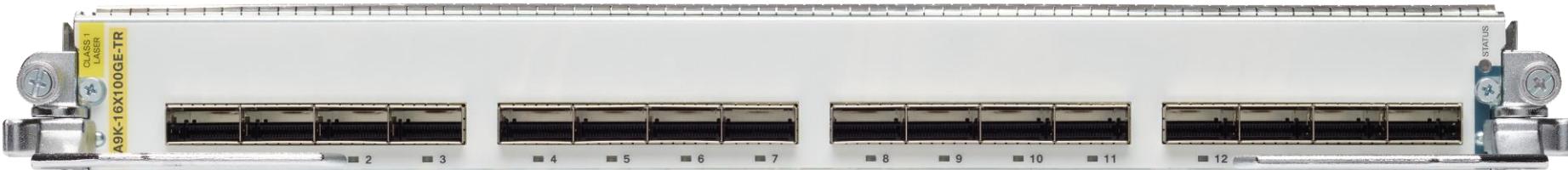
Ultra high control plane scale with eXR

HW acceleration for L2 classification, hashing, prefix lookup, ACL range compression, header re-write, flow ordering, statistics, policers, WRED

Line Cards: 4th Generation (Lightspeed)

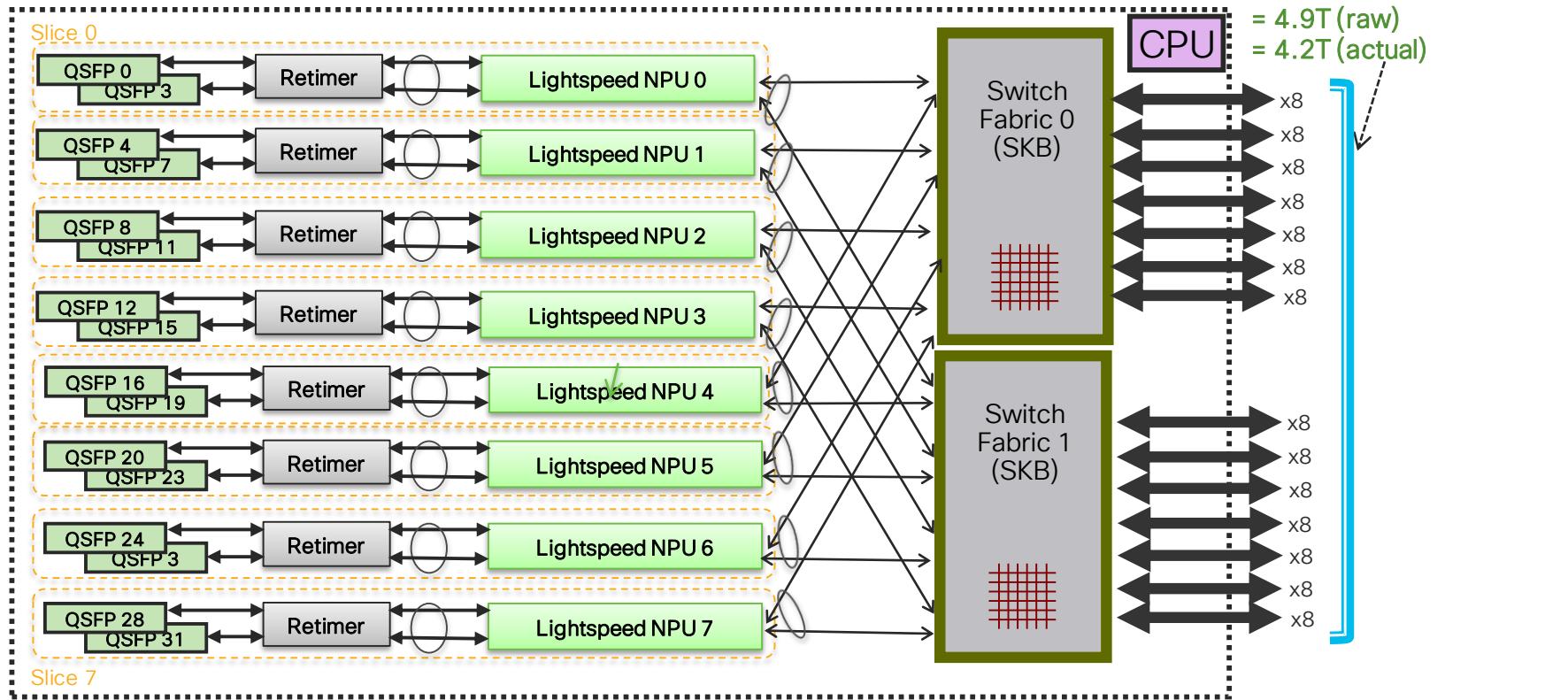


A99-32X100GE-TR



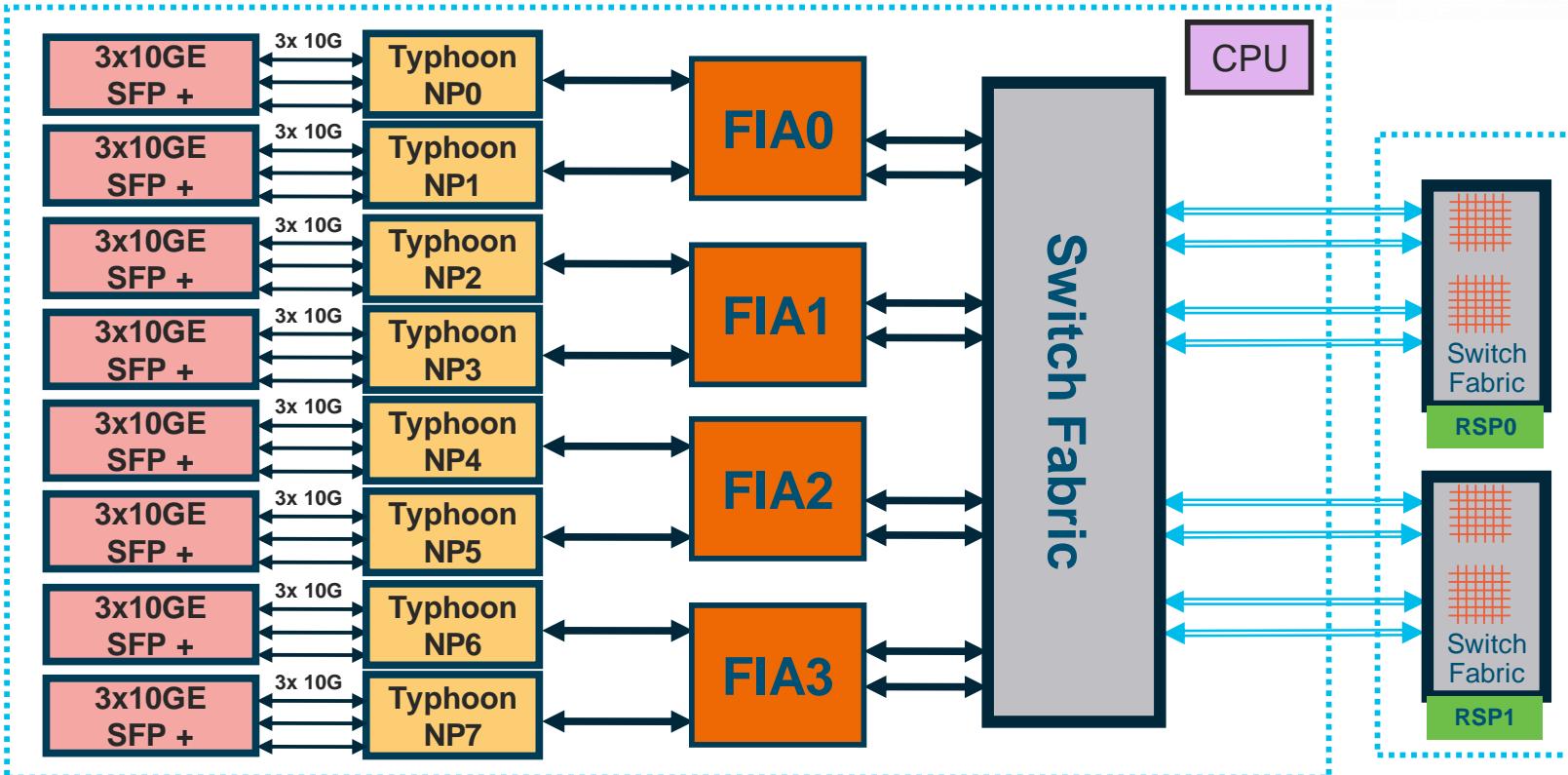
A99-16X100GE-TR

Line Cards: 4th Generation (Lightspeed)



Line Cards: 2nd Generation (Typhoon)

24x 10 GE: A9K-24X10GE-SE and A9K-24X10GE-TR



Line Cards: 2nd Generation [Typhoon NP]

Fixed Port Configuration & Modular Line Cards



A9K-24x10GE



A9K-MOD80

A9K-MOD160



A9K-36x10GE



MPAs
20x1GE
2x10GE
4x10GE
8x10GE
1x40GE
2x40GE

Line Cards: 2nd Generation [Typhoon NP]

Fixed 1GE and 1/10GE Port Configuration



A9K-40GE



A9K-4T16GR

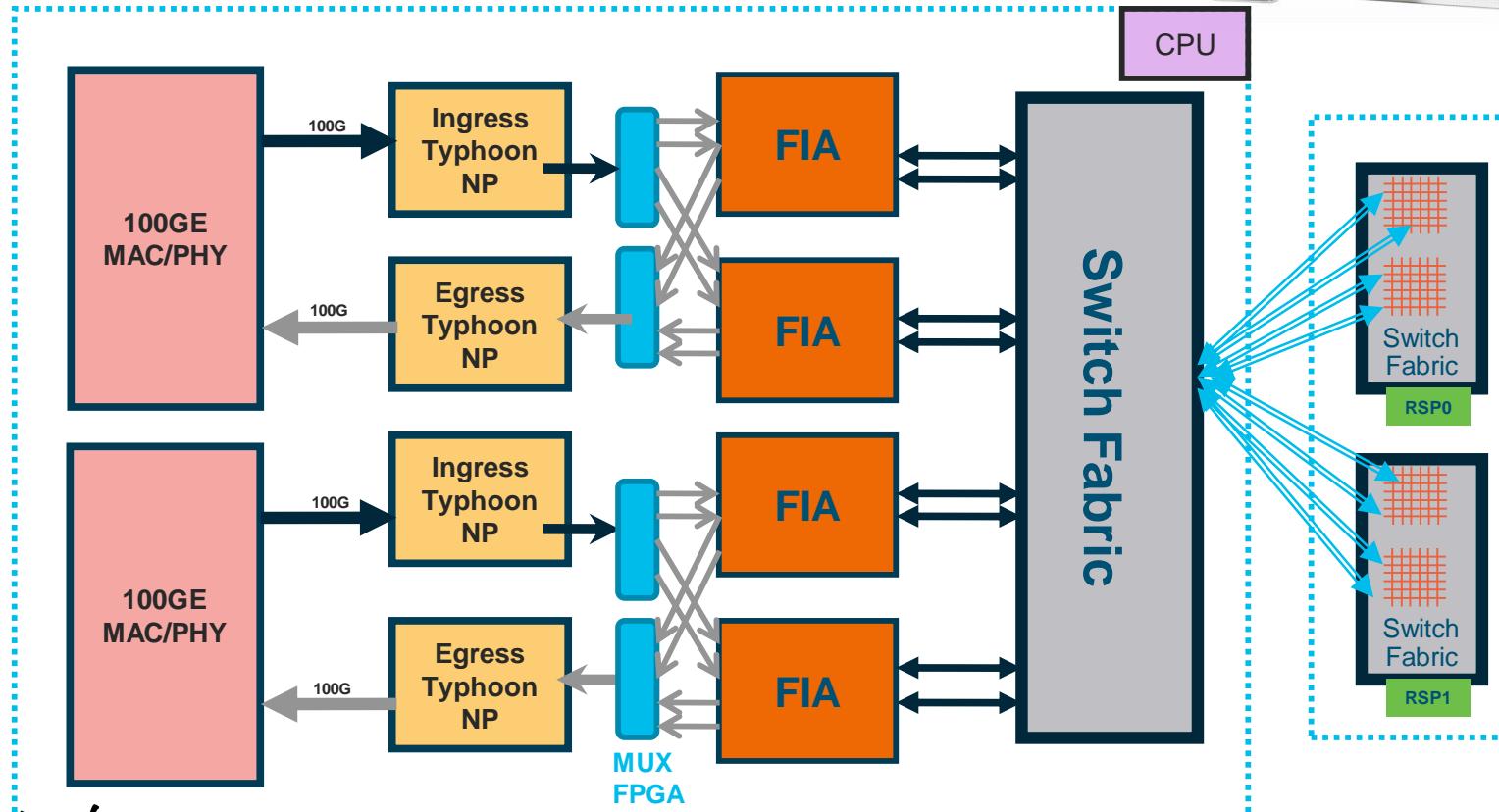
Line Cards

Notes on Tomahawk/Typhoon line cards

- SE and TR versions
 - SE System Edge: More memory, scalable QoS
 - TR Transport: Basic QoS, mostly sufficient for Transport or core-facing
- CPU and memory
 - Processor: Quad core processor
 - RAM: 8GB
- A9K-SIP-700 for TDM
 - Different architecture
 - Supports a variety of channelized and clear OC192/48/12/3 STM64/16/4/1 T3/1 E3/1

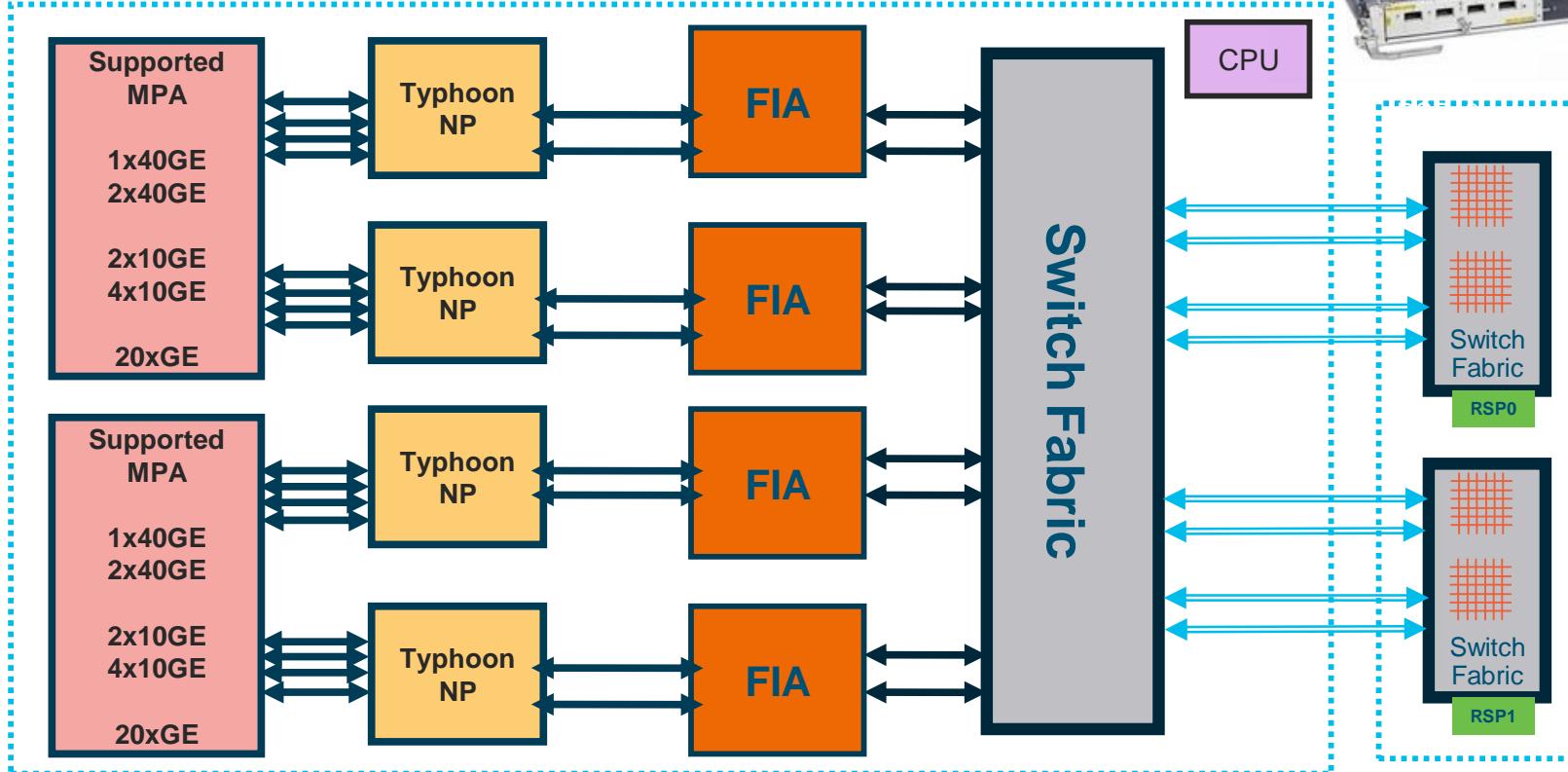
Line Card Architecture

2x 100 GE: A9K-2X100GE-SE and A9K-2X100GE-TR



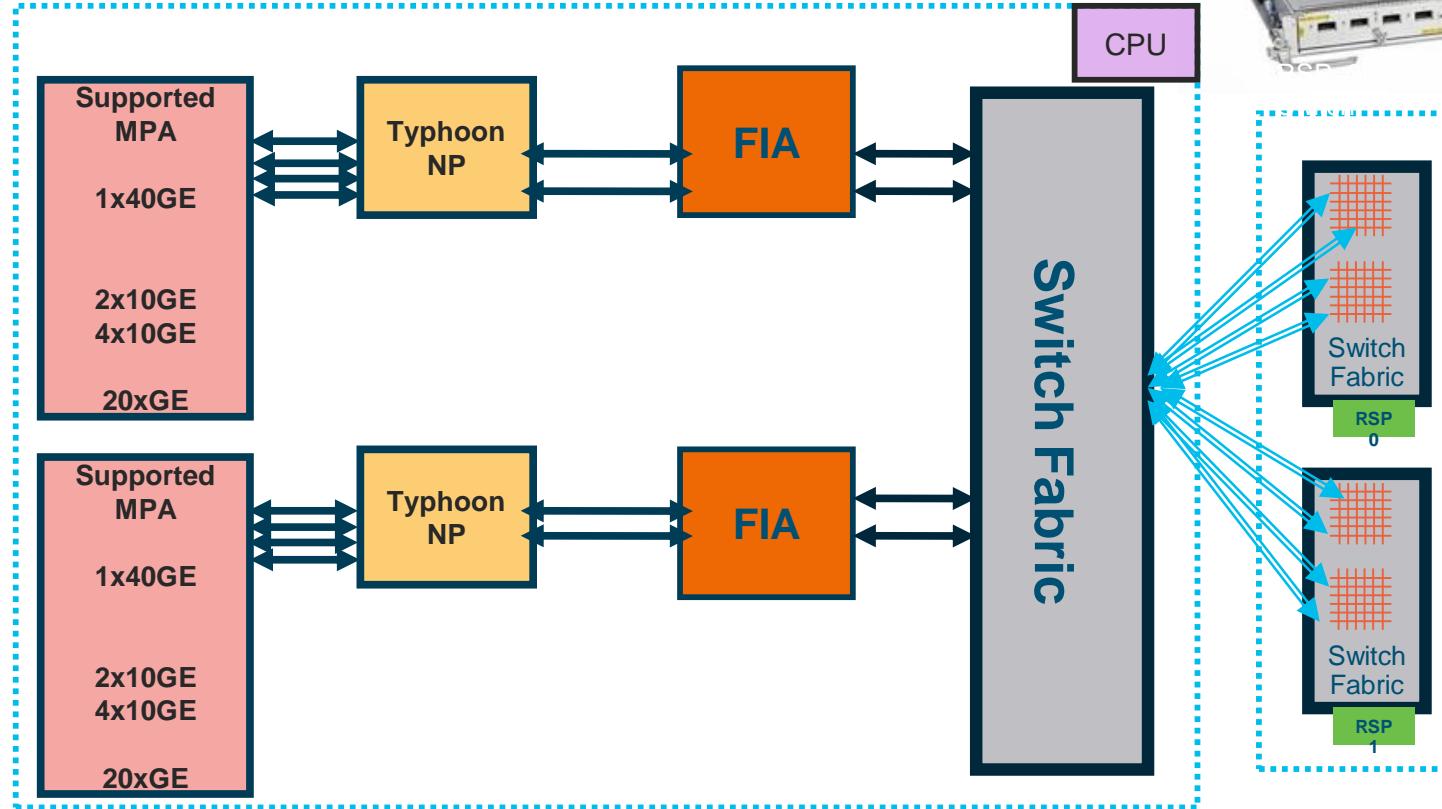
Line Card Architecture

Modular line card: A9K-MOD160-SE and A9K-MOD160-TR



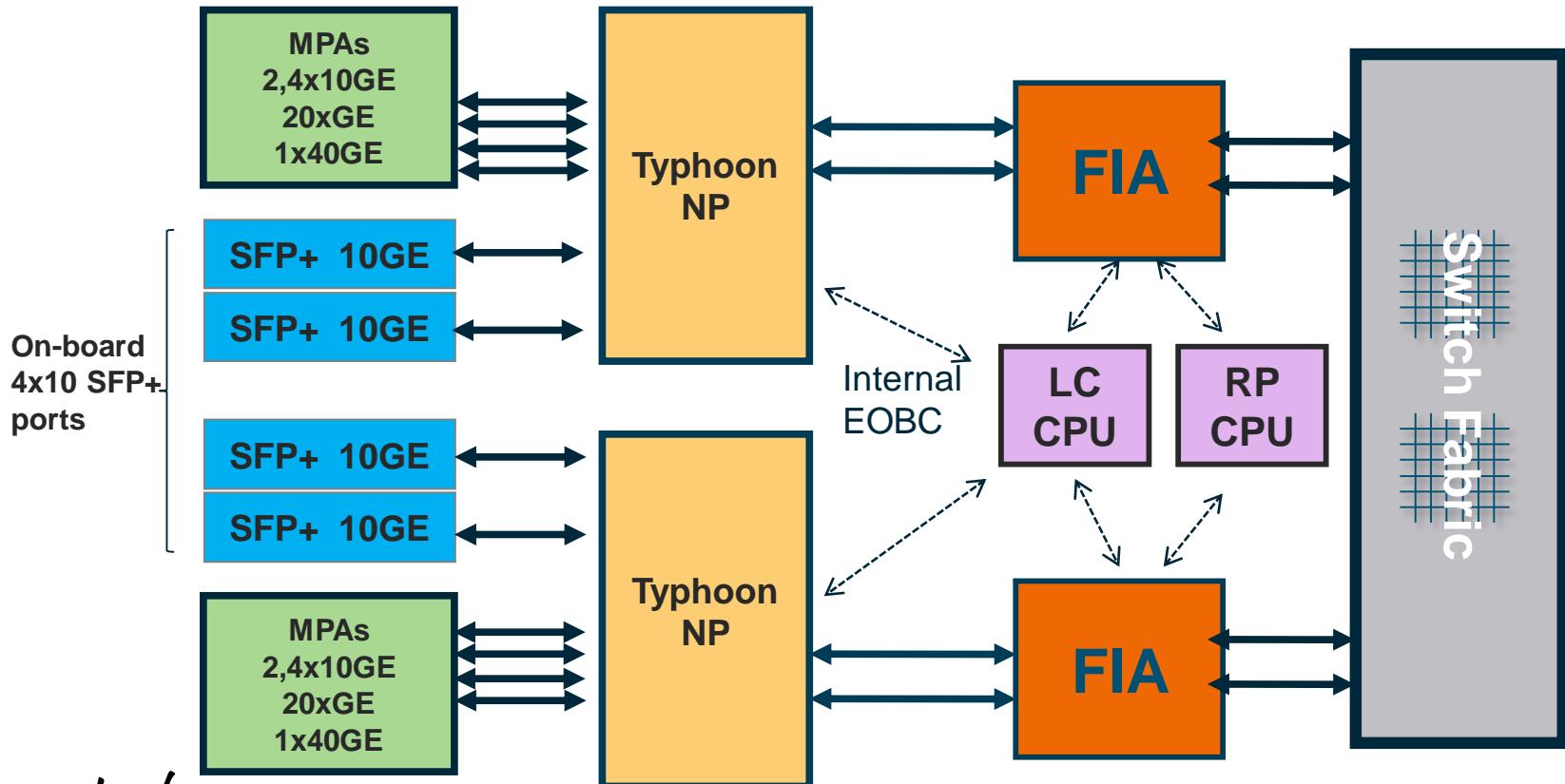
Line Card Architecture

Modular line card: A9K-MOD80-SE and A9K-MOD80-TR



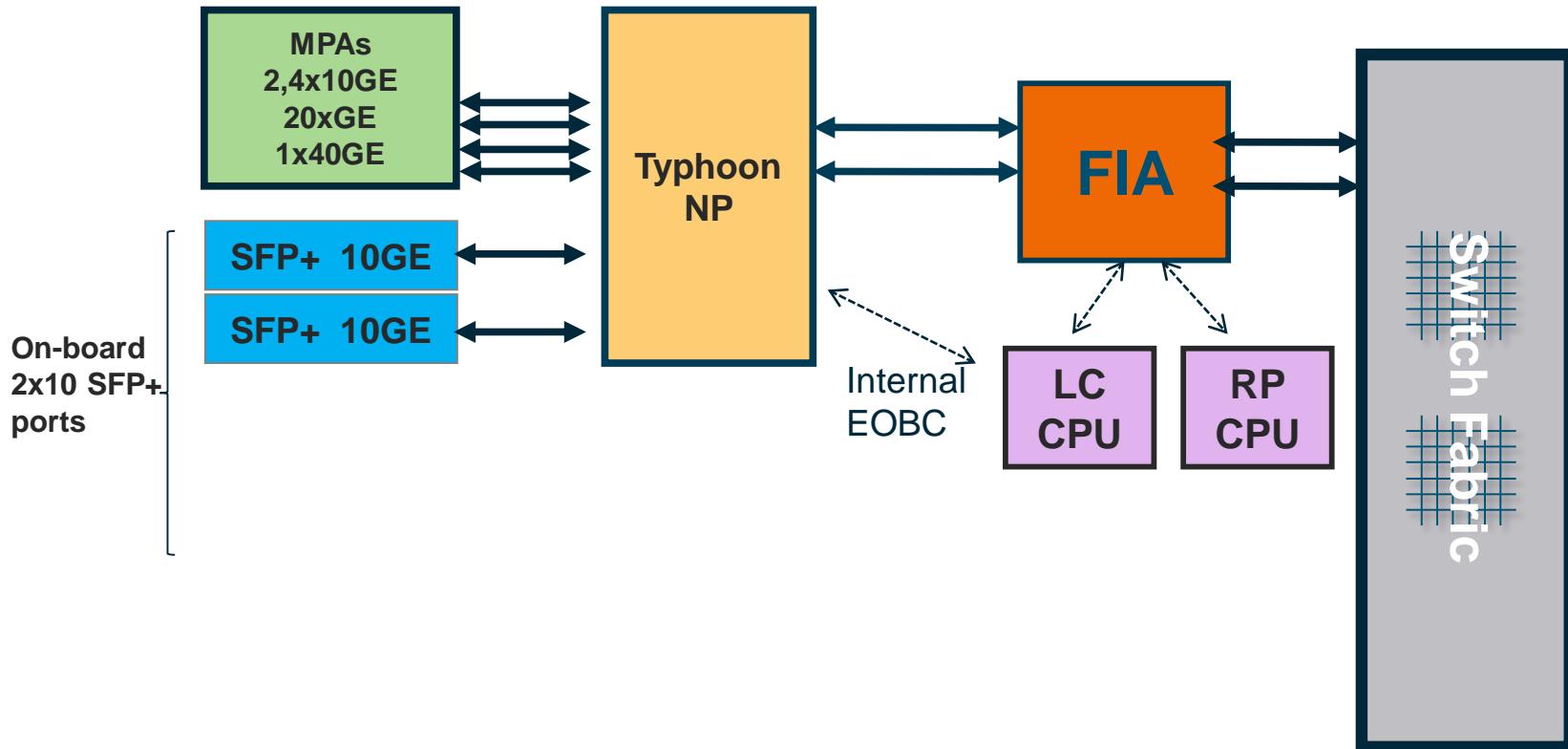
ASR 9001 Architecture

A router + LC in 2 RU



ASR 9001-S Architecture

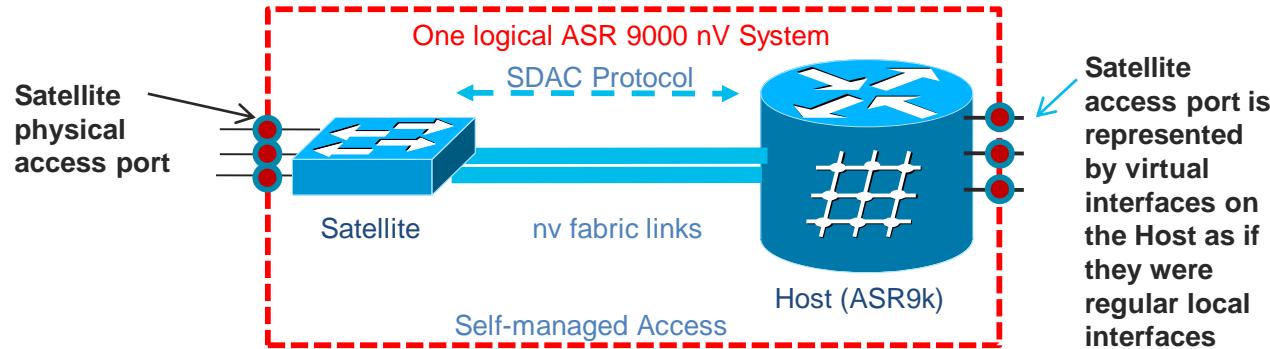
A router + LC in 2 RU





nV Satellite

nV Satellite Overview (Carrier class Virtual Chassis Fabric system)



From end user point of view, satellite looks/feels/works like a ASR9K “remote or virtual” line card. The interfaces on the satellite looks/feels/works the same as the interfaces on the local ASR9K line cards

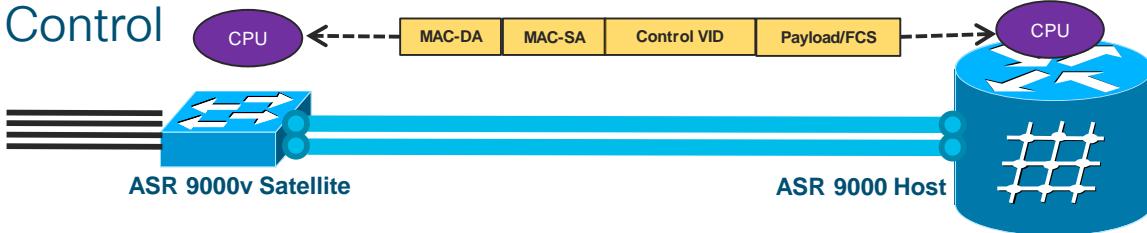
From end user point of view, Host and associated satellites is one virtual Router system.

Satellite is plug-n-play, zero touch configuration

ASR 9000v “Satellite”

Host-satellite operation: Control

- Discovery
 - Like CDP
- Heartbeat
 - One per second
- TCP control connection



```
RP/0/RSP0/CPU0:rasr9000-2w-a#show nv satellite protocol discovery interface Bundle-Ether 3 brief
Sat Dec 14 02:43:00.278 EST
Interface      Sat-ID   Status          Discovered links
-----  -----  -----
BE3           100     Satellite Ready    Te0/1/0/3, Te0/1/1/3

RP/0/RSP0/CPU0:rasr9000-2w-a#show tcp brief | include 10.100.111.100
Sat Dec 14 02:47:59.152 EST
0x1002e004 0x6000000d 0 0 10.100.111.1:17514 10.100.111.100:13680 ESTAB

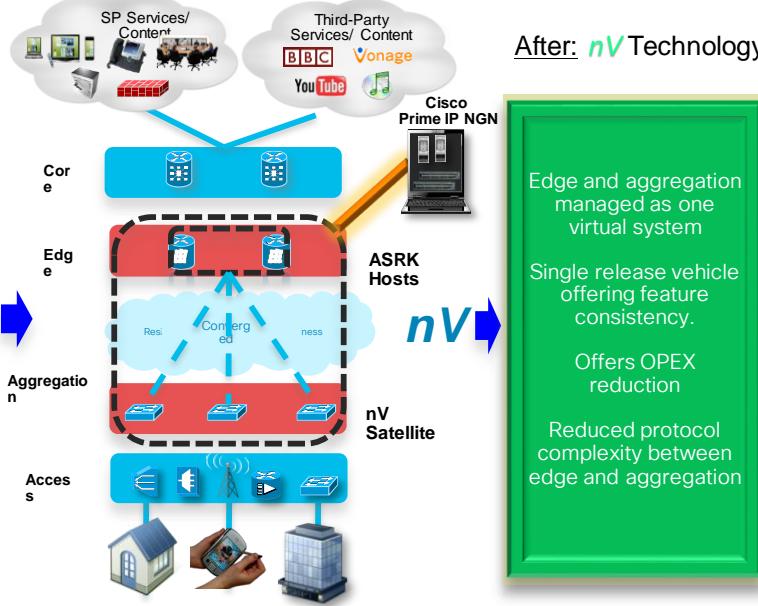
RP/0/RSP0/CPU0:rasr9000-2w-a#show nv satellite protocol control satellite 100 brief
Sat Dec 14 02:48:36.020 EST
Sat-ID  IP Address  Protocol state  Channels
-----  -----
100    10.100.111.100  Connected      Ctrl, If-Ext L1, If-Ext L2, X-link,
                                         VICL, Soft Reset, Inventory,
                                         EnvMon, Alarm, Platform

RP/0/RSP0/CPU0:rasr9000-2w-a# show nv satellite status satellite 100 brief
Sat Dec 14 02:59:56.752 EST
Sat-ID  Type       IP Address  MAC address  State
-----  -----
100    asr9000v  10.100.111.100  8478.ac01.349c  Connected (Stable)
```

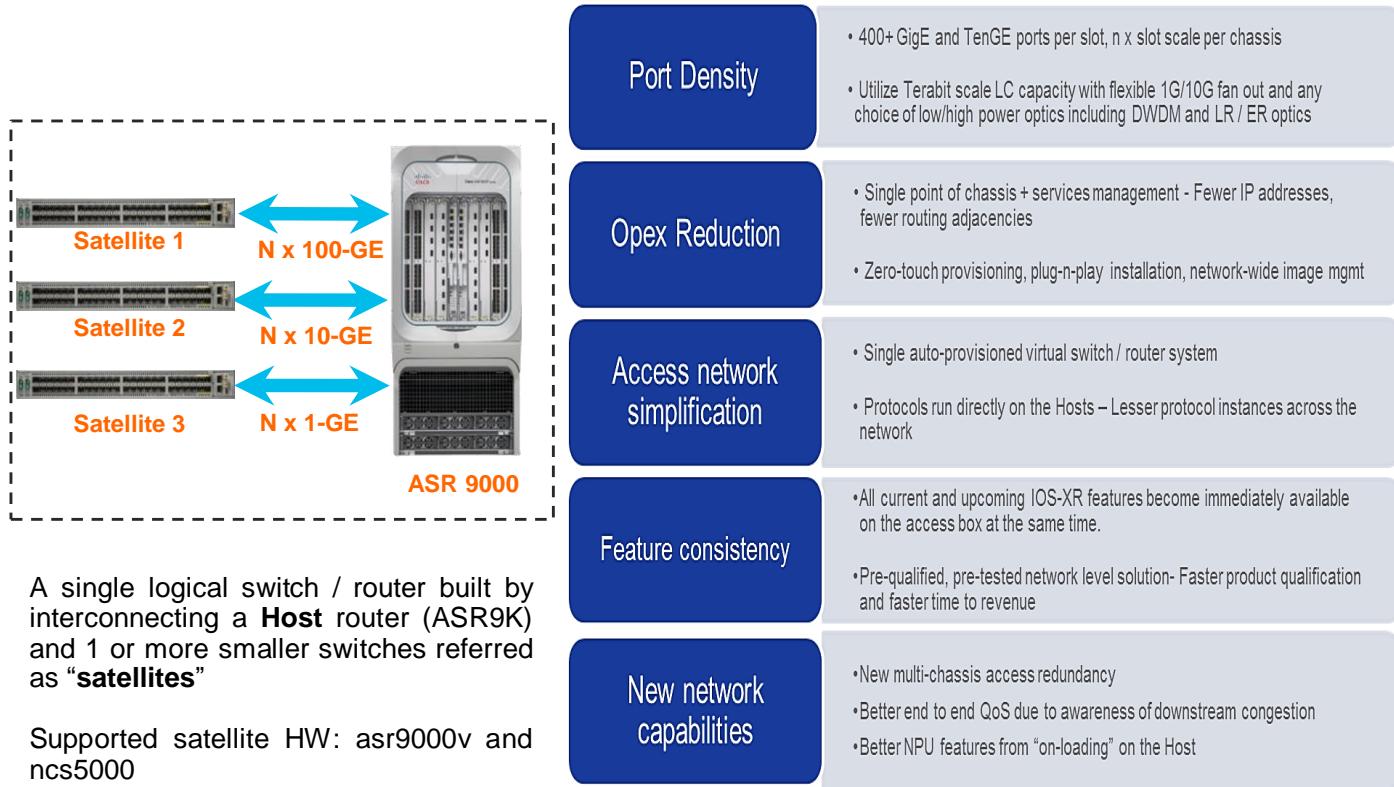
ASR 9000 nV Technology Overview

Before: nV Technology

Each device managed separately.
Inconsistent features between edge and aggregation.
Inconsistent service outages upon device failure.
Port scale limited to chassis.



The nV Satellite solution



ASR 9000v “Satellite”

Configuration view

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show running-config
```

```
vrf NV-MGMT  
description NV SATELLITE MANAGEMENT  
address-family ipv4 unicast
```

```
!
```

```
control-plane  
management-plane  
inband  
interface Bundle-Ether3  
allow TFTP
```

```
interface Bundle-Ether3  
vrf NV-MGMT  
ipv4 point-to-point  
ipv4 unnumbered Loopback100
```

```
nv
```

```
satellite-fabric-link satellite 100  
remote-ports GigabitEthernet 0/0/0-29
```

```
interface Loopback100  
vrf NV-MGMT  
ipv4 address 10.100.111.1 255.255.255.0
```

Satellite control VRF [optional]

Allow TFTP for satellite upgrade

The host-satellite bundle (ICL)

Host control/TCP address [optional]

```
interface GigabitEthernet100/0/0/9  
mtu 4484  
service-policy input DSCP  
service-policy output DSCP  
vrf TRAFFIC  
ipv4 address 192.10.1.1 255.255.255.0  
negotiation auto
```

```
!
```

```
interface TenGigE0/1/0/3  
description ASR9000v  
bundle id 3 mode on
```

```
!
```

```
interface TenGigE0/1/1/3  
description ASR9000v  
bundle id 3 mode on
```

```
!
```

```
nv  
satellite 100  
type asr9000v  
serial-number CAT1702U20H  
description r9000v-1y-a  
ipv4 address 10.100.111.100
```

```
!
```

```
.
```

Sample satellite interface config

Host-satellite bundle links

Satellite control configuration

nV Satellite: Monitoring & troubleshooting



You make multi-cloud **possible**

Monitoring: Basic status check

```
RP/0/RSP0/CPU0:TARDIS# show nv satellite status brief
```

Sat-ID	Type	IP Address	MAC address	State
100	ncs5002	10.0.100.1	c472.95a6.2003	Connected

```
RP/0/RSP0/CPU0:TARDIS# show nv satellite status satellite 100
```

```
-----
```

```
Satellite 100
```

```
-----
```

```
Status: Connected (Stable)
```

```
Type: ncs5002
```

```
MAC address: c472.95a6.2003
```

```
IPv4 address: 10.0.100.1 (auto, VRF: **nVSatellite)
```

```
Serial Number: FOC1920R0V7
```

```
Remote version: Compatibility Unknown (no local version)
```

```
FPGA: 1.0
```

```
XR: 600.1
```

```
Received candidate fabric ports:
```

```
None (channel down)
```

```
Configured satellite fabric links:
```

```
HundredGigE0/1/0/0
```

```
-----
```

```
Status: Satellite Ready
```

```
Remote ports: TenGigE0/0/4-79
```

Monitoring: Discovery protocol status check

```
RP/0/RSP0/CPU0:TARDIS# show nv satellite protocol discovery brief
Interface      Sat-ID Status          Discovered links
-----
Hu0/1/0/0       100   Satellite ready
Hu0/1/0/1       100   Satellite ready
Hu0/1/0/0
Hu0/1/0/1
```

```
RP/0/RSP0/CPU0:TARDIS#show nv satellite protocol discovery interface HundredGigE 0/1/0/0
Interface HundredGigE0/1/0/0
-----
Interface Status: Probing for satellites

Satellite ID: 100
Status: Satellite ready
Host IPv4 Address: 100.100.100.101
Satellite IPv4 Address: 100.100.100.100
Vendor: 1.3.6.1.4.1.9.12.3.1.3.1705,
Serial Id: FOC1920R0V7
Remote ID: 50331907
Remote MAC address: c472.95a6.2056
Chassis MAC address: c472.95a6.2003
```

Monitoring: Control protocol status check

```
RP/0/RSP0/CPU0:TARDIS#sh nv satellite protocol control brief
Sat-ID  IP Address      Protocol state  Channels
-----  -----
100    100.100.100.100  Connected        Ctrl, If-Ext L1, If-Ext L2, X-link,
                                         VICL, DevMgmt, Inventory, EnvMon,
                                         Alarm, Password, Topology,
RP/0/RSP0/CPU0:TARDIS#sh nv satellite protocol control
Satellite 100
-----
Status: Connected since 2015/10/28 16:11:35.930
IP address: 100.100.100.100 (VRF: default)
Channels:
  Control (0)
-----
  Channel status: Open
  Messages sent: 15 (15 control), received: 14 (14 control)
  Version: 0

Interface Extension Layer 1 (1)
-----
  Channel status: Open
  Messages sent: 7 (5 control), received: 459 (3 control)
  Version: 0

Interface Extension Layer 2 (2)
-----
  Channel status: Open
  Messages sent: 15 (5 control), received: 615 (3 control)
  Version: 0
```

Monitoring: Check Satellite Inventory

```
RP/0/RSP0/CPU0:TARDIS(admin)#show inventory
...
NAME: "fantray SAT100/FT0/SP", DESCRIPTOR: "Cisco NCS 5002 Series Router Fan Back"
PID: NCS-5002-FN-BK, VID: N/A, SN: N/A

NAME: "fantray SAT100/FT1/SP", DESCRIPTOR: "Cisco NCS 5002 Series Router Fan Back"
PID: NCS-5002-FN-BK, VID: N/A, SN: N/A

NAME: "power-module SAT100/PM0/SP", DESCRIPTOR: "Cisco NCS 5000 Series Router power AC 650W Back"
PID: NC5K-PAC-650W-BK=, VID: V01, SN: LIT1919198Z

NAME: "power-module SAT100/PM1/SP", DESCRIPTOR: "Cisco NCS 5000 Series Router power AC 650W Back"
PID: NC5K-PAC-650W-BK=, VID: V01, SN: LIT1919199H

NAME: "Satellite Chassis NCS5002 ID 100", DESCRIPTOR: "80-Port 10 GE + 4-Port 100GE NCS5002 Chassis"
PID: NCS-5002, VID: V00, SN: FOC1920R0V7
```

Satellite chassis, fan tray,
power module, optics included within
normal ASR9K inventory reports

```
RP/0/RSP0/CPU0:TARDIS(admin)#show inventory rack
Rack          Chassis PID      S/N
---          -----
0             ASR-9904-AC    FOX1739G94Y
100            NCS-5002     FOC1920R0V7
```

Each satellite appears as
a new rack within the ASR9K
Inventory (rack # -> satellite ID)

Debugging on the satellite (When all else fails ... telnet into the satellite)

In rare cases, when all else fails, you may need to telnet in-band into the satellite for debug. Note that, if discovery and IP connectivity is the issue under debug, then a direct console may be needed to the NCS 5002 device. Once in, the satellite will show normal XR console. Only "basic" show commands should be used here to avoid conflicts with nV host driven state and XR config mode is blocked.

```
RP/0/RSP0/CPU0:TARDIS#telnet vrf **nVSatellite 10.0.100.1
Trying 10.0.100.1...
Connected to 10.0.100.1.
Escape sequence is '^q'.
User Access Verification
Username: root
Password:
RP/0/RP0/CPU0:Satellite#
RP/0/RP0/CPU0:Satellite#show ipv4 interface brief | i Hundred
Thu Oct 29 03:52:47.798 UTC
HundredGigE0/0/1/0      unassigned     Down        Down
HundredGigE0/0/1/1      unassigned     Down        Down
HundredGigE0/0/1/2      10.0.100.1   Up         Up
```

ICL on the satellite side with the IP inherited from unnumbered association to a loopback interface

Direct in-band telnet from ASR9K
IOS-XR prompt to satellite
assigned IP address
("telnet satellite <n>" also supported)

Now use "XR" show
Commands on the satellite

Debug scenarios – On NCS5k satellite

```
RP/0/RP0/CPU0:Satellite#show sdac protocol discovery
```

```
Thu Oct 29 04:15:33.383 UTC
```

```
Interface HundredGigE0/0/1/2
```

```
-----  
Status: Discovered  
Satellite IPv4 Address: 10.0.100.1  
Host IPv4 Address: 10.0.0.1  
Vendor: Cisco System Inc  
Remote ID: 1216  
Remote MAC address: 001d.e5e9.2a4c  
Chassis MAC address: e4c7.223f.0ba6
```

Check the satellite's view of SDAC discovery and control State machines



```
RP/0/RP0/CPU0:Satellite#show sdac protocol control
```

```
Thu Oct 29 04:16:54.775 UTC
```

```
Host: e4c7.223f.0ba6
```



```
-----  
Status: Connected since 03:42:02.513 UTC Thu Oct 29 2015
```

```
IP address: 10.0.0.1
```

```
Channels:
```

```
-----  
  Interface Extension Layer 1 (1)
```

```
-----  
    Channel status: Open
```

```
    Messages sent: 55293 (199 control), received: 2169 (300 control).
```

```
.....
```

Debug scenarios - On NCS5k satellite

```
RP/0/RP0/CPU0:Satellite#show sdac internal intf-mode  
Thu Oct 29 04:19:32.987 UTC
```

Interface Modes:

Interface	Poss Acc Port	Act Acc Port	Poss ICL	Act ICL
Hu0/0/1/0	N	N	Y	N
Hu0/0/1/1	N	N	Y	N
Hu0/0/1/2	N	N	Y	Y
Hu0/0/1/3	N	N	Y	N
Te0/0/0/0	Y	N	N	N
Te0/0/0/1	Y	N	N	N
Te0/0/0/10	Y	Y	N	N

Show mapping mode per interface
Indicates which is Active ICL ,
active access port etc

```
RP/0/RP0/CPU0:Satellite#show 12vpn xconnect
```

Thu Oct 29 04:25:53.018 UTC

Legend: ST = State, UP = Up, DN = Down, AD = Admin Down, UR = Unresolved,
SB = Standby, SR = Standby Ready, (PP) = Partially Programmed

XConnect Group	Name	Segment 1		Segment 2	
		ST	Description	ST	Description
2_6	2_6	UP	Te0/0/0/4	UP	Hu0/0/1/2.6

Show mapping from satellite
Front ports to ICL port

Here access port is Te0/0/0/4 which is mapped to ICL Hu0/0/1/2. 6 is the internal sat
vlan that is added to switch the packets between satellite and host.

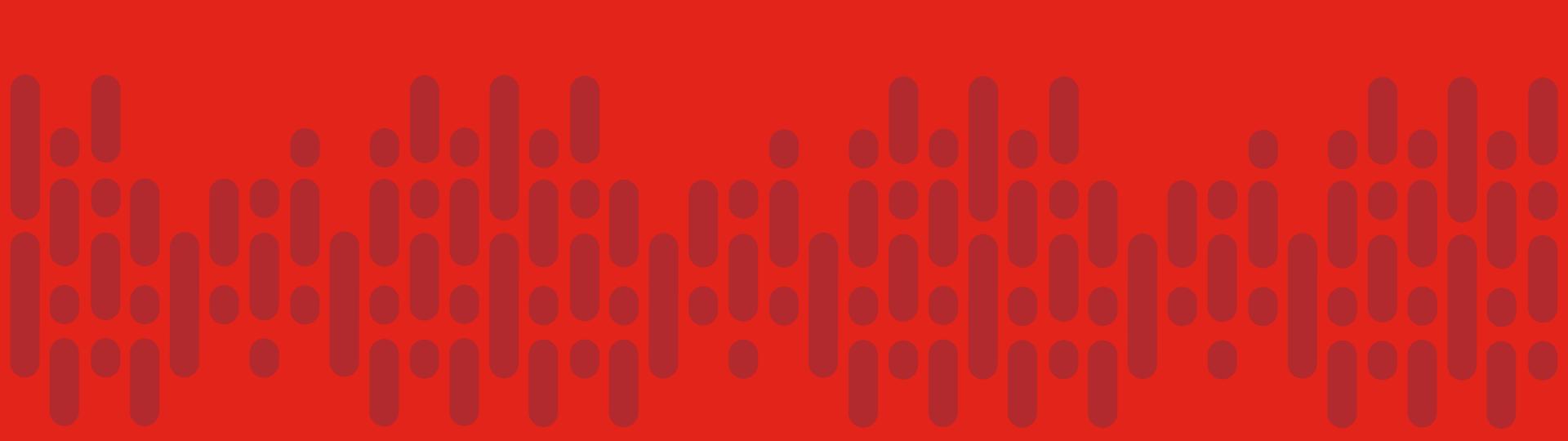
Agenda

- ✓ **System Architecture:** System anatomy and health
- **Operating System & Configuration:** IOS-XR & configuration models
- **Control, Management, & Security:** Processing of control & exceptions
- **Transit Packet/Frame Journey:** Life of L3/L2 unicast/multicast
- **MPLS Operation:** Processing, forwarding and L3/L2 service operation
- **Troubleshooting:** Diagnostics, counters, drops, and packet capture

2 Operating System & Configuration



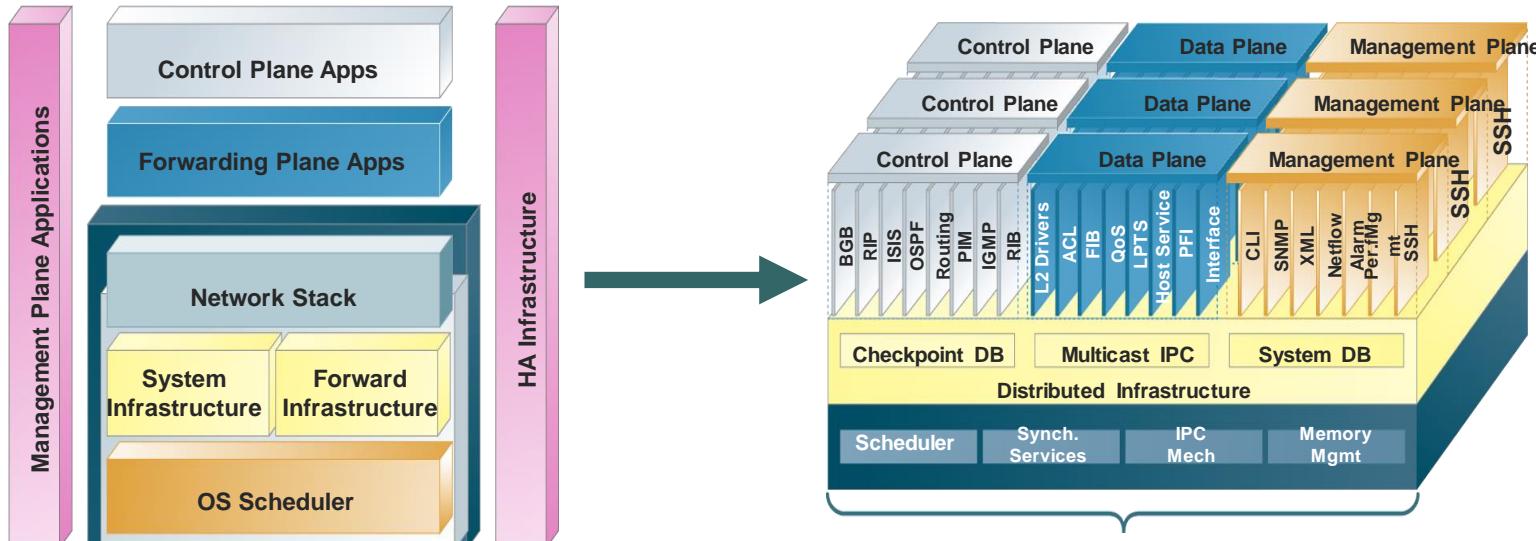
You make the power of data **possible**

A decorative header element consisting of a repeating pattern of red and dark red vertical bars and dots, resembling a stylized barcode or a series of signal bars.

IOS-XR Architecture

From IOS to IOS-XR

From monolithic to micro-kernel



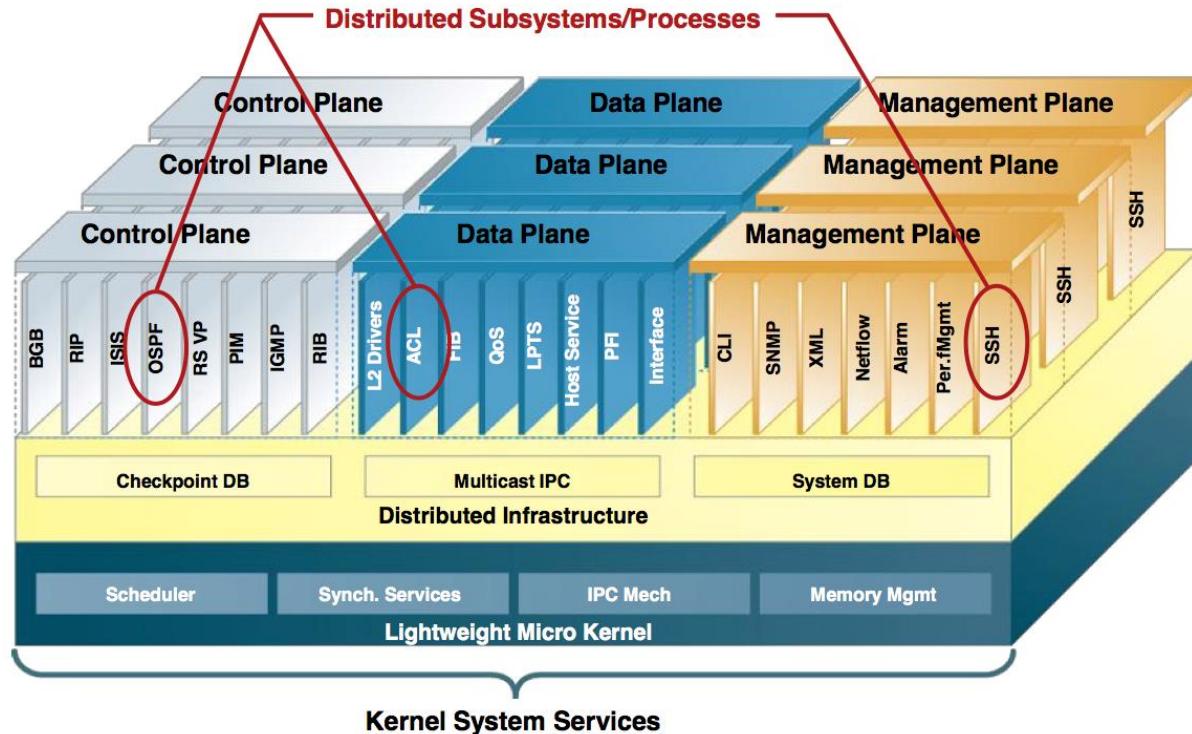
- Monolithic Kernel
- Centralized Infrastructure
- Centralized applications

- Micro Kernel
- Distributed Infrastructure
- Distributed applications

IOS-XR Operating System

Kernel and distributed processes

- Micro-kernel
 - QNX kernel
- Restartable processes
 - A process may start/terminate based on configuration
 - Scheduler keeps track of process starts/spawning/priority /path
 - A process can crash/restart/patched
- Distributed processing
 - Processes run on RP and LC CPU's



IOS-XR Operating System

Kernel and distributed processes

- Process instances

- On RSP (e.g. BGP), LC (e.g. ARP, IGMP), or both
- Mandatory or configuration-dependent (e.g. OSPF)

- Restartable

- Means also patchable!

```
RP/0/RSP0/CPU0:rasr9000-2w-b#run uname -a
Thu Nov 21 12:07:01.637 EST
QNX node0_RSP0_CPU0 6.4.0 2012/07/25-07:54:16PDT asr9k-rsp x86

RP/0/RSP0/CPU0:rasr9000-2w-b#show processes location 0/RSP0/CPU0
Thu Nov 21 12:13:37.588 EST
JID    TID CPU Stack pri state      TimeInState   HR:MM:SS:MSEC  NAME
1      1   0   OK  0  Running     0:00:00:0000  25:25:11:0433  procnto-smp-instr
1      2   1   OK  0  Running     0:00:00:0000  25:22:47:0535  procnto-smp-instr
1      3   2   OK  0  Running     0:00:00:0000  25:19:47:0529  procnto-smp-instr
1      4   3   OK  0  Ready       0:00:00:0000  25:18:23:0806  procnto-smp-instr
1      5   2   OK  10 Receive    0:03:18:0905  0:00:00:0473  procnto-smp-instr
.
RP/0/RSP0/CPU0:rasr9000-2w-b#show processes location 0/RSP0/CPU0 | include bgp
Thu Nov 21 12:27:52.017 EST
143    1   1   36K 10 Receive    25:35:35:0474  0:00:00:0035  bgp_policy_reg_agent
143    2   1   36K 10 Receive    25:43:46:0465  0:00:00:0000  bgp_policy_reg_agent
143    3   0   36K 10 Receive    25:43:46:0345  0:00:00:0000  bgp_policy_reg_agent
1048   1   2   388K 10 Receive   0:00:25:0434  0:00:00:0253  bgp
.
RP/0/RSP0/CPU0:rasr9000-2w-b#show processes location 0/0/CPU0 | include arp
Thu Nov 21 12:28:07.105 EST
116    1   3   56K 10 Receive    0:00:14:0000  0:00:00:0336  arp
116    2   1   56K 10 Receive    25:31:48:0919  0:00:00:0020  arp
116    3   0   56K 10 Receive    25:53:18:0643  0:00:00:0000  arp
116    4   3   56K 10 Receive    25:53:18:0637  0:00:00:0001  arp
116    5   1   56K 10 Receive    0:00:00:0802  0:00:00:0290  arp
327    1   2   16K 10 Receive   0:00:19:0397  0:00:00:0066  slarp_lite
```

Processes

On an 8-core CPU [RSP880]

```
RP/0/RSP1/CPU0:ASR9006-2w-a.PE2_CE1#admin show processes location 0/RSP1/CPU0
Thu Feb 16 16:27:59.815 EST
      JID   TID CPU Stack pri state      TimeInState    HR:MM:SS:MSEC    NAME
      1     1   0   OK  0  Running      0:00:00:0000 1003:07:39:0085  procnto-smp-instr
      1     2   1   OK  0  Running      0:00:00:0000 1003:07:00:0840  procnto-smp-instr
      1     3   2   OK  0  Running      0:00:00:0000 1002:11:09:0034  procnto-smp-instr
      1     4   3   OK  0  Running      0:00:00:0000 1000:35:38:0237  procnto-smp-instr
      1     5   4   OK  0  Running      0:00:00:0000 994:28:11:0049  procnto-smp-instr
      1     6   5   OK  0  Running      0:00:00:0000 989:59:09:0679  procnto-smp-instr
      1     7   6   OK  0  Ready       0:00:00:0000 980:21:04:0983  procnto-smp-instr
      1     8   7   OK  0  Running      0:00:00:0000 978:19:01:0459  procnto-smp-instr
      1     9   6   OK  10 Receive     0:00:00:0079  0:17:56:0824  procnto-smp-instr
      1    10   6   OK  10 Receive     0:02:59:0387  0:21:13:0432  procnto-smp-instr
      1    11   6   OK  10 Receive    1004:36:29:0567 0:00:00:0000  procnto-smp-instr
      1    12   6   OK  10 Receive    1004:39:39:0705 0:00:00:0000  procnto-smp-instr
      1    13   6   OK  10 Running    0:00:00:0000 0:28:36:0391  procnto-smp-instr
      1    15   6   OK  10 Receive     0:00:00:0072  0:00:00:0033  procnto-smp-instr
      1    17   3   OK  10 Receive    1004:36:29:0567 0:00:00:0000  procnto-smp-instr
      1    19   6   OK  10 Receive    1004:36:29:0567 0:00:00:0000  procnto-smp-instr
      1    20   4   OK  10 Receive    1004:39:39:0705 0:00:00:0000  procnto-smp-instr
      1    22   6   OK  10 Receive     0:00:00:0000 0:28:57:0786  procnto-smp-instr
      1    26   5   OK  10 Receive    1004:41:13:0004 0:00:00:0000  procnto-smp-instr
      97   1     6  96K 10 Receive    1004:42:27:0059 0:00:00:0017  wd-critical-mon
      97   3     3  96K  63 Nanosleep  0:00:00:0240 0:00:00:0007  wd-critical-mon
      97   4     0  96K  11 Nanosleep  0:00:00:0061 0:00:00:0018  wd-critical-mon
      97   5     1  96K  11 Nanosleep  0:00:00:0018 0:00:00:0018  wd-critical-mon
.
```

Distributed Processing

Process example

```
RP/0/RSP0/CPU0:rasr9k-1y#show processes location 0/0/cpu0
Wed Mar 13 12:52:30.904 UTC
JID TID CPU Stack pri state      TimeInState   HR:MM:SS:MSEC  NAME
250  1   2   24K  10 Receive    0:01:03:0295  0:00:00:0099 12snoop
250  2   0   24K  10 Receive    485:14:51:0408  0:00:00:0000 12snoop
250  3   0   24K  10 Sigwaitinfo 485:14:51:0407  0:00:00:0000 12snoop

RP/0/RSP0/CPU0:rasr9k-1y#show processes location 0/rsp0/cpu0
Wed Mar 13 13:05:04.550 UTC
JID TID CPU Stack pri state      TimeInState   HR:MM:SS:MSEC  NAME
306  1   2   24K  10 Receive    0:01:51:0885  0:00:00:0046 12snoop
306  2   2   24K  10 Receive    485:31:56:0557  0:00:00:0000 12snoop
306  3   1   24K  10 Sigwaitinfo 485:31:56:0557  0:00:00:0000 12snoop

RP/0/RSP0/CPU0:rasr9k-1y#show processes location 0/rsp1/cpu0 | include snoop
Wed Mar 13 13:11:50.386 UTC
306  1   2   24K  10 Receive    0:00:37:0754  0:00:00:0043 12snoop
306  2   0   24K  10 Receive    485:36:33:0246  0:00:00:0000 12snoop
306  3   3   24K  10 Sigwaitinfo 485:36:33:0245  0:00:00:0000 12snoop

RP/0/RSP0/CPU0:rasr9k-1y#show processes distribution 12snoop
Wed Mar 13 13:13:18.810 UTC
3 processes found
NODE          PID      JID #THR  TYPE  PROGRAM
0/RSP0/CPU0  274643  306   3  RP   12snoop
0/RSP1/CPU0  266401  306   3  RP   12snoop
0/0/CPU0    233611  250   3  LC   12snoop
```

Running the Needed Processes

Process example

```
RP/0/RSP0/CPU0:rasr9k-1y#show processes location 0/rsp0/cpu0 | include eigrp
Wed Mar 13 17:04:38.971 UTC
203    1    3   36K  10 Receive      489:30:31:0725  0:00:00:0029 eigrp_policy_reg_agent
203    2    3   36K  10 Receive      489:30:32:0243  0:00:00:0000 eigrp_policy_reg_agent
203    3    2   36K  10 Receive      489:30:32:0193  0:00:00:0000 eigrp_policy_reg_agent
RP/0/RSP0/CPU0:rasr9k-1y#configure
Wed Mar 13 17:04:43.082 UTC
RP/0/RSP0/CPU0:rasr9k-1y(config)#router eigrp 100
RP/0/RSP0/CPU0:rasr9k-1y(config-eigrp)#commit
Wed Mar 13 17:04:50.633 UTC
RP/0/RSP0/CPU0:Mar 13 17:04:50.681 : rmf_svr[386]: %HA-REDCON-1-STANDBY_NOT_READY : standby card is NOT ready
RP/0/RSP0/CPU0:Mar 13 17:04:50.682 : rmf_svr[386]: %HA-REDCON-1-BACKUP_NOT_READY : backup process groups between 0/RSP0/CPU0 and 0/RSP1/CPU0 are NOT ready
RP/0/RSP1/CPU0:Mar 13 17:04:50.681 : rmf_svr[386]: %HA-REDCON-1-STANDBY_NOT_READY : standby card is NOT ready
RP/0/RSP0/CPU0:Mar 13 17:04:50.684 : rmf_svr[386]: %HA-REDCON-1-BACKUP_READY : backup process groups between 0/RSP0/CPU0 and 0/RSP1/CPU0 are ready
RP/0/RSP0/CPU0:Mar 13 17:04:50.684 : rmf_svr[386]: %HA-REDCON-1-BACKUP_NOT_READY : backup process groups between 0/RSP0/CPU0 and 0/RSP1/CPU0 are NOT ready
RP/0/RSP0/CPU0:Mar 13 17:04:50.687 : rmf_svr[386]: %HA-REDCON-1-BACKUP_READY : backup process groups between 0/RSP0/CPU0 and 0/RSP1/CPU0 are ready
RP/0/RSP0/CPU0:Mar 13 17:05:00.682 : rmf_svr[386]: %HA-REDCON-1-STANDBY_READY : standby card is ready
```

Running the Needed Processes

Process example - continued

```
RP/0/RSP0/CPU0:rasr9k-1y(config-eigrp)#do show processes location 0/rsp0/cpu0 | include eigrp
Wed Mar 13 17:05:32.977 UTC
203 1 3 36K 10 Receive 489:31:25:0732 0:00:00:0029 eigrp_policy_reg_agent
203 2 3 36K 10 Receive 489:31:26:0249 0:00:00:0000 eigrp_policy_reg_agent
203 3 2 36K 10 Receive 489:31:26:0199 0:00:00:0000 eigrp_policy_reg_agent
1002 1 2 124K 10 Receive 0:00:40:0441 0:00:00:0147 eigrp
1002 2 1 124K 10 Receive 0:00:42:0400 0:00:00:0000 eigrp
1002 3 2 124K 10 Receive 0:00:42:0387 0:00:00:0000 eigrp
1002 4 3 124K 10 Sigwaitinfo 0:00:42:0104 0:00:00:0000 eigrp
1002 5 2 124K 10 Receive 0:00:42:0169 0:00:00:0000 eigrp
1002 6 2 124K 10 Receive 0:00:42:0047 0:00:00:0003 eigrp
1002 7 1 124K 10 Receive 0:00:42:0031 0:00:00:0000 eigrp
1002 8 0 124K 10 Receive 0:00:42:0030 0:00:00:0000 eigrp
1002 9 2 124K 10 Receive 0:00:42:0030 0:00:00:0000 eigrp
1002 10 0 124K 10 Receive 0:00:42:0030 0:00:00:0000 eigrp
1002 11 2 124K 10 Receive 0:00:42:0029 0:00:00:0000 eigrp
RP/0/RSP0/CPU0:rasr9k-1y(config-eigrp)#no router eigrp 100
RP/0/RSP0/CPU0:rasr9k-1y(config)#commit
Wed Mar 13 17:05:46.305 UTC
RP/0/RSP0/CPU0:rasr9k-1y(config)#do show processes location 0/rsp0/cpu0 | include eigrp
Wed Mar 13 17:05:50.441 UTC
203 1 3 36K 10 Receive 489:31:43:0186 0:00:00:0029 eigrp_policy_reg_agent
203 2 3 36K 10 Receive 489:31:43:0704 0:00:00:0000 eigrp_policy_reg_agent
203 3 2 36K 10 Receive 489:31:43:0654 0:00:00:0000 eigrp_policy_reg_agent
```

IOS-XR Operating System

RSP and LC CPU's

- To monitor: a CPU on every card
- Instances of processes running on RSP and LC CPU's

```
RP/0/RSP0/CPU0:rasr9k-1y#show processes cpu location 0/RSP0/CPU0 |  
exclude " 0%      0%      0%"  
Wed Nov 28 01:36:52.203 UTC
```

CPU utilization for one minute: 26%; five minutes: 25%; fifteen minutes: 22%

PID	1Min	5Min	15Min	Process
94243	3%	3%	3%	spp
254074	23%	22%	19%	netio

```
RP/0/RSP0/CPU0:rasr9k-1y#show processes cpu location 0/0/CPU0 |  
exclude " 0%      0%      0%"  
Wed Nov 28 01:28:52.281 UTC
```

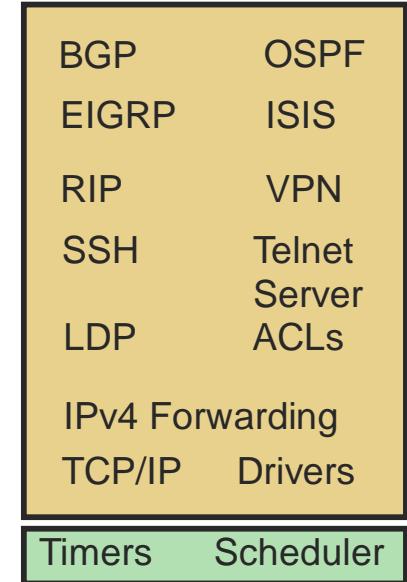
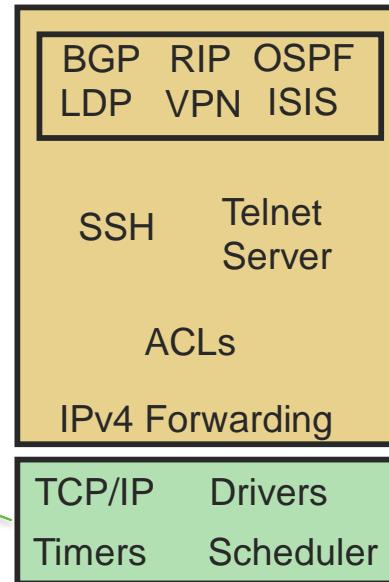
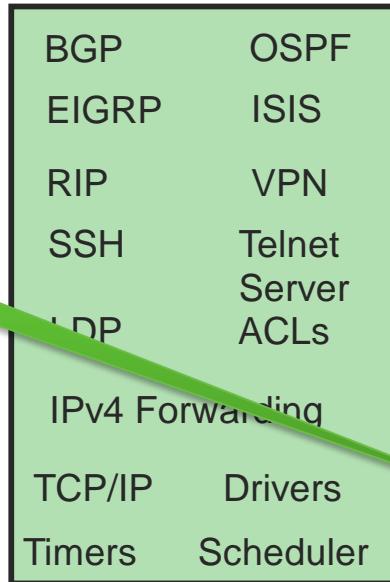
CPU utilization for one minute: 46%; five minutes: 48%; fifteen minutes: 39%

PID	1Min	5Min	15Min	Process
45085	22%	23%	22%	spp
180316	23%	23%	23%	netio

Process Restart

Most processes are re-startable

Green areas
cannot restart



Monolithic
IOS

Kernel
BSD based routers

Microkernel
IOS XR

Demonstrating Process Restart

Same Job ID, New Process ID

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show processes bgp
Wed Jan 15 17:58:34.050 EST
    Job Id: 1048
        PID: 287056
        Executable path: /disk0/iosxr-routing-
4.2.3.CSCuh52959-1.0.0/0x100305/bin/bgp
            Instance #: 1
            Version ID: 00.00.0000
            Respawn: ON
            Respawn count: 1
        Max. spawns per minute: 12
            Last started: Thu Jan  2 09:11:18 2014
            Process state: Run
            Package state: Normal
            Started on config: default
                Feature name: ON
                Tag : default
            Process group: v4-routing
                core: MAINMEM
                Max. core: 0
                Placement: Placeable
                startup_path: /pkg/startup/bgp.startup
                    Ready: 0.700s
                    Available: 85.082s
                Process cpu time: 21.760 user, 2.619 kernel,
24.379 total
        JID   TID CPU Stack pri state      TimeInState
        HR:MM:SS:MSEC   NAME
        1048   1   2  384K  10 Receive      0:00:03:0395
.
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#process restart bgp
Wed Jan 15 18:03:24.836 EST
RP/0/RSP0/CPU0:Jan 15 18:03:24.874 :
    sysmgr_control[65784]: %OS-SYSGR-4-PROC_RESTART_NAME :
        User cisco (con0_RSP0_CPU0) requested a restart of
        process bgp at 0/RSP0/CPU0
RP/0/RSP0/CPU0:rasr9000-2w-a#show processes bgp
Wed Jan 15 18:03:28.726 EST
    Job Id: 1048
        PID: 3182840
        Executable path: /disk0/iosxr-routing-
4.2.3.cscuh52959-1.0.0/0x100305/bin/bgp
            Instance #: 1
            Version ID: 00.00.0000
            Respawn: ON
            Respawn count: 2
        Max. spawns per minute: 12
            Last started: Wed Jan 15 18:03:24 2014
            Process state: Run (last exit due to SIGTERM)
            Package state: Normal
            Started on config: default
                Feature name: ON
                Tag : default
            Process group: v4-routing
                core: MAINMEM
                Max. core: 0
                Placement: Placeable
                startup_path: /pkg/startup/bgp.startup
                    Ready: 0.225s
.
```

Process Dumps

Where?

```
RP/0/RSP0/CPU0:rasr9000-2w-a#admin show exception
Sat Jan 4 00:15:27.885 EST
Exception path for choice 1 is not configured or removed
Exception path for choice 2 is not configured or removed
Exception path for choice 3 is not configured or removed
Choice fallback one path = dumper_harddisk:/dumper compress = on filename = <process_name>
Choice fallback two path = dumper_disk1a:/dumper compress = on filename = <process_name>
Choice fallback three path = dumper_disk0a:/dumper compress = on filename = <process_name>
Kernel dump not configured
Tftp route for kernel core dump not configured
No config for pakmem tuple
No config for sparse tuple
No config for sprsize tuple
No config for coresize tuple
No config for memory-threshold tuple
No config for core-verification tuple

RP/0/RSP0/CPU0:rasr9000-2w-a#dir harddisk:/dumper
Sat Jan 4 00:16:10.138 EST
Directory of harddisk:/dumper
24922 -rw- 216304651 Sat Jan 4 00:16:08 2014 ce_switch.log
24665 -rw- 42408 Tue Nov 5 19:06:35 2013 crashinfo.by.kernel.19070930-173606
24694 -rw- 1586390 Tue Nov 5 19:06:36 2013 kernel_core.by.kernel.19070930-173606.z
24695 -rw- 1044480 Tue Nov 5 19:06:36 2013 pcds_dump.19070930-173606
24697 -rw- 4813080 Fri Nov 8 17:03:11 2013 first.mpls_lsd_338.node0_RSP0_CPU0.x86.z
.
```

Process Dumps

On line cards

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show filesystem location 0/1/CPU0 | include lc
```

```
Sat Jan 4 00:26:39.269 EST
1644150784 1635583488          rw  lcdisk0:
411041792  410915840          rw  lcdisk0a:
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#dir lcdisk0:/dumper location 0/0/CPU0
```

```
Sat Jan 4 00:29:22.703 EST
```

```
Directory of net/node0_0_CPU0/lcdisk0:/dumper
```

```
6361      -rw-  3205840      Fri Nov  8 23:00:02 2013  first.cluster_dlm_lc_143.sparse.node0_0_CPU0.ppc.Z
6362      -rw-  7289       Fri Nov  8 23:00:02 2013  first.cluster_dlm_lc_143.sparse.node0_0_CPU0.ppc.txt
6363      -rw-  495281      Fri Nov  8 23:00:08 2013  first.cluster_dlm_lc_143.sparse.node0_0_CPU0.ppc.cpu_info.Z
6370      -rw-  2293471     Fri Nov  8 23:29:30 2013  first.eth_server_57.by.wdssysmon.sparse.node0_0_CPU0.ppc.Z
6365      -rw-  13722       Fri Nov  8 23:00:33 2013  l2fib_mgr_247.sparse.node0_0_CPU0.ppc.txt
6366      -rw-  515048      Fri Nov  8 23:00:36 2013  l2fib_mgr_247.sparse.node0_0_CPU0.ppc.cpu_info.Z
6367      -rw-  5632747     Fri Nov  8 23:00:40 2013  pm_294.sparse.node0_0_CPU0.ppc.Z
6368      -rw-  10818       Fri Nov  8 23:00:41 2013  pm_294.sparse.node0_0_CPU0.ppc.txt
6369      -rw-  543561      Fri Nov  8 23:00:41 2013  pm_294.sparse.node0_0_CPU0.ppc.cpu_info.Z
6371      -rw-  4429        Fri Nov  8 23:29:30 2013  first.eth_server_57.by.wdssysmon.sparse.node0_0_CPU0.ppc.txt
6372      -rw-  311267      Fri Nov  8 23:29:30 2013  first.eth_server_57.by.wdssysmon.sparse.node0_0_CPU0.ppc.cpu_info.Z
```

The background of the slide features a repeating pattern of the Cisco logo, which consists of a grid of green rounded rectangles and smaller white circles.

IOS-XR Components

eXR for Tomahawk, cXR for any

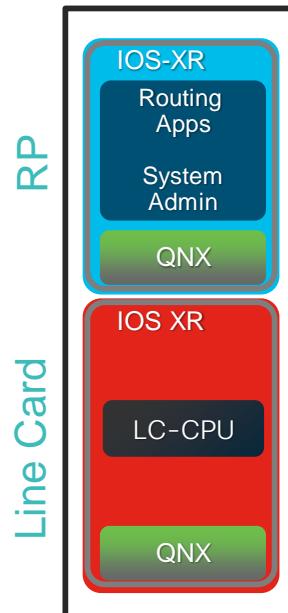
- Starting 6.1.2: eXR is 64-bit, cXR is 32-bit
- eXR only if all hardware supports. cXR for any mix
- eXR: Support for 3rd party app hosting ☺
- Wind River Linux OS

```
RP/0/RP0/CPU0:PE137# run uname -a
Wed Feb 1 08:28:57.332 EST
Linux xr-vm_node0_RP0_CPU0 3.14.23-WR7.0.0.2_standard #1 SMP Fri Jun 17 17:51:29 PDT 2016 x86_64 x86_64 x86_64
GNU/Linux
```

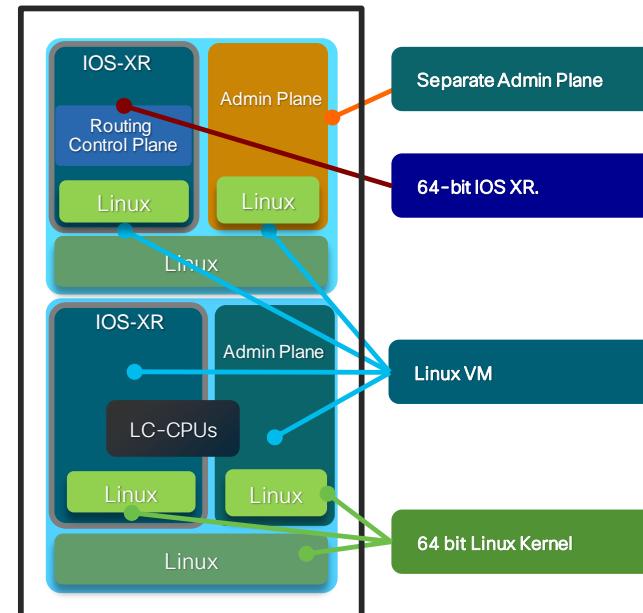
IOS XR 64 Bit: Architecture Overview

cXR-Classis XR-32 Bit eXR-extended XR Release-64 Bit

- IOS XR Exists in two flavors
- **32-bit** in XR12k, CRS, ASR9000
 - QNX-based
 - No virtualization
- **64-bit** in ASR9000, NCS 5500, NCS 5000, NCS 1000 and in NCS 6000
 - Linux based
 - Larger addressable memory
 - Separation Networking OS and Admin Plane
 - Virtualization: VM or Container
 - ASR9000 Running with VMs



“Classic” IOS XR
32 Bit

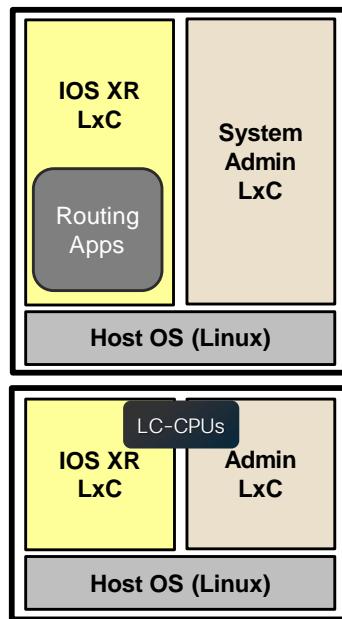


Linux-based Virtualized
IOS XR 64 Bit

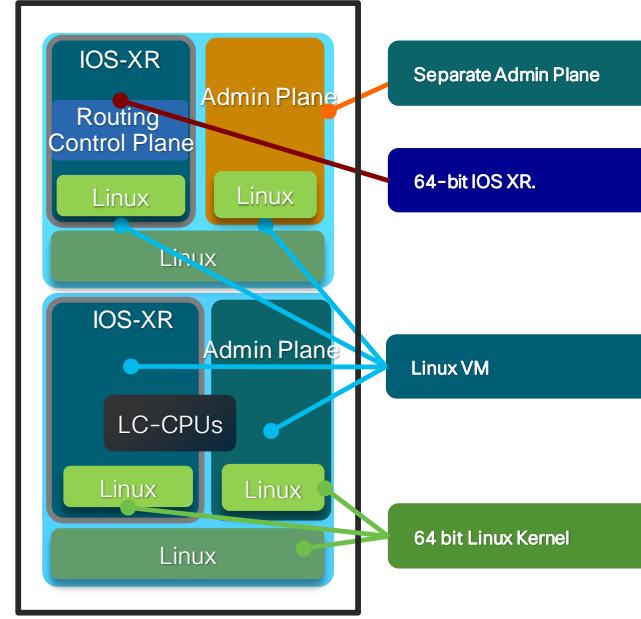
IOS XR 64 Bit

Container versus VM

- IOS XR 64 Bit Can Run with Container or VM
- VM Based 64 Bit XR:
 - In ASR9000, NCS6000
 - VM OS Completely Separated from Host OS
- Container Based 64 Bit XR:
 - In NCS 5500, NCS5000
 - Container OS share the same kernel as Host OS



Container Based
IOS XR 64 Bit
NCS5500, NCS5000



Virtual Machine Based
IOS XR 64 Bit
ASR9000, NCS6000

ASR 9000 Network OS Difference Summary

32 BIT versus 64 BIT

Category	IOS XR 32-bit (Classic XR)	IOS XR 64-bit (Enhanced XR)
Kernel	QNX (32 bit)	Yocto WR Linux (64 bit)
Virtualization	All applications running as different processes. No virtualization.	Two VMs: Admin VM and XR VM on RP/LC CPU
Software Packaging	<ul style="list-style-type: none">• PIE based packages.• Special VM image for fresh installation (Turboboot)	<ul style="list-style-type: none">• ISO/RPM based packages.• ISO image for bootup and fresh installation.• Flexible Golden ISO image for customer• Offline RPM package management.
Boot Facility	ROMMON: <ul style="list-style-type: none">• CLI based• TFTP Network boot	iPXE: <ul style="list-style-type: none">• Menu Based• Enables Zero-Touch-Provisioning (ZTP)• TFTP/FTP/SFTP/HTTP/HTTPs

Software Packaging Terminology

Package types



PIE?

Cisco *live!*



Mini?



Package?

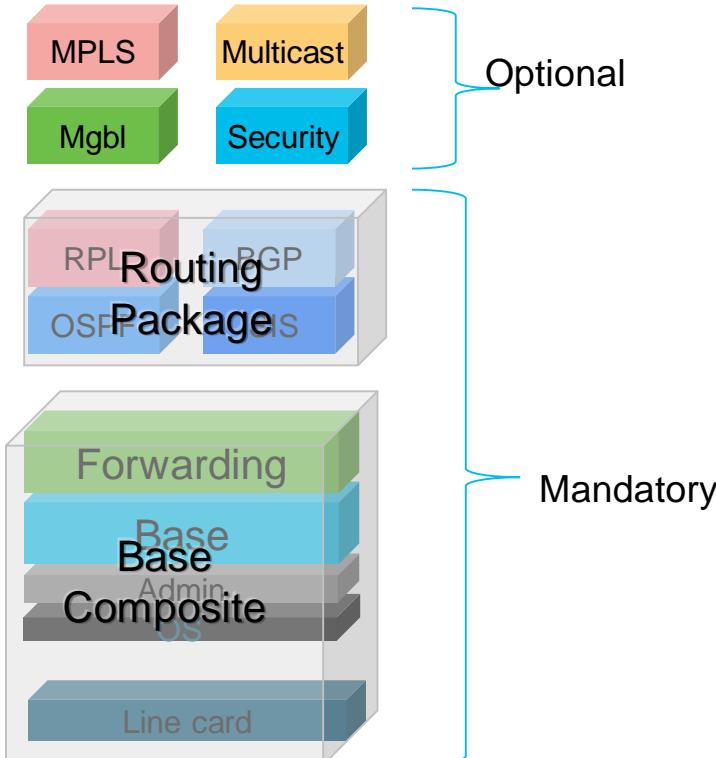


SMU?

Package Terminology

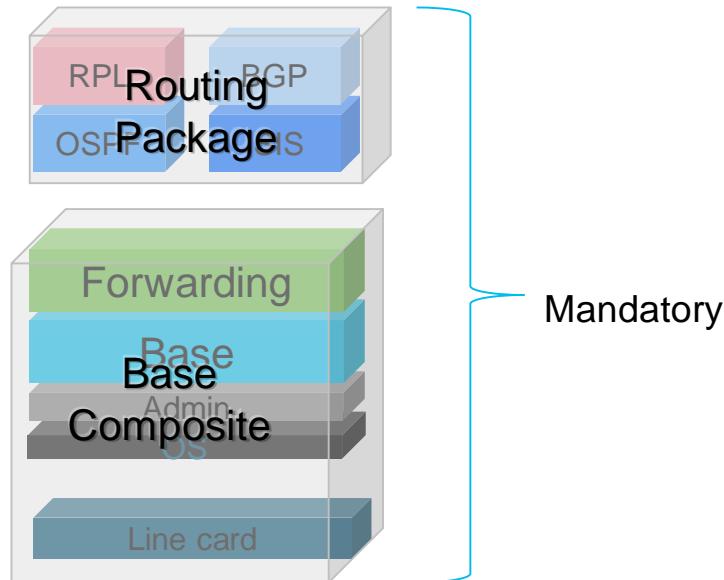
- PIE - Package Installation Envelopes (PIEs) are nonbootable files that contain a single package or a set of packages (called a composite package or bundle). Because the files are nonbootable, they are used to add software package files to a running router. PIE files have a pie extension
- SMU - When a PIE file contains software for a specific bug fix, it is called a software maintenance upgrade (SMU).
- Umbrella SMU – When A SMU contains multiple bug fixes
- Service Pack – Multiple SMU's in a package, reload required
- Turboboot – The initial installation of IOS XR SW to disk
- Install Upgrade – Performing an IOS XR SW Upgrade via the install process
- FPD – Field Programmable Devices

Packages: Mandatory and Optional



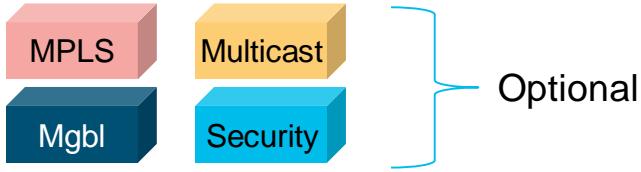
- **Packages** are unique sets of components and represent *potential* units of delivery
- Packages are visible in the code base – “build” infrastructure prevents **illegal dependencies** between packages
- Packages can be grouped into **composites** for ease of delivery
- Code base files are organized into **components** – these are versioned and visible to the development engineer
- Packages can be downloaded from Cisco.com via “tar” files

Packages: Mandatory



- The Cisco IOS XR Unicast Routing Core Bundle is a **Mandatory** composite package containing the following packages:
 - Forwarding
 - Administration
 - Base
 - Operating system (OS)
 - Routing
 - Line card drivers

Packages: Optional



Optional packages provide additional features:

- **Manageability** – Support for HTTP, XML, SNMP and other management tools
- **Multicast** – Support for multicast protocols
- **MPLS** – Support for Multiprotocol Label Switching (MPLS)
- **Security** – Support for Secure Sockets Layer (SSL), certificates and other security tools

Note: These are just some of the optional packages available on the ASR9K, there are additional optional SW packages

PIE – Package Installation Envelope

- PIEs are a delivery mechanism for packages
 - Used to deliver
 - Releases – (5.1.3, 5.3.4, 6.1.2)
 - SMUs – Fix for a specific bug
- Mini is a bundle of the mandatory packages
- Includes authentication info
- Installed from admin mode



Reading Installed Packages

Example

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show install active
detail
Sun Jan 4 23:43:14.325 EST
Secure Domain Router: Owner
Node 0/RSP0/CPU0 [RP] [SDR: Owner]
  Boot Device: disk0:
  Boot Image: /disk0/asr9k-os-mbi-
5.1.3/0x100305/mbiasr9k-rsp3.vm
  Active Packages:
    disk0:asr9k-mpls-px-5.1.3
      disk0:iosxr-mpls-5.1.3
    disk0:asr9k-mgb1-px-5.1.3
      disk0:asr9k-mgb1-supp-5.1.3
      disk0:iosxr-mgb1-5.1.3
    disk0:asr9k-optic-px-5.1.3
      disk0:asr9k-optics-supp-5.1.3
    disk0:asr9k-k9sec-px-5.1.3
      disk0:iosxr-security-5.1.3
      disk0:asr9k-k9sec-supp-5.1.3
    disk0:asr9k-doc-px-5.1.3
      disk0:asr9k-doc-supp-5.1.3
disk0:asr9k-fpd-px-5.1.3
  disk0:asr9k-fpd-5.1.3
disk0:asr9k-mini-px-5.1.3
  disk0:asr9k-scfclient-5.1.3
  disk0:asr9k-os-mbi-5.1.3
    disk0:asr9k-cpp-5.1.3
  disk0:asr9k-ce-5.1.3
  disk0:iosxr-ce-5.1.3
  disk0:asr9k-diags-supp-5.1.3
```

```
disk0:iosxr-diags-5.1.3
disk0:asr9k-fwding-5.1.3
disk0:iosxr-fwding-5.1.3
disk0:iosxr-routing-5.1.3
disk0:iosxr-infra-5.1.3
disk0:asr9k-base-5.1.3
disk0:asr9k-mcast-px-5.1.3
  disk0:asr9k-mcast-supp-5.1.3
  disk0:iosxr-mcast-5.1.3
.

.

Node 0/1/CPU0 [LC] [SDR: Owner]
  Boot Device: mem:
  Boot Image: /disk0/asr9k-os-mbi-5.1.3/lc/mbiasr9k-
lc.vm
  Active Packages:
    disk0:asr9k-mpls-px-5.1.3
      disk0:iosxr-mpls-5.1.3
    disk0:asr9k-optic-px-5.1.3
      disk0:asr9k-optics-supp-5.1.3
    disk0:asr9k-mini-px-5.1.3
      disk0:asr9k-scfclient-5.1.3
      disk0:asr9k-os-mbi-5.1.3
      disk0:asr9k-cpp-5.1.3
      disk0:asr9k-ce-5.1.3
      disk0:iosxr-ce-5.1.3
      disk0:asr9k-diags-supp-5.1.3
      disk0:iosxr-diags-5.1.3
```

SMU and Service Pack Delivery

- SMU is named by release and bugid
 - asr9k-px-5.3.4.CSCvb41169.tar
 - asr9k-px-5.1.3.CSCvc42959.tar

IOS-XR Version

Defect ID

- Service Pack is named by release and SP number
 - asr9k-px-5.1.3.sp10.tar

Service Pack

IOS XR ASR 9000 64 Bit Packaging

eXR ISO , Packages & SMU's

Bootable Images

Minimum Image	asr9k-mini-x64-6.1.2.iso	Core packages: OS, Admin, Forwarding, Modular Services Card, Basic Routing, SNMP, Alarm Correlation
Golden ISO (GISO)	Customized ISO image includes mini ISO + required packages + SMUs + XR config	

Optional Feature Packages

asr9k-eigrp-x64-1.0.0.0-r612.x86_64.rpm
asr9k-isis-x64-1.1.0.0-r612.x86_64.rpm
asr9k-ospf-x64-1.1.0.0-r612.x86_64.rpm
asr9k-m2m-x64-2.0.0.0-r612.x86_64.rpm
asr9k-mgbl-x64-3.0.0.0-r612.x86_64.rpm
asr9k-mpls-te-rsvp-x64-1.2.0.0-r612.x86_64.rpm

asr9k-mpls-x64-2.1.0.0-r612.x86_64.rpm
asr9k-mcast-x64-2.0.0.0-r612.x86_64.rpm
asr9k-optic-x64-1.0.0.0-r612.x86_64.rpm
asr9k-li-x64-1.1.0.0-r612.x86_64.rpm
asr9k-k9sec-x64-3.1.0.0-r612.x86_64.rpm

Managing SMU: Cisco Software Manager App

The screenshot shows the Cisco Software Manager interface with the following key components:

- Network Elements Tree:** On the left, it shows managed nodes and their XR versions. A blue callout bubble points to this area with the text "Managed nodes and XR versions".
- SMU List:** The main pane displays a table of 48 SMUs. A blue callout bubble points to the "Defect info" column with the text "Defect info". Another blue callout bubble points to the "Download & tar" button in the toolbar with the text "Download & tar".
- Detail View:** A modal window titled "New SMU Alert - ASR9K-PX-4.3.1" shows details for a specific SMU entry.
- Installed SMUs:** A separate pane at the bottom shows installed SMUs for device 172.16.200.150, with a blue callout bubble pointing to the "Installed" column with the text "Installed".

SMU List Headers: ST, DDTs, Type, Description, Impact, Functional Areas, SMU ID, SMU Name, Posted ...

SMU List Data (partial):

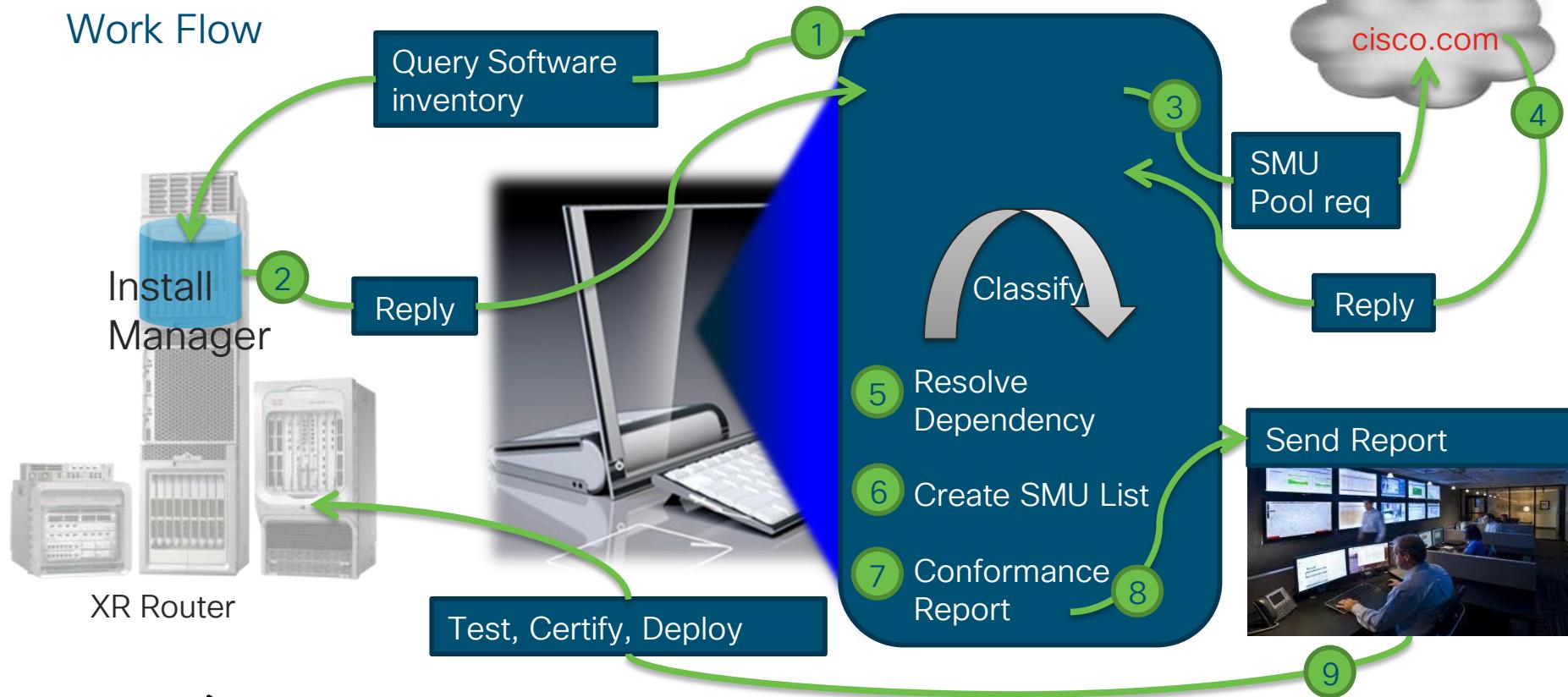
ST	DDTs	Type	Description	Impact	Functional Areas	SMU ID	SMU Name	Posted ...
✓	▲ CSCu81580	PSIRT	ASR9K SIP-700 Malformed packet causes Egress CPP crash and LC restart	traffic loss	FORWARDING	AA07975	asr9k-px-4.2.3.CSCu81580	2014/01/0
✓	▲ CSCu52017	Optional	[4,2,3] Combo SMU for CSCu48815 and CSCu27832	traffic loss	FORWARDING	AA08141	asr9k-px-4.2.3.CSCu52017	2014/01/0
✓	▲ CSCu57104	Recommended	Defensive mechanism for invalid PSID to protect TM	needs reboot	INFRASTRUCTURE	AA08124	asr9k-px-4.2.3.CSCu57104	2013/12/1
✓	▲ CSCu91840	Optional	Isp-nl command on IOS-XR is NOT limiting the size of the CSNP MTU	traffic loss	ISIS	AA07907	asr9k-px-4.2.3.CSCu91840	2013/11/2
✓	▲ CSCuH7453	Optional	510-SIT: vrrp crash@ group_handle_msg_common on active RSP when OIR LC	issu/reload	INFRASTRUCTURE	AA07606	asr9k-px-4.2.3.CSCuH7453	2013/11/22
✓	▲ CSCu30063	Optional	IPSLA Umbrella DDTs	hitless	IPSLA	AA07983	asr9k-px-4.2.3.CSCu30063	2013/11/21
✓	▲ CSCu69332	Recommended	Cluster-PRIMARY missing on query ciscoEntityRedundancy on BACKUP reload	hitless	SNMP	AA07531	asr9k-px-4.2.3.CSCu69332	2013/11/13
✓	▲ CSCu24002	Optional	Cisco VSAs are being dropped by RSP3 based ASR9K	hitless	AAA	AA07863	asr9k-px-4.2.3.CSCu24002	2013/11/05
✓	▲ CSCu86569	Optional	taeasd process mutex at max server connection flap	hitless	AAA	AA07522	asr9k-px-4.2.3.CSCu86569	2013/11/04
✓	▲ CSCu86628	Optional	Change the recovery action in case of recovery of redundant EMUX FPGA errors	needs reboot	FABRIC	AA07857	asr9k-px-4.2.3.CSCu86628	2013/11/01
✓	▲ CSCu34330	Optional	BGP Umbrella DDTs #4 for 4.2.3	traffic loss	BGP	AA07822	asr9k-px-4.2.3.CSCu34330	2013/10/31
✓	▲ CSCu79123	Recommended	EIGRP umbrella SMU	traffic loss	EIGRP	AA07932	asr9k-px-4.2.3.CSCu79123	2013/10/31
✓	▲ CSCv06696	Recommended	Add CLI option to handle out-of-subnet ARP requests	needs reboot	ARP	AA07830	asr9k-px-4.2.3.CSCv06696	2013/10/28
✓	▲ CSCu43419	Recommended	After fib_migr forced crash, neighbor is not recovered	hitless	FORWARDING	AA07546	asr9k-px-4.2.3.CSCu43419	2013/10/28
✓	▲ CSCu05685	Recommended	4.2.3 PFD/RMONMON Bundle	issu/reload	FPD	AA07731	asr9k-px-4.2.3.CSCu05685	2013/10/28
✓	▲ CSCu31495	Recommended	Continuous ingress punt for IRB multicast route	needs reboot	MCAST	AA07838	asr9k-px-4.2.3.CSCu31495	2013/10/10
✓	▲ CSCu33805	Recommended	423 SMU Pack3 for ASR9K NP, PRM and DR	needs reboot	ETHER	AA07681	asr9k-px-4.2.3...	asr9k-fpd-px, asr...
✓	▲ CSCu10155	Optional	continuous'cpl_qos_ss_proc_stats:121:STAT5 error Not enough memory'	needs reboot	QOS	AA07741	asr9k-px-4.2.3...	asr9k-mini-px
✓	▲ CSCu45262	Optional	Sack Hole data reported incorrectly	traffic loss	TCP	AA07556	asr9k-px-4.2.3...	asr9k-mini-px
✓	▲ CSCu40703	Optional	PW notification msg sending different encap types (vlan,Ethernet)	needs reboot	L2VPN, LDP	AA07695	asr9k-px-4.2.3.CSCu40703	2013/08/21
✓	▲ CSCu35303	Optional	after reload location all, cpnCPUTotal1min,Smin no value for some LC	hitless	INFRASTRUCTURE	AA07451	asr9k-px-4.2.3.CSCu35303	2013/08/19
✓	▲ CSCu14630	Optional	umbrella SMU DDTs for CSCu91711 and CSCu03237	AA07519	asr9k-px-4.2.3.CSCu14630	2013/08/01
✓	▲ CSCu64988	Recommended	ppp_ma crash due to large aaaa attr buffer.	AA07584	asr9k-px-4.2.3.CSCu64988	2013/07/31
✓	▲ CSCu276950	Optional	TE-tunnel fails if RSVP request contains burst greater than 2^32	AA07427	asr9k-px-4.2.3.CSCu276950	2013/07/29
✓	▲ CSCv06900	Optional	Junk characters not be displayed as PID for SFP	AA07372	asr9k-px-4.2.3.CSCv06900	2013/07/17

Installed SMUs:

Location	Active Packages
disk0	asr9k-px-4.2.3.CSCud37351.1.0.0
disk0	asr9k-px-4.2.3.CSCup30231.1.0.0
disk0	asr9k-px-4.2.3.CSCf32158.1.0.0
disk0	asr9k-px-4.2.3.CSCue10883.1.0.0
disk0	asr9k-9000v-nv-px-4.2.3
disk0	asr9k-optic-px-4.2.3
disk0	asr9k-mini-px-4.2.3
disk0	asr9k-doc-px-4.2.3
disk0	asr9k-k9sec-px-4.2.3

Cisco Software Manager Server

Work Flow



What CSM Does

- Software Management:
 - Automated and Simplified image (releases and SMUs) retrieval, reporting and alerts
 - Pushes image to one or many devices
 - End to end SW management
 - Patch recommendation, and conformance reporting
 - Migration from 32-bit XR to 64-bit XR
- Operations Simplification:
 - Auto-updates: you can schedule installation, pre- and post- installation verifications
 - Easier access to image and patch details (documentation)
 - Multi-platform and multi-OS support
- Inventory Management:
 - Visibility into hardware, cards, slots, S/N, optic types

Solves For:

- Time consuming, manual, laborious, repetitive, error-prone SW installation
- Complicated patch dependencies
- High costs

Big Wins:

- Huge time and resource savings
- Up to 90% time savings on SW upgrades

CSM Server – Supported Cisco Tool

How to download	Download CSM: https://software.cisco.com/download/release.html?mdfid=282423206&softwareid=284777134&release=3.5&relind=AVAILABLE&rellifecycle=&reltype=latest
How to use	CSM Server Documentation: https://supportforums.cisco.com/document/13154846/cisco-software-manager-33-overview-documentation CSM Server Videos: Introduction to CSM Server: https://youtu.be/lsxN08x-mr4 Getting Started with CSM Server: https://www.youtube.com/watch?v=omdpr3uP_b4 ASR9K IOS XR 32 bit to 64 bit Migration using CSM Server: https://youtu.be/RVgR0TdbpVw CSM Application Video: https://www.youtube.com/watch?v=PYO2Om-nUKQ
Support forum	https://community.cisco.com/t5/service-providers/ct-p/4441-service-providers

Supported on:

- IOS XR:
 - CRS
 - NCS
 - ASR 9000
- IOS XE:
 - asr9xx
- More coming soon!

IOS XR 64 Bit Package Naming

Typical RPM package name :

asr9k-bgp-x64-1.1.0.0-r6225.x86_64.rpm

Name Convention:



IOS XR 64 Bit Package Naming

Typical XR SMU name :

asr9k-mcast-x64-2.1.0.3-r6225l.CSCvf43058.x86_64.rpm

Typical Admin SMU name :

asr9k-sysadmin-mgbl-6.2.25.13-r6225l.CSCvf09972.x86_64.rpm

Typical ISO name:

asr9k-mini-x64-6.2.25.iso

Golden ISO Solution Overview (GISO)

64 Bit IOS XR

- Golden ISO is a customized ISO which customers can build offline out of the mini ISO by using the Cisco Released Golden ISO build script
- When the System is booted up with the Golden ISO, additional SMU's & Optional packages present in the Golden ISO will be auto installed
- The XR config if present in the Golden ISO will be auto applied (ASR 9000 only).
- Golden ISO holds additional files apart from files present in MINI ISO.
 - Third-party(Yocto pkg/SMU) for host, calvados and XR
 - Cisco SMU's for Host,
 - Cisco SMU's for Calvados
 - Cisco pkg/smu for XR.
 - XR configuration. (ASR9K-eXR)

Golden ISO Use Cases

ASR 9000 64 Bit IOS XR

- **cXR(Classic XR) to eXR Migration (ASR9K):**
 - Golden ISO allows customers to migrate their router software from Classic XR to eXR
 - customer can build their own Golden ISO with relevant XR configs and boot the system
 - Golden ISO will make the migration simpler
 - Retains the desired XR configurations and all the applicable SMU/Optional packages installed
- First time router deployment with latest software.
- Software Disaster recovery.
- System Upgrade (SU).

Golden ISO supported platforms (eXR):

- ASR9K-X64
- NCS1K
- NCS5K
- NCS5500

ASR9922 cXR to eXR Migration GISO script (Golden ISO)

ASR 9000 64 Bit IOS XR

```
root@virl:/home/6225# ./gisobuild.py -i /home/dpothier/6225/asr9k-mini-x64-6.2.25.iso -r /home/dpothier/6225/ -l v1 -m  
requirements)  
Golden ISO build process starting...
```

System requirements check [PASS]

/dev/loop1

Platform: asr9k Version: 6.2.25

Scanning repository [/home/6225]...

Building RPM Database...

Total 5 RPM(s) present in the repository path provided in CLI

/dev/loop1

Following XR x86_64 rpm(s) will be used for building Golden ISO:

```
(+) asr9k-isis-x64-1.2.0.0-r6225.x86_64.rpm  
(+) asr9k-mgbl-x64-2.0.0.0-r6225.x86_64.rpm  
(+) asr9k-k9sec-x64-2.2.0.0-r6225.x86_64.rpm  
(+) asr9k-mpls-x64-2.0.0.0-r6225.x86_64.rpm  
(+) asr9k-mpls-te-rsvp-x64-1.3.0.0-r6225.x86_64.rpm
```

/dev/loop1

...RPM compatibility check [PASS]

Building Golden ISO...

Summary

XR rpms:

```
asr9k-isis-x64-1.2.0.0-r6225.x86_64.rpm  
asr9k-mgbl-x64-2.0.0.0-r6225.x86_64.rpm  
asr9k-k9sec-x64-2.2.0.0-r6225.x86_64.rpm  
asr9k-mpls-x64-2.0.0.0-r6225.x86_64.rpm  
asr9k-mpls-te-rsvp-x64-1.3.0.0-r6225.x86_64.rpm
```

...Golden ISO creation SUCCESS.

Golden ISO Image Location: /home/6225/asr9k-goldenk9-x64.iso-6.2.25.v1
Detail logs: /home/6225/Giso_build.log-2019-01-16:18:52:45.421533

execute script on external server (has

	gisobuild.py options
-i	path to 64-bit mini-x iso
-r	path to rpm's + smu's
-l	label version
-m	build the migration tar from 32-bit cXR to 64-bit eXR

directory with rpm's + any smu's included in golden iso tar file

```
root@virl:/home/dpothier/6225# tar -tf asr9k-goldenk9-x64-migrate_to_eXR.tar-6.2.25.v1  
boot/  
boot/certs/  
boot/certs/crl.der  
boot/certs/Root_Certificate_Store.bin  
boot/certs/CertFile  
boot/initrd.img  
boot/signature.initrd.img  
boot/bzImage  
EFI/boot/  
EFI/boot/grub.cfg  
EFI/boot/grub.efi  
asr9k-goldenk9-x64.iso-6.2.25.v1
```

creates Golden ISO Image: asr9k-goldenk9-x64.iso-6.2.25.v1

creates Migration tar: asr9k-goldenk9-x64-migrate_to_eXR.tar-6.2.25.v1

New install commands

64 Bit IOS XR (eXR)

- 6.2.25
 - show install active summary (the summary keyword was added)
 - show install inactive summary
 - show install commit summary
 - show install supersede (to view superseded SMU's)
 - requires SMU CSCvj64412
- 6.3.3
 - install update source harddisk:/sw/633 asr-goldenk9-x-6.3.3-v1.iso **replace** noprompt (the "replace" keyword is added)
 - install upgrade (the "upgrade" keyword will be deprecated in later releases)

A decorative header element consisting of a repeating pattern of dark blue vertical bars of varying heights, creating a visual effect similar to a bar chart or a stylized city skyline.

IOS-XR Install & Upgrade

Turboboot

A “fresh” start!

```
Rommon1>unset BOOT  
Rommon2>confreg 0x102  
Rommon3>sync  
Rommon4>reset
```

```
Rommon1>IP_ADDRESS=<a.b.c.d>  
Rommon2>IP_SUBNET_MASK=<mask>  
Rommon3>TFTP_SERVER=<a.b.c.d>  
Rommon4>DEFAULT_GATEWAY=<a.b.c.d>  
Rommon5>TFTP_RETRY_COUNT=4  
Rommon6>TFTP_TIMEOUT=60  
Rommon7>TFTP_CHECKSUM=1  
Rommon8>priv  
Rommon9>diswd  
Rommon10>unset BOOT  
Rommon11>TURBOBOOT=on,disk0,format  
Rommon12>sync  
Rommon13>boot tftp://a.b.c.d/path/asr9k-  
mini-px.vm-4.2.3
```

- Previous disk data is wiped
- A clean “re-image” as a new router
- Potential recovery mechanism
- Not an “upgrade” method

PIE Installation Concepts

- PIE install used once system is operational w/ XR
 - .vm files can be used if booting from rommon is required
- Packages can be added or upgraded
- Install from Exec or Admin Mode
- 3 phase install
 - Add – Copy package and unpack
 - Activate – Restart processes/nodes with new code
 - Commit – Lock activated packages through reset



Install Add

Copy package to disk

```
RP/0/RSP0/CPU0:Nevada# install add tftp://7.1.1.1/asr9k-mpls-p.pie-4.3.2 sync
Install operation 3 'install add /tftp://7.1.1.1/asr9k-mpls-p.pie-4.3.2
synchronous' started by user 'ww' on SDR Owner via CLI at 22:21:54 EDT Sun Jul
26 2009.
Warning: This add operation will add the specified package to SDR: Owner only.
Warning: Any further operations on this package will only be allowed from SDR:
Warning: Owner.
Warning: If the package is meant to be added to the entire router, then please
Warning: stop this operation and perform the operation from the admin level.
Continue with the operation? [confirm]
Info: The following package is now available to be activated:
Info:
Info:     disk0:asr9k-mpls-4.3.2
Info:
Info: The package can be activated on the following SDR:
Info:
Info:     Owner
Info:
Install operation 3 completed successfully at 22:22:14 EDT Sun Jul 26 2009.
```

- Copy pie from tftp, harddisk, flash, or other source
- Unpack pie into destination directory in disk
- Does not restart processes or trigger any changes to functionality
- Displays package name to activate in next step

Install Activate

Activate (install) packages

```
RP/0/RSP0/CPU0:Nevada# install activate disk0:asr9k-mp1s-4.3.2 sync
Install operation 4 'install activate disk0:asr9k-mp1s-4.3.2 synchronous'
started by user 'ww' on SDR Owner via CLI at 22:24:50 EDT Sun Jul 26 2009.
Info:   Install Method: Parallel Process Restart
Info:   The changes made to software configurations will not be persistent
Info:   across system reloads. Use the command '(admin) install commit' to
Info:   make changes persistent.
Info:   Please verify that the system is consistent following the software
Info:   change using the following commands:
Info:       show system verify
Info:       install verify packages
Install operation 4 completed successfully at 22:25:38 EDT Sun Jul 26 2009.
```

- Restart appropriate processes or nodes with new software
- May trigger reboot, depending on software being activated
- New functions will be available once activation completes

Install Commit

Commit the active packages

```
RP/0/RSP0/CPU0:rasr9000-2w-a#admin install commit
Sun Jan 26 16:59:22.742 EST
Install operation 36 '(admin) install commit' started by user 'cisco' via CLI
at 16:59:22 EST Sun Jan 26 2014.
Install operation 36 completed successfully at 16:59:24 EST Sun Jan 26 2014.
RP/0/RSP0/CPU0:rasr9000-2w-a#admin show install committed summary
Sun Jan 26 16:59:44.478 EST
Default Profile:
SDRs:
Owner
Committed Packages:
disk0:asr9k-px-4.2.3.cscud37351-1.0.0
disk0:asr9k-px-4.2.3.cscug30234-1.0.0
disk0:asr9k-px-4.2.3.CSCuf32158-1.0.0
disk0:asr9k-px-4.2.3.cscue21083-1.0.0
disk0:asr9k-9000v-nV-px-4.2.3
disk0:asr9k-optic-px-4.2.3
disk0:asr9k-mini-px-4.2.3
disk0:asr9k-doc-px-4.2.3
disk0:asr9k-k9sec-px-4.2.3
.
```

- The active packages become committed for future system loads

Install Deactivate

Removing a package from “running”

```
RP/0/RSP0/CPU0:Nevada# show install active
Node 0/RSP0/CPU0 [RP] [SDR: Owner]
  Boot Device: disk0:
  Boot Image: /bootflash/disk0/asr9k-os-mbi-4.3.2/mbiasr9k-rp.vm
  Active Packages:
    disk0:asr9k-mpls-4.3.2
    disk0:asr9k-base-4.3.2.cscsy23972-1.0.0
    disk0:comp-asr9k-mini-4.3.2

RP/0/RSP0/CPU0:Nevada# install deactivate disk0:asr9k-mpls-4.3.2 sync
Install operation 6 'install deactivate disk0:asr9k-mpls-4.3.2 synchronous'
started by user 'ww' on SDR Owner via CLI at 22:28:55 EDT Sun Jul 26 2009.
Info:   Install Method: Parallel Process Restart
Info:   The changes made to software configurations will not be persistent
Info:   across system reloads. Use the command '(admin) install commit' to
Info:   make changes persistent.
Info:   Please verify that the system is consistent following the software
Info:   change using the following commands:
Info:       show system verify
Info:       install verify packages
Install operation 6 completed successfully at 22:29:49 EDT Sun Jul 26 2009.
```

- Package's features are no longer available
- Package is still “added” and on disk
- Package can be reactivated

Install Remove

Deleting packages from disk

```
RP/0/RSP0/CPU0:Nevada# install remove disk0:asr9k-mpls-4.3.2 sync
Install operation 9 'install remove disk0:asr9k-mpls-4.3.2 synchronous' started
by user 'ww' on SDR Owner via CLI at 22:35:08 EDT Sun Jul 26 2009.
Info: This operation will remove the following package:
Info: disk0:asr9k-mpls-4.3.2
Info: After this install remove the following install rollback point will
Info: no longer be reachable, as the required packages will not be present:
Info: 4
Proceed with removing these packages? [confirm]
Install operation 9 completed successfully at 22:35:12 EDT Sun Jul 26 2009.
```

- Package/PIE is completely removed
- **install remove inactive** available for cleaning up disk

Installation Log

Example

```
RP/0/RSP0/CPU0:rasr9000-2w-b#admin show install log reverse
Thu Jan  9 23:09:25.511 EST
Install operation 42 started by user 'cisco' via CLI at 21:27:00 EST Thu Jan 09 2014.
  (admin) install commit
  Install operation 42 completed successfully at 21:27:01 EST Thu Jan 09 2014.
-----
Install operation 41 started by user 'cisco' via CLI at 21:11:27 EST Thu Jan 09 2014.
  (admin) install rollback to 39
  Install operation 41 completed successfully at 21:12:22 EST Thu Jan 09 2014.
-----
Install operation 40 started at 14:11:08 UTC Thu Jan 02 2014.
  Reload of router to the committed software.
-----
Install operation 39 started by user 'cisco' via CLI at 17:18:32 EST Thu Dec 19 2013.
  (admin) install activate disk0:*4.3.1*
  Install operation 39 completed successfully at 17:27:56 EST Thu Dec 19 2013.
-----
Install operation 38 started by user 'cisco' via CLI at 17:17:24 EST Thu Dec 19 2013.
  (admin) install activate disk0:*4.3.1* test
  Install operation 38 completed successfully at 17:18:06 EST Thu Dec 19 2013.
```

Installation Entries

Example

```
RP/0/RSP0/CPU0:Nevada# show install log 6 detail
Install operation 6 started by user 'ww' on SDR Owner via CLI at 22:28:55 EDT
Sun Jul 26 2009.
install deactivate disk0:asr9k-mpls-4.3.2 synchronous
Install operation 6 completed successfully at 22:29:49 EDT Sun Jul 26 2009.
Install logs:
  Install operation 6 'install deactivate disk0:asr9k-mpls-4.3.2 synchronous'
  started by user 'ww' on SDR Owner via CLI at 22:28:55 EDT Sun Jul 26 2009.
    Info:      Install Method: Parallel Process Restart
    Info:      The changes made to software configurations will not be
    Info:      persistent across system reloads. Use the command '(admin)
    Info:      install commit' to make changes persistent.
    Info:      Please verify that the system is consistent following the
    Info:      software change using the following commands:
    Info:          show system verify
    Info:          install verify packages
  Install operation 6 completed successfully at 22:29:49 EDT Sun Jul 26 2009.

Summary:
  Sub-operation 1:
  Install method: Parallel Process Restart
  Summary of changes on node 0/RSP0/CPU0:
    Deactivated: asr9k-mpls-4.3.2
      6 asr9k-mpls processes affected (0 updated, 0 added, 6 removed, 0 impacted)
  Summary of changes on node 0/0/CPU0:
    Deactivated: asr9k-mpls-4.3.2
      1 asr9k-mpls processes affected (0 updated, 0 added, 1 removed, 0 impacted)
```

Cards' FPD

Verify/upgrade FPD version

```
RP/0/RSP0/CPU0:rasr9000-2w-b#admin show hw-module fpd location all
```

Existing Field Programmable Devices							
Location	Card Type	HW Version	Type	Subtype	Inst	Current SW Version	Upg/ Dng?
0/RSP0/CPU0	A9K-RSP440-SE	1.0	1c	cbc	0	16.115	No
			1c	fpga1	0	0.09	No
			1c	fpga2	0	1.06	No
			1c	fpga3	0	4.09	No
			1c	rommon	0	0.62	No
0/RSP0/CPU0	ASR-9006-FAN	1.0	1c	cbc	2	5.02	No
0/0/CPU0	A9K-24x10GE-SE	1.0	1c	cbc	0	19.110	No
			1c	fpga2	0	1.02	No
			1c	fpga3	0	1.01	No
			1c	fpga4	0	1.05	No
			1c	rommon	0	1.28	No
0/1/CPU0	A9K-MOD80-SE	1.0	1c	cbc	0	20.116	No
			1c	fpga2	0	1.01	No
			1c	fpga4	0	1.05	No
			1c	rommon	0	1.28	No

No == good. No change needed

```
RP/0/RSP0/CPU0:rasr9000-2w-a#admin upgrade hw-module fpd all location 0/1/CPU0
```

If LC1 needs upgrade

Cards' FPD

Verify/upgrade FPD version

```
RP/0/RSP0/CPU0:rasr9000-2w-a#admin show running-config
```

```
fpd auto-upgrade
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#admin upgrade hw-module fpd all location all  
Wed Jan 15 18:57:04.683 EST
```

```
***** UPGRADE WARNING MESSAGE: *****
```

```
* This upgrade operation has a maximum timeout of 160 minutes. *
* If you are executing the cmd for one specific location and *
* card in that location reloads or goes down for some reason *
* you can press CTRL-C to get back the RP's prompt. *
* If you are executing the cmd for _all_ locations and a node *
* reloads or is down please allow other nodes to finish the *
* upgrade process before pressing CTRL-C. *
```

```
% RELOAD REMINDER:
```

- The upgrade operation of the target module will not interrupt its normal operation. However, for the changes to take effect, the target module will need to be manually reloaded after the upgrade operation. This can be accomplished with the use of "hw-module <target> reload" command.
- If automatic reload operation is desired after the upgrade, please use the "reload" option at the end of the upgrade command.
- The output of "show hw-module fpd location" command will not display correct version information after the upgrade if the target module is not reloaded.

NOTE: Chassis CLI will not be accessible while upgrade is in progress.

Continue? [confirm]

Auto FPD upgrade configuration

Manual FPD upgrade

Satellite OS and Firmware

Verify/upgrade satellites

```
RP/0/RSP0/CPU0:rasr9000-2w-a#admin show install committed summary | include nv
Sat Dec 14 21:28:38.192 EST
    disk0:asr9k-9000v-nv-px-4.2.3
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show nv satellite status satellite 100
Sat Dec 14 20:55:00.733 EST
Satellite 100
```

```
-----
State: Connected (Stable)
Type: asr9000v
Description: r9000v-1y-a
MAC address: 8478.ac01.349c
IPv4 address: 10.100.111.100
Configured Serial Number: CAT1702U20H
Received Serial Number: CAT1702U20H
Remote version: Compatible (not latest version)
    ROMMON: 124.0 (Available: 125.0)
    FPGA: 1.13 (Latest)
    IOS: 200.5 (Available: 210.0)
```

```
Configured satellite fabric links:
    Bundle-Ether3
```

```
-----
State: Satellite Ready
Port range: GigabitEthernet0/0/0-29
Discovered satellite fabric links:
    TenGigE0/1/1/3: Satellite Ready; No conflict
    TenGigE0/1/0/3: Satellite Ready; No conflict
```



Host has a newer version

Satellite Upgrade

Prepare

```
RP/0/RSP0/CPU0:rasr9000-2w-a#admin show install committed summary | include nv
Sat Dec 14 21:28:38.192 EST
disk0:asr9k-9000v-nv-px-4.2.3
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show running-config control-plane management-plane inband
Sat Dec 14 21:29:28.655 EST
control-plane
management-plane
inband
  interface Bundle-Ether3
    allow TFTP
!
!
!
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#install nv satellite 100 transfer
Sat Dec 14 21:24:28.826 EST
Install operation initiated successfully.
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show logging | inc transfer
Sat Dec 14 21:24:31.977 EST
```

```
RP/0/RSP0/CPU0:Dec 14 21:23:19.083 : icpe_gco[1149]: %PKT_INFRA-ICPE_GCO-6-TRANSFER_DONE : Image transfer completed on Satellite 100
```

Satellite Upgrade

Upgrade

```
RP/0/RSP0/CPU0:rusr9000-2w-a#install nv satellite 100 activate
Sat Dec 14 21:25:26.000 EST
WARNING: This install operation will reload the requested satellite(s)
Do you wish to continue?[confirm(y/n)]
y
Install operation initiated successfully.
RP/0/RSP0/CPU0:rusr9000-2w-a#LC/0/1/CPU0:Dec 14 21:25:28.992 : ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface TenGigE0/1/1/3, changed state to Down
LC/0/1/CPU0:Dec 14 21:25:28.995 : ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface TenGigE0/1/0/3, changed state to Down
RP/0/RSP0/CPU0:Dec 14 21:25:28.999 : ifmgr[247]: %PKT_INFRA-LINK-3-UPDOWN : Interface GigabitEthernet100/0/0/11, changed state to Down
RP/0/RSP0/CPU0:Dec 14 21:25:28.999 : ifmgr[247]: %PKT_INFRA-LINK-3-UPDOWN : Interface GigabitEthernet100/0/0/9, changed state to Down
LC/0/1/CPU0:Dec 14 21:25:42.929 : pfm_node_1c[291]: %PLATFORM-XFP-2-LOW_RX_POWER_ALARM : Set|envmon_1c[172118]|XFP(0x102a003)|Port_0/03
LC/0/1/CPU0:Dec 14 21:25:42.929 : pfm_node_1c[291]: %PLATFORM-XFP-2-LOW_RX_POWER_ALARM : Set|envmon_1c[172118]|XFP(0x102a017)|Port_1/03
LC/0/1/CPU0:Dec 14 21:27:04.331 : ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface TenGigE0/1/0/3, changed state to Up
LC/0/1/CPU0:Dec 14 21:27:04.332 : ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface TenGigE0/1/1/3, changed state to Up
LC/0/1/CPU0:Dec 14 21:27:04.334 : ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface TenGigE0/1/0/3, changed state to Down
LC/0/1/CPU0:Dec 14 21:27:04.339 : ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface TenGigE0/1/1/3, changed state to Down
LC/0/1/CPU0:Dec 14 21:27:05.337 : ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface TenGigE0/1/0/3, changed state to Up
LC/0/1/CPU0:Dec 14 21:27:05.338 : ifmgr[201]: %PKT_INFRA-LINK-3-UPDOWN : Interface TenGigE0/1/1/3, changed state to Up
RP/0/RSP0/CPU0:Dec 14 21:27:08.659 : eem_ed_oir[191]: Messge received content : Event 0 NodeId: 0xffffffff
RP/0/RSP0/CPU0:Dec 14 21:27:08.660 : eem_ed_oir[191]: Messge received content : Event 0 NodeId: 0xffffffff
RP/0/RSP0/CPU0:Dec 14 21:27:09.210 : envmon[206]: %PLATFORM-ENVMON-2-SAT_FAN_MFGMEM : Fan MFGMEM failure - cleared on Satellite 100
RP/0/RSP0/CPU0:Dec 14 21:27:09.210 : envmon[206]: %PLATFORM-ENVMON-2-SAT_FAN_MISSING : Fan unit missing - cleared on Satellite 100
RP/0/RSP0/CPU0:Dec 14 21:27:09.210 : eem_ed_oir[191]: Messge received content : Event 0 NodeId: 0xffffffff
RP/0/RSP0/CPU0:Dec 14 21:27:09.210 : envmon[206]: %PLATFORM-ENVMON-2-SAT_BAT_FAL_A : Battery Failure A - cleared on Satellite 100
RP/0/RSP0/CPU0:Dec 14 21:27:09.210 : envmon[206]: %PLATFORM-ENVMON-2-SAT_BAT_FAL_B : Battery Failure B - cleared on Satellite 100
RP/0/RSP0/CPU0:Dec 14 21:27:09.244 : ifmgr[247]: %PKT_INFRA-LINK-3-UPDOWN : Interface GigabitEthernet100/0/0/9, changed state to Up
RP/0/RSP0/CPU0:Dec 14 21:27:09.612 : ifmgr[247]: %PKT_INFRA-LINK-3-UPDOWN : Interface GigabitEthernet100/0/0/11, changed state to Up
```

Satellite Upgrade

Verify

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show nv satellite status satellite 100
```

```
Sat Dec 14 21:27:24.660 EST
```

```
Satellite 100
```

```
-----  
State: Connected (Stable)
```

```
Type: asr9000v
```

```
Description: r9000v-1y-a
```

```
MAC address: 8478.ac01.349c
```

```
IPv4 address: 10.100.111.100
```

```
Configured Serial Number: CAT1702U20H
```

```
Received Serial Number: CAT1702U20H
```

```
Remote version: Compatible (latest version)
```

```
ROMMON: 125.0 (Latest)
```

```
FPGA: 1.13 (Latest)
```

```
IOS: 210.0 (Latest)
```

```
Configured satellite fabric links:
```

```
Bundle-Ether3
```

```
-----  
State: Satellite Ready
```

```
Port range: GigabitEthernet0/0/0-29
```

```
Discovered satellite fabric links:
```

```
TenGigE0/1/0/3: Satellite Ready; No conflict
```

```
TenGigE0/1/1/3: Satellite Ready; No conflict
```

Based on host package
asr9k-9000v-nV-px-4.2.3

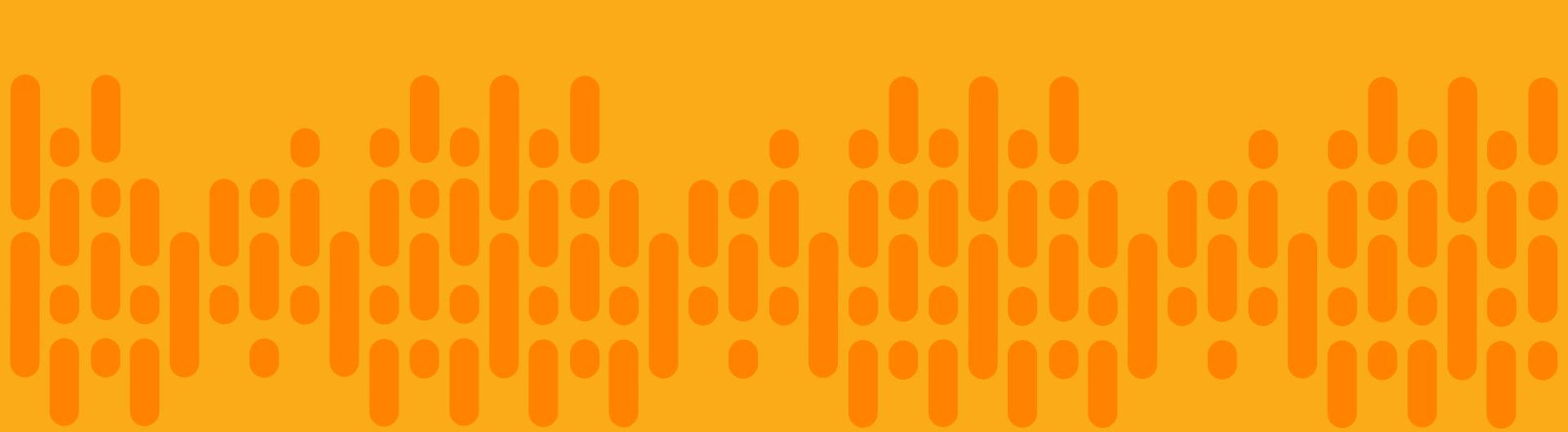
Package Installation Process Summary

- PIE install used once system is operational
- Packages can be added or upgraded
 - Versions of all packages must be consistent
- Install from Exec or Admin Mode
- 3 phase install
 1. Add – Copy package and unpack
 2. Activate – Start new code
 3. Commit – Lock down installed code
- FPD check – Satellite upgrade – Remove old

System Reloading Operation Difference

XR 64 Bit	cXR
<ul style="list-style-type: none">• 2 VMs on each of RSP/RP/LC CPU. Reloading can happen at VM (Admin/XR), hardware module and whole chassis level• “reload” command from XR CLI only reload XR VM• “reload” command from Admin CLI reload VMs (Admin VM, XR VM or all VMs) only• “hw-module location \$location reload” from Admin CLI to reload specific module or the whole chassis.	<ul style="list-style-type: none">• No VMs. Reloading only happens at hardware module(each RSP/RP/LC) or whole chassis level.• “reload” command from XR CLI only reload the corresponding RSP/RP node• “reload” command from Admin CLI reload the specified hardware module. “Reload location all” reloads the whole chassis• “hw-module location \$location reload” from Admin CLI to reload specific module

FPD upgrading requires Module/Chassis Reload. VM level reloading does not make new FPD effective

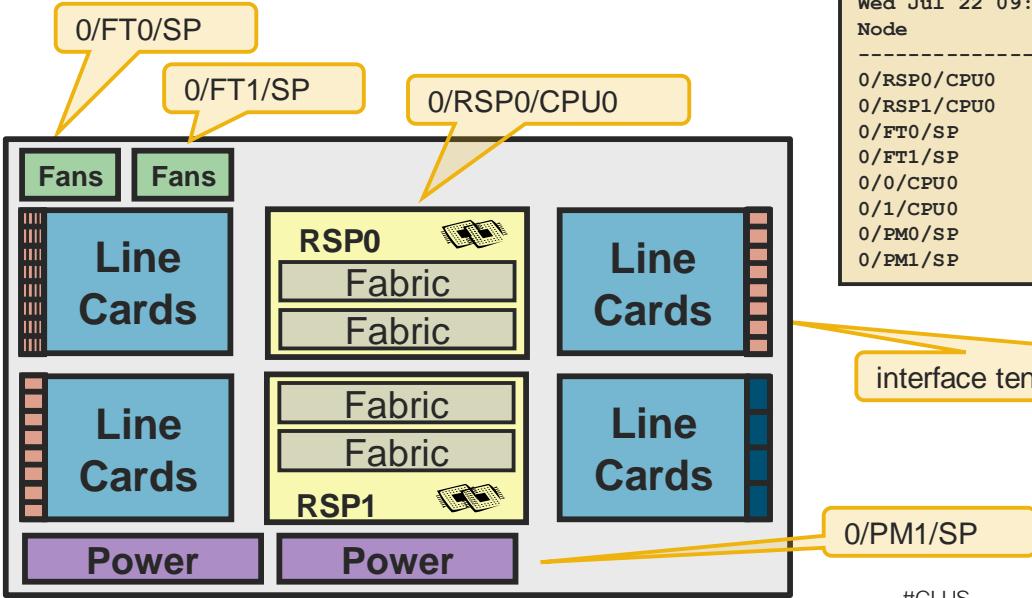


Configuration: Numbering Scheme

Inventory and Addressing

Exec and admin modes

- XR interfaces use 4-5 layer naming
 - Rack (0 for single chassis)
 - /Slot (0+ for LC, RSP0, RSP1)
 - /Bay (0, 0+ on MOD and SIP)
 - /Port (0+)
 - .Subinterface/EFP (optional)

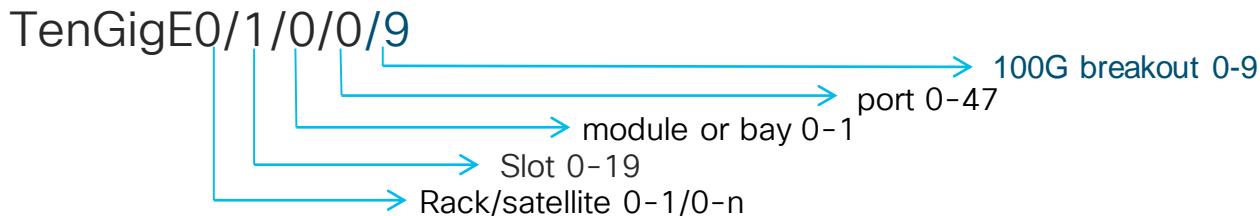


```
RP/0/RSP1/CPU0:viking-1#show platform
Node          Type           State        Config State
---           ---           ---          ---
A9K-RSP-4G(Standby)  IOS XR RUN    PWR,NSHUT,MON
0/RSP1/CPU0      A9K-RSP-4G(Active) IOS XR RUN    PWR,NSHUT,MON
0/0/CPU0        A9K-40GE-E     IOS XR RUN    PWR,NSHUT,MON
0/1/CPU0        A9K-8T/4-B     IOS XR RUN    PWR,NSHUT,MON
                                         0/RSP0/CPU0
```

```
RP/0/RSP1/CPU0:viking-1#admin show platform
Wed Jul 22 09:23:32.482 EST
Node          Type           State        Config State
---           ---           ---          ---
0/RSP0/CPU0      A9K-RSP-4G(Standby) IOS XR RUN    PWR,NSHUT,MON
0/RSP1/CPU0      A9K-RSP-4G(Active)  IOS XR RUN    PWR,NSHUT,MON
0/FT0/SP        FAN TRAY       READY
0/FT1/SP        FAN TRAY       READY
0/0/CPU0        A9K-40GE-E     IOS XR RUN    PWR,NSHUT,MON
0/1/CPU0        A9K-8T/4-B     IOS XR RUN    PWR,NSHUT,MON
0/PM0/SP        A9K-3KW-AC    READY
0/PM1/SP        A9K-3KW-AC    READY
```

#CLUS

Interface/Component Numbering Scheme



```
RP/0/RP0/CPU0:asr9k#show platform
```

Node	Type	State	Config State
<hr/>			
<snip>			
0/1/CPU0	A9K-24x10GE-SE	IOS XR RUN	PWR , NSHUT , MON

TenGigE0/1/0/0

up to

TenGigE0/1/0/23

port numbering always begins at 0 for
any LineCard, MPA, or SPA

Cisco live!

Rack/Slot/Module/Port

```
RP/0/RSP0/CPU0:asr9001(admin)#show platform
```

Node	Type	State	Config State
0/RSP0/CPU0	ASR9001-RP(Active)	IOS XR RUN	PWR ,NSHUT ,MON
0/FT0/SP	FAN TRAY	READY	
0/0/CPU0	ASR9001-LC	IOS XR RUN	PWR ,NSHUT ,MON
0/0/0	A9K-MPA-4X10GE	OK	PWR ,NSHUT ,MON
0/0/1	A9K-MPA-4X10GE	OK	PWR ,NSHUT ,MON
0/PM0/SP	A9K-750W-AC	READY	PWR ,NSHUT ,MON

```
RP/0/RSP0/CPU0:asr9001-nV-Edge(admin)#show platform
```

Node	Type	State	Config State
0/RSP0/CPU0	ASR9001-RP(Active)	IOS XR RUN	PWR ,NSHUT ,MON
0/FT0/SP	FAN TRAY	READY	
0/0/CPU0	ASR9001-LC	IOS XR RUN	PWR ,NSHUT ,MON
0/0/0	A9K-MPA-20X1GE	OK	PWR ,NSHUT ,MON
0/0/1	A9K-MPA-4X10GE	OK	PWR ,NSHUT ,MON
0/PM0/SP	A9K-750W-DC	READY	PWR ,NSHUT ,MON
1/RSP0/CPU0	ASR9001-RP(Active)	IOS XR RUN	PWR ,NSHUT ,MON
1/FT0/SP	FAN TRAY	READY	
1/0/CPU0	ASR9001-LC	IOS XR RUN	PWR ,NSHUT ,MON
1/0/0	A9K-MPA-20X1GE	OK	PWR ,NSHUT ,MON
1/0/1	A9K-MPA-2X10GE	OK	PWR ,NSHUT ,MON
1/PM0/SP	A9K-750W-DC	READY	PWR ,NSHUT ,MON

A cluster node

ASR9K CPAK - Mode-Change CLI



- Configuration happens at exec-config level
- Example Config:
- *hw-module location 0/0/cpu0 port 0 breakout 2xFortyGigE*
- *hw-module location 0/0/cpu0 port 1 breakout 10xTenGigE*

- Decide which Port ? and at what Speed ?
- Each CPAK port can have different speed (10,40 or 100). 100G is default.
- Reload of Line card is not necessary after rate change on ASR9K.

ASR9K CPAK - 5 Tuple Port Numbering

- 10G interface: *Interface Tengig0/5/0/1/0-9* (qty=10 TenGig ports)



- *Rack, Slot, Instance (Bay/EP), Port (physical plughole), Breakout port*
- 40G Interface¹: *Interface FortyGige0/0/0/0/0-1* (qty=2 FortyGig ports)
- There is no Gige interface in 530
- 5 Tuple only applies to 10G and 40G¹ speeds
- 100G speeds remain as 4 Tuple. (HunGig0/0/0/0)

* 40G is not supported in 5.3

ASR9K CPAK - 5 Tuple Port Numbering - Example 1

Node, port numbering - with slice A9K-8x100GE-SE

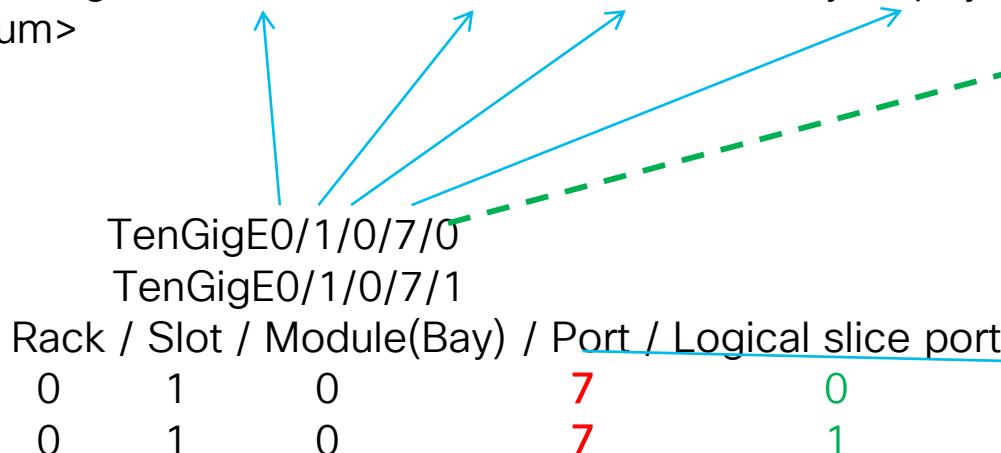
RP/0/RP0/CPU0:ASR9K#show run | i module

Building configuration...

hw-module location 0/1/CPU0 port 7 breakout 10xTenGigE

- 10G interfaces uses 5th octet for breakout-10GE-port numbering

TenGigE<rack_num>/<slot_id>/<module/Bay>/<physical-port_num>/<breakout-port-num>



slice	100GE port	10GE port
0	0	0-9
	1	0-9
1	2	0-9
	3	0-9
2	4	0-9
	5	0-9
3	6	0-9
	7	0-9

ASR9K CPAK - 5 Tuple Port Numbering - Example 2

Interface Order

hw-module location 0/1/CPU0 port **7** breakout **10xTenGigE**

- **10G interfaces uses 5th octet for breakout-10GE-port numbering**

TenGigE<rack_num>/<slot_id>/<module/Bay>/<physical-port_num>/<breakout-port-num>

A9K-8x100GE-SE

HundredGigE0/1/0/0	10.1.50.1	Down	Down
HundredGigE0/1/0/1	unassigned	Down	Down
HundredGigE0/1/0/2	unassigned	Shutdown	Down
HundredGigE0/1/0/3	unassigned	Shutdown	Down
HundredGigE0/1/0/4	unassigned	Shutdown	Down
HundredGigE0/1/0/5	unassigned	Up	Up
HundredGigE0/1/0/6	unassigned	Shutdown	Down
TenGigE0/1/0/ 7/0	10.1.10.1	Up	Up
TenGigE0/1/0/ 7/1	10.1.11.1	Up	Up
<snip>			
TenGigE0/1/0/ 7/8	10.1.12.1	Up	Up
TenGigE0/1/0/ 7/9	10.1.14.1	Up	Up

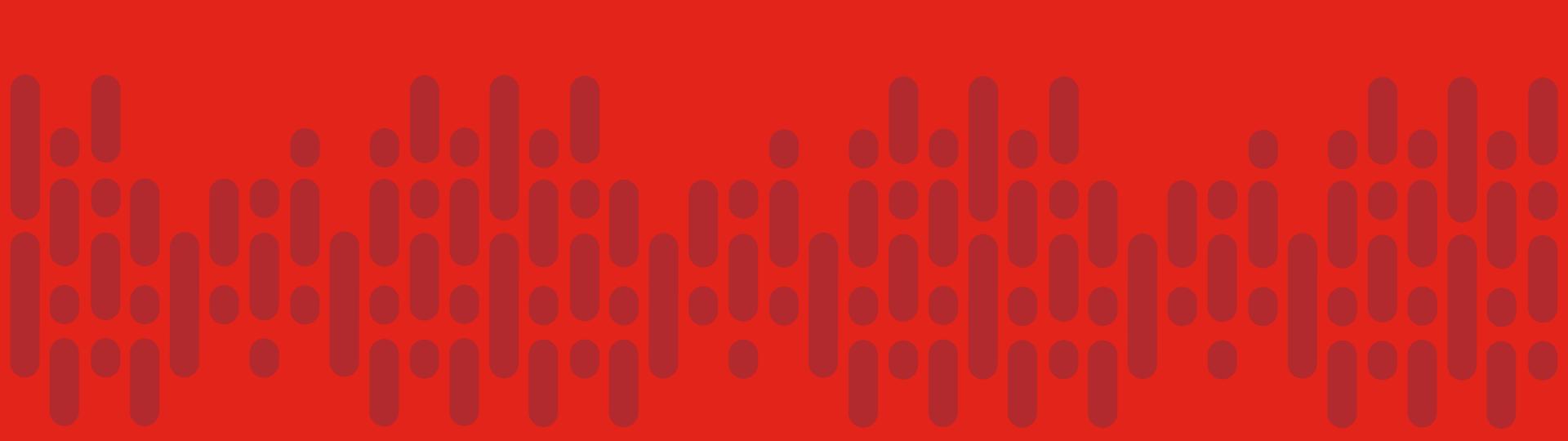
- 1) Baseline this is an 8x100GE LC ports 0-7
- 2) We have broken out 100GE port 7 into a 10x10GE breakout, so we no longer have a 100GE port 7
- 3) We now have 10x10GE ports from TenGigE0/1/0/7/0 - TenGigE0/1/0/7/9
- 4) We still have 7x100GE ports left, HundredGigE0/1/0/0 - HundredGigE0/1/0/6

ASR9K Tomahawk 8x100GE Example 3

Node, port numbering - with slice

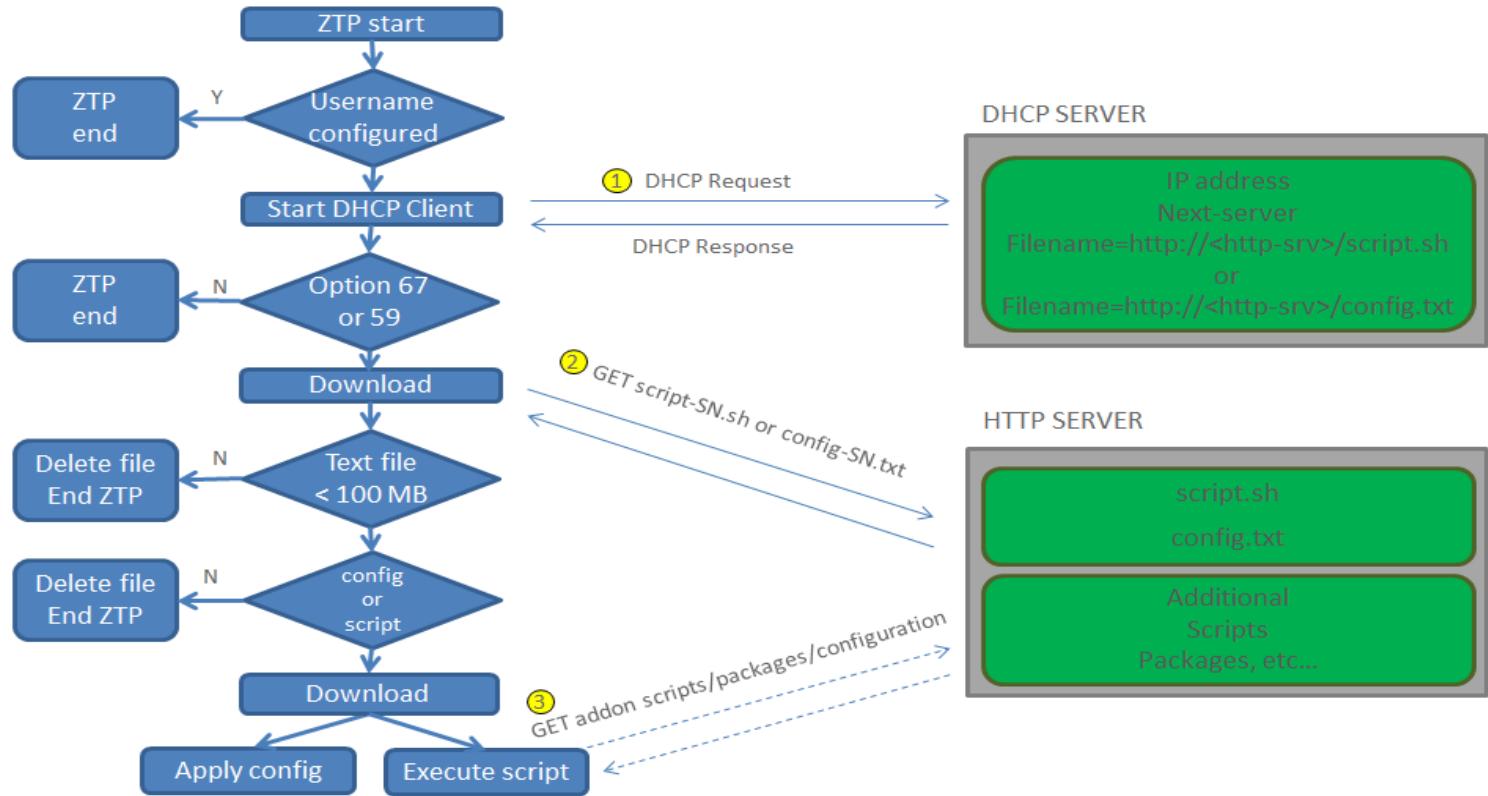
```
RP/0/RP0/CPU0:asr9922#show run | i hw-module
Building configuration...
hw-module location 0/1/CPU0 port 4 breakout 10xTenGigE
hw-module location 0/1/CPU0 port 6 breakout 10xTenGigE
..
RP/0/RP0/CPU0:asr9922#show platform slices
Line Card    Slice Config      Status
0/1/CPU0     0      Power on   Completed
              1      Power on   Completed
              2      Power on   Completed
              3      Power on   Completed
..<snip>
RP/0/RP0/CPU0:asr9922#show controller np ports all loc 0/1/cpu0
    Node: 0/1/CPU0:
-----
NP Bridge Fia          Ports
-----
0 -- 0 HundredGigE0/1/0/0 - HundredGigE0/1/0/1
1 -- 1 HundredGigE0/1/0/2 - HundredGigE0/1/0/3
2 -- 2 TenGigE0/1/0/4/0 - TenGigE0/1/0/4/9, HundredGigE0/1/0/5
3 -- 3 TenGigE0/1/0/6/0 - TenGigE0/1/0/6/9, HundredGigE0/1/0/7
RP/0/RP0/CPU0:asr9922#
```

slice	100GE port	10GE port
0	0	0-9
	1	0-9
1	2	0-9
	3	0-9
2	4	0-9
	5	0-9
3	6	0-9
	7	0-9



Zero Touch Provisioning

ZTP Tools & Process: DHCP & HTTP



ZTP: Outcomes and Process

- Upgrade: Download and install packages
- Script: Download and run a shell script
- Configure: Download and commit a config file
- You need to:
 - Test
 - Verify: Error checking – build in process
 - Validate: Validate the node functionality [control and forwarding] – automate

HTTP Server: XR Config file

```
cisco@mamikhai-ubuntu:~$ more /var/www/html/ztp/pe125-config-initial.txt  
!! IOS XR Configuration version = 6.2.1
```

```
!  
hostname PE125  
group ISIS-P2P  
router isis 'ISIS'  
  interface 'GigabitEthernet0/0/0/0\..+'  
    point-to-point  
!  
!  
end-group  
clock timezone EST America/New_York  
domain name cisco.com  
  
interface Loopback0  
  ipv4 address 10.101.125.1 255.255.255.255  
  ipv6 address 2001:db8:125::1/128  
!  
interface GigabitEthernet0/0/0/0  
  mtu 4470  
!  
interface GigabitEthernet0/0/0/0.300 12transport  
  encapsulation dot1q 300  
!  
interface GigabitEthernet0/0/0/0.1225  
.
```

File start:
!! IOS XR == XR config

HTTP Server: XR Script

```
cisco@mamikhai-ubuntu:~$ more /var/www/html/ztp/pe125-script.sh
#!/bin/bash

source ztp_helper.sh
config_file='/disk0:/ztp/tmp/config.txt'
config_log='/disk0:/ztp/customer/config-log.txt'

/bin/touch $config_log

if [ -f $config_file ]; then
    /bin/rm -f $config_file
else
    /bin/touch $config_file
fi

echo 'username cisco' >> $config_file
echo 'group root-lr' >> $config_file
echo 'group cisco-support' >> $config_file
echo 'secret cisco' >> $config_file
echo 'interface MgmtEth0/RP0/CPU0/0' >> $config_file
echo '    ipv4 address 192.168.30.125 255.255.255.0' >> $config_file
echo '    no shutdown' >> $config_file
echo 'netconf-yang agent' >> $config_file
echo '    ssh' >> $config_file
echo 'ssh server v2' >> $config_file
echo 'ssh server netconf vrf default' >> $config_file
```

File start:
#!/bin/bash == script

HTTP Server: XR Script - continued

```
xrapply_with_reason 'Initial ZTP config' $config_file

if [[ -z $(xrcmd "show crypto key mypubkey rsa") ]]; then
    echo "2048" | xrcmd "crypto key generate rsa"
else
    echo -ne "yes\n 2048\n" | xrcmd "crypto key generate rsa"
fi

xrcmd 'show running-config' >> $config_log
xrcmd 'show configuration failed' >> $config_log
xrcmd 'show crypto key mypubkey rsa' >> $config_log
```

+ can prep ssh ☺
[for NETCONF]

```
cisco@mamikhai-ubuntu:~$ ll /var/www/html/ztp/
total 40
drwxr-xr-x 2 root root 4096 Oct 22 08:52 .
drwxr-xr-x 3 root root 4096 Aug 7 11:26 ../
-rw-r--r-- 1 root root 513 Oct 18 19:46 pe125-config-initial.txt
-rw-r--r-- 1 root root 8503 Oct 18 08:14 pe125-config.txt
.
-rw-r--r-- 1 root root 1090 Oct 22 08:52 pe125-script.sh
```

Served by HTTP server

DHCP Server: Initial Parameters & Pointer

```
cisco@mamikhai-ubuntu:~$ more /etc/dhcp/dhcpd.conf

# option definitions common to all supported networks...
option domain-name "cisco.com";
option domain-name-servers 171.70.168.183, 64.102.6.247;

default-lease-time 600;
max-lease-time 7200;

subnet 192.168.30.0 netmask 255.255.255.0 {
}

.

host PE125 {
    hardware ethernet 00:50:56:85:da:18;
    fixed-address 192.168.30.125;
    option routers 192.168.30.1;
    filename "http://192.168.30.101/ztp/pe125-script.sh";
}
```

ZTP Node Ready for NETCONF

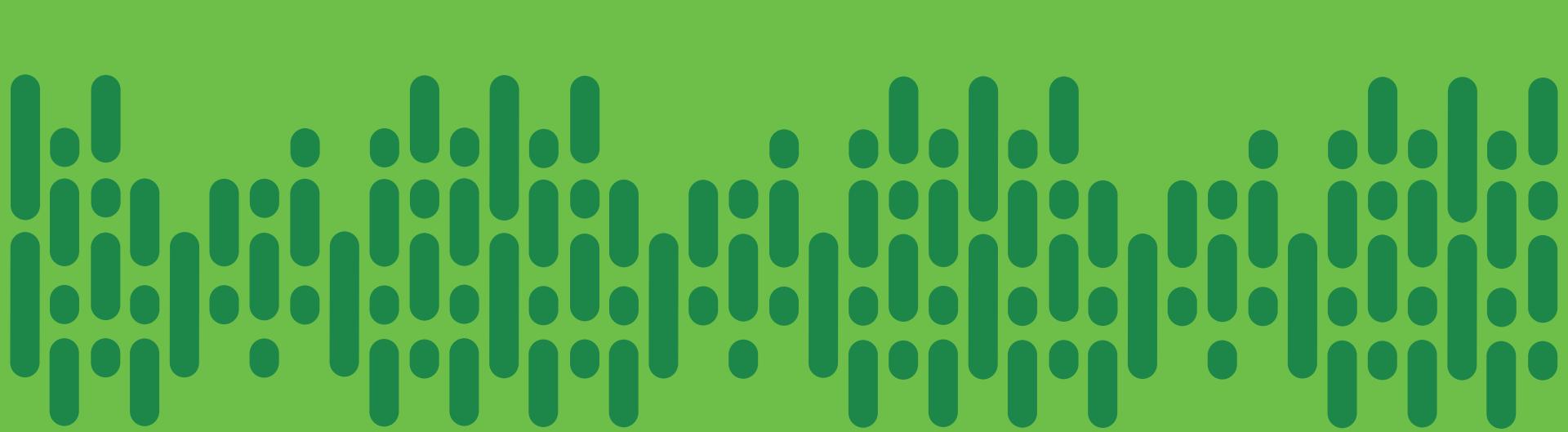
```
<?xml version="1.0" encoding="UTF-8"?><data
xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0">

<interface-configuration>
<active>act</active>
<interface-name>MgmtEth0/RP0/CPU0/0</interface-name>
<ipv4-network xmlns="http://cisco.com/ns/yang/Cisco-IOS-
XR-ipv4-io-cfg">
<addresses>
<primary>
<address>192.168.30.125</address>
<netmask>255.255.255.0</netmask>
</primary>
</addresses>
</ipv4-network>
</interface-configuration>

<ssh xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-crypto-
ssh-cfg">
<server>
<v2/>
<netconf-vrf-table>
<vrf>
<vrf-name>default</vrf-name>
<enable/>
</vrf>
</netconf-vrf-table>
</server>
</ssh>
```

```
<netconf-yang xmlns="http://cisco.com/ns/yang/Cisco-IOS-XR-
man-netconf-cfg">
<agent>
<ssh>
<enable/>
</ssh>
</agent>
</netconf-yang>

<aaa xmlns="http://tail-f.com/ns/aaa/1.1">
<authentication>
<users>
<user>
<name>cisco</name>
<uid>9000</uid>
<gid>100</gid>
<password>$1$glu0$OEyQD/4ePFuNrZ2d0xtQo0</password>
<ssh_keydir>/var/confd/homes/cisco/.ssh</ssh_keydir>
<homedir>/var/confd/homes/cisco</homedir>
</user>
</users>
<groups>
<group>
<name>aaa-r</name>
<gid>100</gid>
<users>%__system_user__%</users>
</group>
<group>
<name>admin-r</name>
<gid>100</gid>
<users>%__system_user__%</users>
```

A decorative header element consisting of a repeating pattern of green vertical bars of varying heights, creating a textured, bar-like appearance.

Configuration: NetConf-YANG

Configure NetConf over SSH

Pre-requisites: Manageability Package and SSH Service

```
RP/0/RSP1/CPU0:rasr9000-2w-a#admin show install active
summary
Fri Dec 4 00:44:26.004 EST
Default Profile:
SDRs:
  Owner
Active Packages:
disk0:asr9k-services-infra-5.3.1
disk0:asr9k-bng-px-5.3.1
disk0:asr9k-video-px-5.3.1
disk0:asr9k-mgb1-px-5.3.1
disk0:asr9k-mcast-px-5.3.1
disk0:asr9k-k9sec-px-5.3.1
disk0:asr9k-services-px-5.3.1
disk0:asr9k-optic-px-5.3.1
disk0:asr9k-mpls-px-5.3.1
disk0:asr9k-doc-px-5.3.1
disk0:asr9k-fpd-px-5.3.1
disk0:asr9k-9000v-nv-px-5.3.1
disk0:asr9k-li-px-5.3.1
disk0:asr9k-mini-px-5.3.1
```

```
RP/0/RSP1/CPU0:rasr9000-2w-a#crypto key generate rsa
Fri Dec 4 00:44:47.039 EST
The name for the keys will be: the_default
Choose the size of the key modulus in the range of 512
to 4096 for your General Purpose Keypair. Choosing a key
modulus greater than 512 may take a few minutes.
```

```
How many bits in the modulus [1024]:
Generating RSA keys ...
Done w/ crypto generate keypair
[OK]
```

```
RP/0/RSP1/CPU0:rasr9000-2w-a#configure
Fri Dec 4 00:45:02.974 EST
RP/0/RSP1/CPU0:rasr9000-2w-a(config)#ssh server v2
RP/0/RSP1/CPU0:rasr9000-2w-a(config)#commit
Fri Dec 4 00:45:10.994 EST
RP/0/RSP1/CPU0:rasr9000-2w-a(config)#
RP/0/RSP1/CPU0:rasr9000-2w-a#
```

Configure NetConf over SSH

NETCONF – YANG – SSH Port

```
RP/0/RSP1/CPU0:rusr9000-2w-a#show running-config | begin  
netconf  
Fri Dec 4 02:45:23.593 EST  
Building configuration...  
netconf agent tty  
!  
netconf-yang agent  
ssh  
!  
ssh server v2  
ssh server netconf port 830  
. .
```

```
RP/0/0/CPU0:PE178#ssh 10.101.137.1 username cisco source-interface  
loopback 0 command netconf format  
.  
Password:  
. .  
<?xml version="1.0" encoding="UTF-8"?>  
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">  
  <capabilities>  
    <capability>  
      urn:ietf:params:netconf:base:1.0  
    </capability>  
    <capability>  
      urn:ietf:params:netconf:capability:candidate:1.0  
    </capability>  
    <capability>  
      urn:ietf:params:netconf:capability:notification:1.0  
    </capability>  
  </capabilities>  
  <session-id>  
    285212672  
  </session-id>  
</hello>  
]]>]]>
```

NETCONF Example: <get-config> Operation

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc message-id="101"
xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<get-config>
  <source>
    <running/>
  </source>
  <filter>
    <Configuration>
      <InterfaceConfigurationTable>
        <InterfaceConfiguration>
          <Naming>
            <Active>act</Active>
            <InterfaceName Match="Loopback.*"/>
          </Naming>
        </InterfaceConfiguration>
      </InterfaceConfigurationTable>
    </Configuration>
  </filter>
</get-config>
</rpc>
]]>]]>
```

```
<?xml version="1.0" encoding="UTF-8"?>
<rpc-reply message-id="101"
xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
<data>
<Configuration>
<InterfaceConfigurationTable MajorVersion="5" MinorVersion="4">
<InterfaceConfiguration>
<Naming>
<Active>
  act
</Active>
<InterfaceName>
  Loopback0
</InterfaceName>
</Naming>
<InterfaceVirtual>
  true
</InterfaceVirtual>
<IPV4Network MajorVersion="6" MinorVersion="4">
<Addresses>
<Primary>
<Address>
  10.101.137.1
</Address>
<Netmask>
  255.255.255.255
</Netmask>
</Primary>
</Addresses>
</IPV4Network>
<IPV6Network MajorVersion="2" MinorVersion="3">
```

NETCONF-YANG

Sessions

```
RP/0/0/CPU0:PE178#show netconf-yang clients
```

Fri Dec 4 12:51:32.840 EST

Netconf clients

client session ID	NC version	client connect time	last OP time	last OP type	<lock>	No
20890	1.1	0d 0h 6m 12s	12:45:19	get		

```
RP/0/0/CPU0:PE178#show netconf-yang statistics
```

Fri Dec 4 12:51:37.999 EST

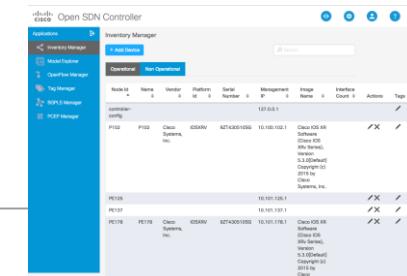
Summary statistics

	# requests	total time	min time per request	max time per request	avg time per request
other	0	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms
close-session	0	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms
kill-session	0	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms
get-schema	57	0h 0m 2s 489ms	0h 0m 0s 0ms	0h 0m 0s 319ms	0h 0m 0s 8ms
get	6	0h 0m 0s 669ms	0h 0m 0s 9ms	0h 0m 0s 299ms	0h 0m 0s 111ms
get-config	0	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms
edit-config	0	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms
commit	0	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms
cancel-commit	0	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms	0h 0m 0s 0ms

```
RP/0/0/CPU0:PE178#show tcp brief | include 830
```

Fri Dec 4 12:51:50.959 EST

0x1015b21c 0x60000000	0	0 :::830	:::0	LISTEN
0x101577b8 0x00000000	0	0 :::830	:::0	LISTEN
0x1015f728 0x60000000	0	0 10.101.178.1:830	192.168.30.102:35406	ESTAB
0x1015b064 0x60000000	0	0 0.0.0.0:830	0.0.0.0:0	LISTEN
0x10153fa0 0x00000000	0	0 0.0.0.0:830	0.0.0.0:0	LISTEN



XR XML Schema: Config & Operational

```
RP/0/0/CPU0:PE178#show xml schema  
Thu Sep 3 11:06:50.353 EDT
```

```
Username:cisco
```

```
Password:
```

```
Enter 'help' or '?' for help  
xml-schema[config]:> ls
```

[container]	AAA
[container]	AIB
[container]	ARP
[container]	BMP
[container]	BGP
[container]	BulkStatistics
[container]	LACP
[container]	CallHome
[container]	CDP
[container]	CEM
[container]	NETCONF_YANG
[container]	Clock
[container]	Crypto
AddressPoolService	
[container]	DHCPV6
[container]	HardwareModule
[container]	Exception
[container]	EIGRP
[container]	PolicyManager
[container]	ERP

```
xml-schema[config]:> oper  
xml-schema[oper]:> ls  
[container] AAA  
[container] AIB  
[container] ARP_GMP  
[container] ARP  
[container] BGP  
[container] BundlesAdjacency  
[container] Bundles  
[container] BundleInformation  
[container] LACPbundles  
[container] LACPbundleMembers  
[container] LACPData  
[container] CDP  
[container] CEM  
[container] CHDLC_MA  
[container] Cinetd  
[container] CLNS  
[container] CryptocertificateAuthority  
[container] CryptoEngine  
[container] IKE  
[container] IPSecStaticSessionInfo  
[container] IPSecDynamicSessionInfo  
.
```

[container]	ErrorDisable
[container]	ES_ACL
[container]	EventManager
[container]	LR
[container]	HSRP
[container]	HTTPC
[container]	HTTP
[container]	nvSatelliteTable
[container]	GenericInterfaceListTable
[container]	GlobalInterfaceConfiguration
[container]	InterfaceConfigurationTable
[container]	NSR
[container]	OneP
[container]	RCC
[container]	SLA
[container]	Statistics
[container]	Syslog
[container]	SyslogService
[container]	LISP
[container]	IPAddressPool
[container]	BFD
[container]	IPDomain
.	.

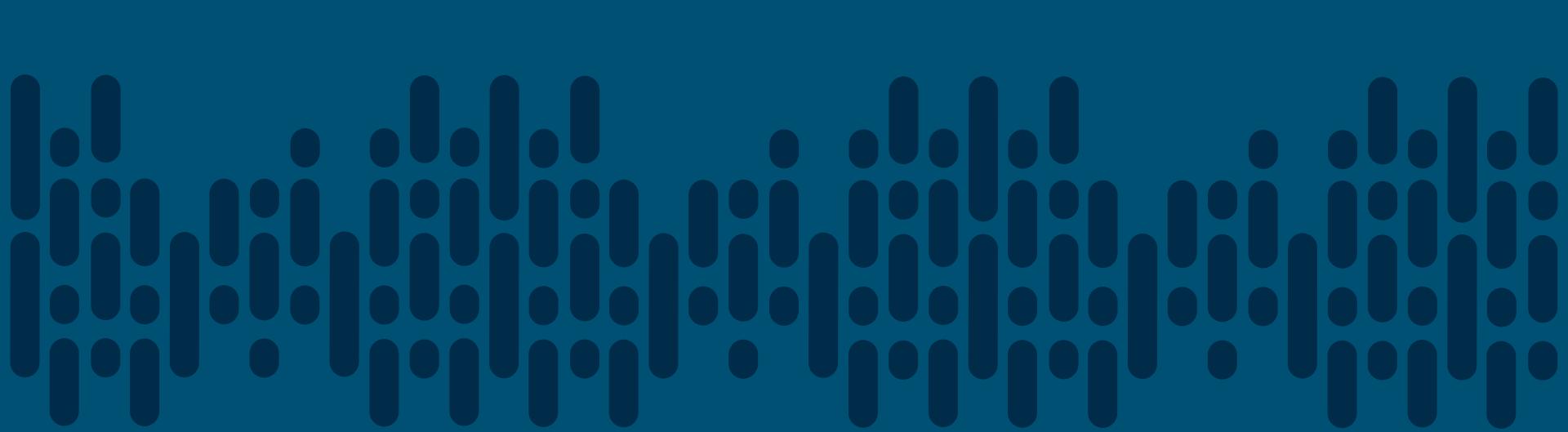
Open DayLight: NETCONF Mounting Nodes

Setting up network nodes to be controlled by the controller

The screenshot shows the OpenDayLight REST API Builder interface. The top navigation bar includes 'Runner', 'Import', 'Builder' (which is selected), 'Team Library', and various status indicators like 'IN SYNC'. The left sidebar lists available API endpoints categorized by method (PUT, DEL, GET) and name. The main workspace displays a 'node-add-mdsal-netconf' configuration. The 'Body' tab is selected, showing a PUT request to the URL `http://10.82.66.101:8181/restconf/config/network-topology:network-topology/topology=topology-netconf/node/PE124`. The request body is an XML document defining a new node configuration:

```
<node xmlns="urn:TBD:params:xml:ns:yang:network-topology">
<node-id>PE124</node-id>
<host xmlns="urn:opendaylight:netconf-node-topology">10.101.124.1</host>
<port xmlns="urn:opendaylight:netconf-node-topology">830</port>
<username xmlns="urn:opendaylight:netconf-node-topology">cisco</username>
<password xmlns="urn:opendaylight:netconf-node-topology">cisco</password>
<tcp-only xmlns="urn:opendaylight:netconf-node-topology">false</tcp-only>
</node>
```

The status bar at the bottom right indicates a successful response: 'Status: 201 Created Time: 102 ms'.



Configuration: Command Line [CLI]

Command Modes

Exec, exec config, admin, admin config

Exec – Normal operations – monitoring interfaces, routing, CEF, and VPNs

```
RP/0/RSP1/CPU0:viking-1#
show ipv4 interface brief      show running-config
show install active          show cef summary location 0/5/CPU0
show 12vpn xconnect
```

Config – Normal configuration for router

```
RP/0/RSP1/CPU0:viking-1(config)#
router bgp 100           12vpn           policy-map foo
mpls ldp                 ipv4 access-list block-junk
```

Admin – Chassis operations (i.e. fans & power)

```
RP/0/RSP1/CPU0:viking-1(admin)#
Config-register <0x1922>      show platform
```

Admin Config – admin plane config

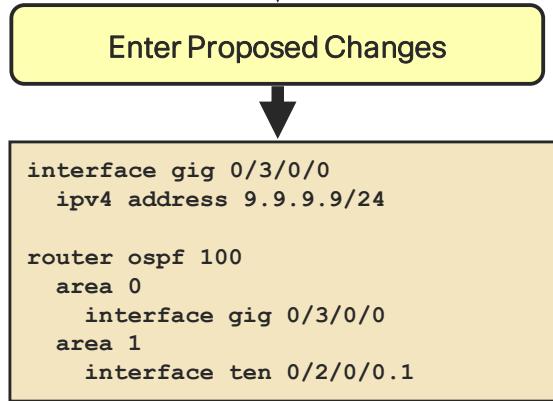
```
RP/0/RSP1/CPU0:viking-1(admin-config)#
username admin-root
```

XR Configuration Key Concepts

- Two Stage Commit
- Config History Database
- Rollback
- Atomic vs. Best Effort
- Multiple Config Sessions

Commit

Two stage



Active Configuration
Before Commit

```
hostname Leif
line default
exec-timeout 1440 0
!
taskgroup ops
task read boot
task write boot
task execute bgp
!
router static
```

Active Configuration
After Commit

```
hostname Leif
line default
exec-timeout 1440 0
!
Interface GigabitEthernet0/3/0/0
    ipv4 address 9.9.9.9/24
!
taskgroup ops
task read boot
task write boot
task execute bgp
!
router ospf 100
    area 0
        interface GigabitEthernet0/3/0/0
    area 1
        interface TenGigE0/2/0/0.1
!
router static
```

Commit

Changes take effect

Commit: Verification

Syntax by line, then logic at commit



Syntax Check
after each line

```
interface gig 0/3/0/0
  ipv4 address 9.9.9.9/24

router ospf 100
  area 0
    interface gig 0/3/0/0
  area 1
    interface ten 0/2/0/0.1
```

Target Configuration

Active Configuration
Before Commit

```
hostname Leif
line default
exec-timeout 1440 0
!
taskgroup ops
task read boot
task write boot
task execute bgp
!
router static
```

Active Configuration
After Commit

```
hostname Leif
line default
exec-timeout 1440 0
!
Interface GigabitEthernet0/3/0/0
  ipv4 address 9.9.9.9/24
!
taskgroup ops
task read boot
task write boot
task execute bgp
!
router ospf 100
  area 0
    interface GigabitEthernet0/3/0/0
  area 1
    interface TenGigE0/2/0/0.1
!
router static
```

Semantic Check
during commit

Commit: History and Labels

Keeping track of changes

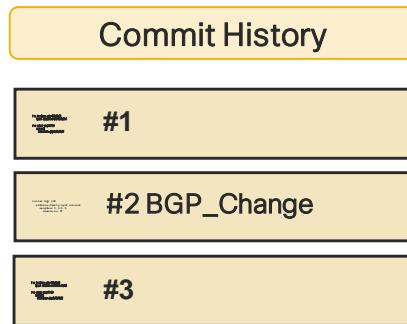


Enter Proposed Changes



```
interface gig 0/3/0/0
  ipv4 address 9.9.9.9/24

router ospf 100
  area 0
    interface gig 0/3/0/0
  area 1
    interface ten 0/2/0/0.1
```



Unique ID Automatically Generated

Earlier commit
with optional label

Changes added to commit history

Commit

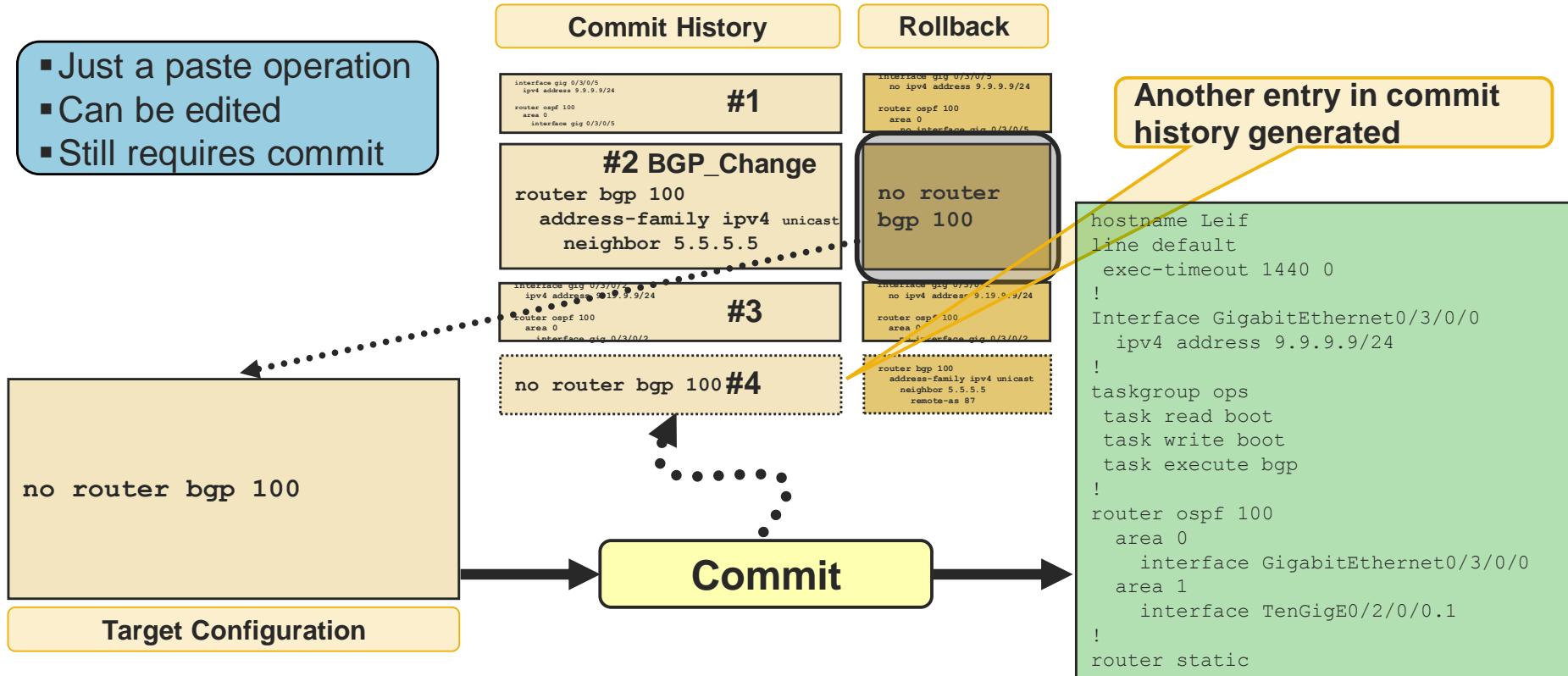
```
hostname Leif
line default
exec-timeout 1440 0
!
Interface GigabitEthernet0/3/0/0
  ipv4 address 9.9.9.9/24
!
taskgroup ops
  task read boot
  task write boot
  task execute bgp
!
router ospf 100
  area 0
    interface GigabitEthernet0/3/0/0
  area 1
    interface TenGigE0/2/0/0.1
!
router static
```

Target Configuration

Rollback a Specific Commit

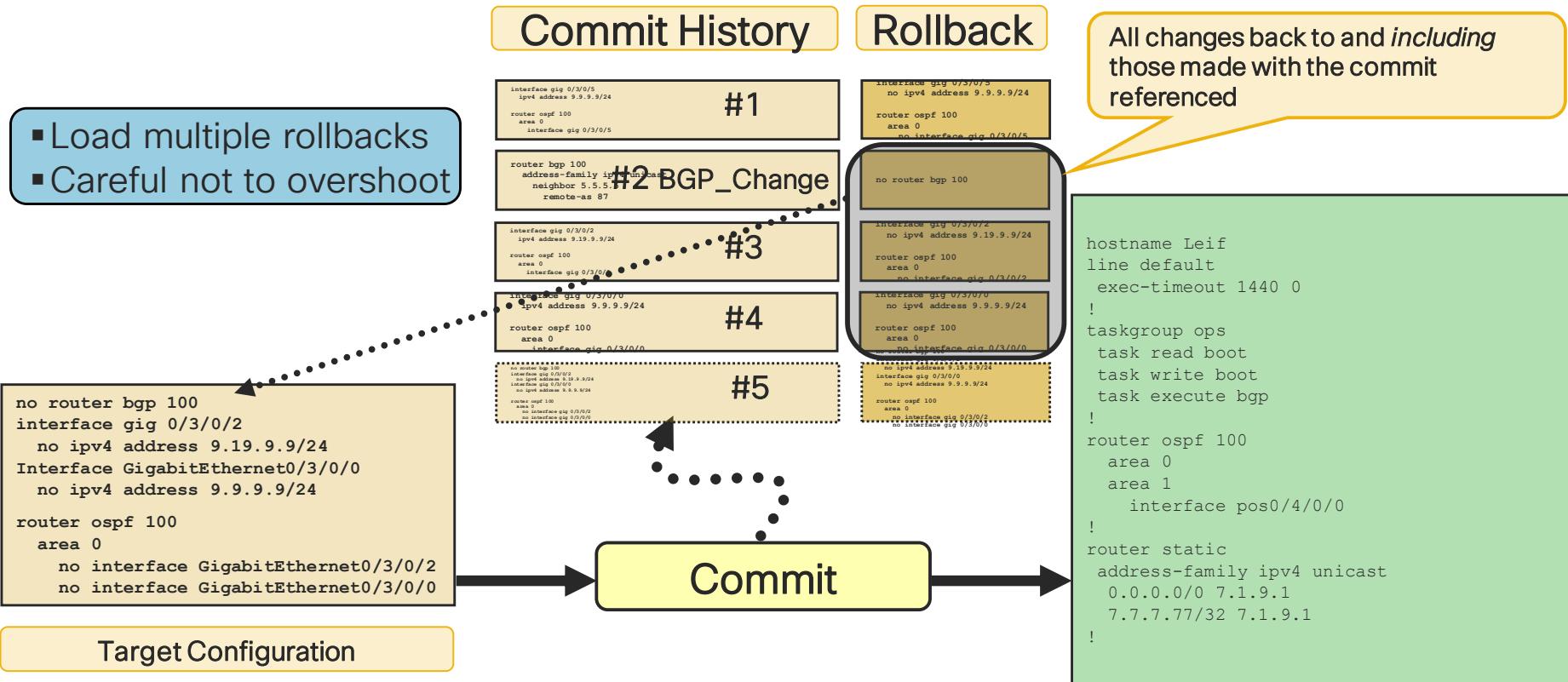
(config)#load rollback changes BGP_Change [or commit id]

- Just a paste operation
- Can be edited
- Still requires commit



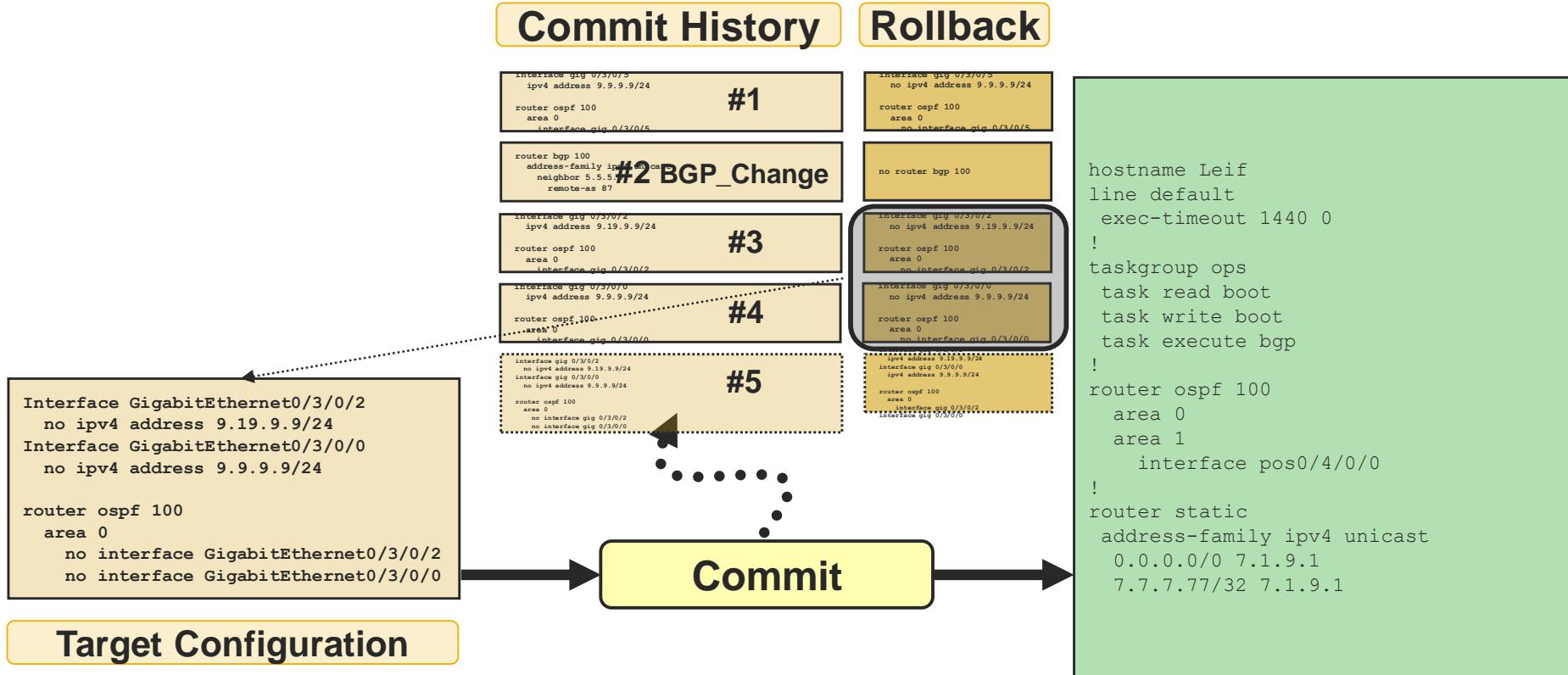
Rollback to Previous Commit

(config)#load rollback changes to BGP_Change (or commit id)



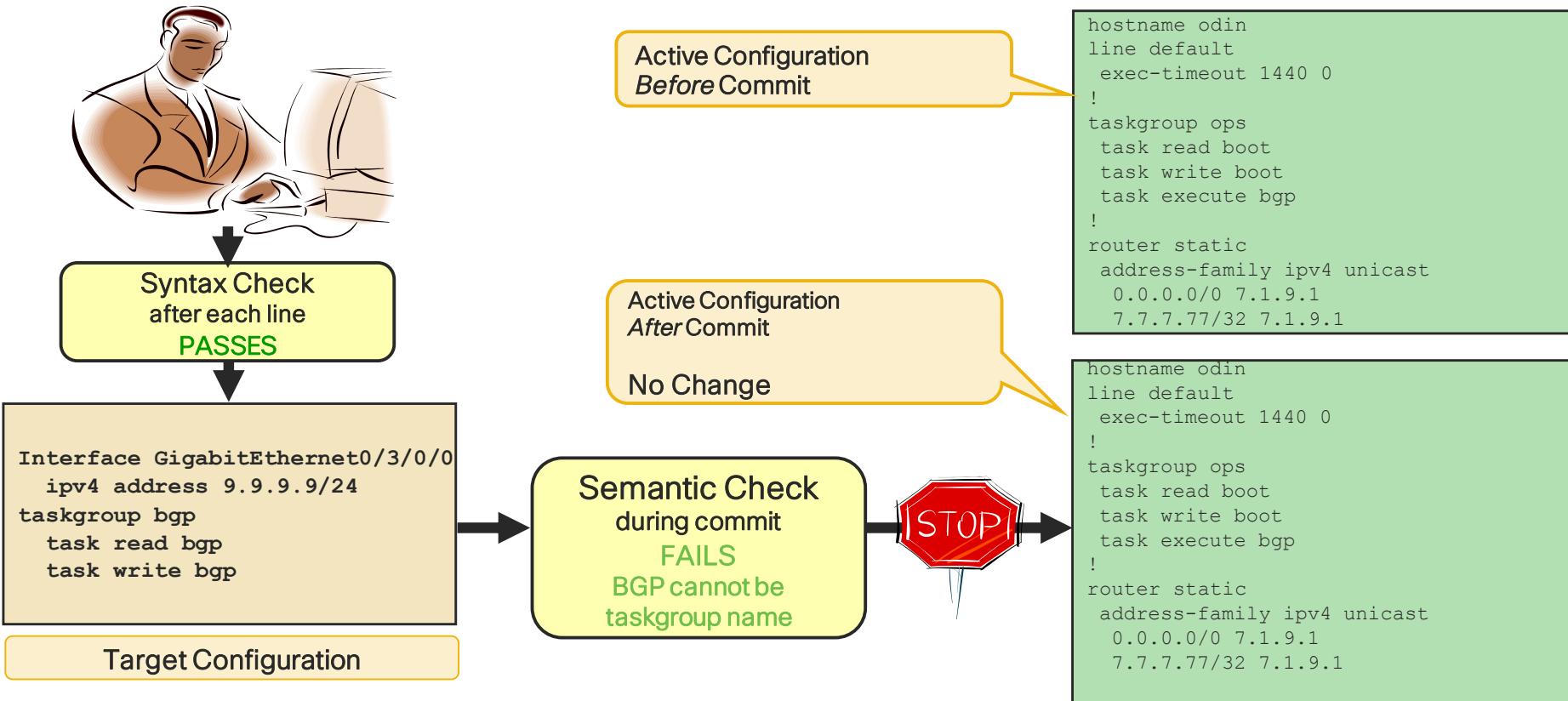
Rollback n Commits

(config)#load rollback changes last 2



Commit Behavior: Atomic

Commit all or nothing [default behavior]



Commit Behavior: Best Effort

Commit valid sections



Syntax Check
after each line
PASSES

```
Interface GigabitEthernet0/3/0/0
  ipv4 address 9.9.9.9/24
taskgroup bgp
  task read bgp
  task write bgp
```

Target Configuration

Active Configuration
Before Commit

```
hostname odin
line default
exec-timeout 1440 0
!
taskgroup ops
task read boot
task write boot
task execute bgp
!
router static
address-family ipv4 unicast
  0.0.0.0/0 7.1.9.1
  7.7.7.77/32 7.1.9.1
```

Active Configuration
After Commit

Partial Commit

Semantic Check
during commit
FAILS
BGP cannot be
taskgroup name



```
hostname Olav
line default
exec-timeout 1440 0
!
Interface GigabitEthernet0/3/0/0
  ipv4 address 9.9.9.9/24
!
taskgroup ops
task read boot
task write boot
task execute bgp
!
```

Atomic Configuration Replace – NEW Behavior

Replace/remove/add interface config lines without removing interface

1

Original Configuration

```
RP/0/RSP0/CPU0:PE1#sh run int gigabitEthernet 0/0/0/19
Mon Feb 16 13:00:32.153 UTC
interface GigabitEthernet0/0/0/19
description ***AAABBBCCC***
cdp
ipv4 address 13.3.5.5 255.255.255.0
negotiation auto
shutdown
load-interval 30
!
```

2

Target Configuration

```
RP/0/RSP0/CPU0:PE1(config)#no interface GigabitEthernet0/0/0/19
RP/0/RSP0/CPU0:PE1(config)#
RP/0/RSP0/CPU0:PE1(config)#interface GigabitEthernet0/0/0/19
RP/0/RSP0/CPU0:PE1(config-if)# ipv6 address 2603:10b0:100:10::21/126
RP/0/RSP0/CPU0:pE1(config-if)# commit
```

3

Committed Configuration

```
RP/0/RSP0/CPU0:PE1#show configuration commit changes last 1
Mon Feb 16 13:15:36.655 UTC
Building configuration...
!! IOS XR Configuration 5.1.2
interface GigabitEthernet0/0/0/19
  no description ***AAABBBCCC***
  no cdp
  no ipv4 address 13.3.5.5 255.255.255.0
  ipv6 address 2603:10b0:100:10::21/126
  no negotiation auto
  no shutdown
  no load-interval 30
!
end
```

Example:

Consider an interface with a target config where all config lines are new

NEW Behavior:

When issuing the “no” interface config, the system does not destroy the subtree but instead performs a SET of new config and REMOVE of unwanted config lines

Global Configuration Replace

Replace interface with interface

```
interface GigabitEthernet0/0/0/0
description first
ipv4 address 10.20.30.40 255.255.0.0
shutdown
!
router ospf 10
cost 100
area 200
cost 200
interface GigabitEthernet0/0/0/0
transmit-delay 5
```

Original
Running
Configuration

```
RP/0/0/CPU0:fella(config)#replace interface gigabitEthernet 0/0/0/0 with
loopback 450
Building configuration...
Loading.
232 bytes parsed in 1 sec (230)bytes/sec

RP/0/0/CPU0:fella(config-ospf-ar-if)#show configuration
Wed Feb 25 18:27:16.110 PST
Building configuration...
!! IOS XR Configuration 0.0.0
interface Loopback450
description first
ipv4 address 10.20.30.40 255.255.0.0
shutdown
!
no interface GigabitEthernet0/0/0/0
router ospf 10
area 200
interface Loopback450
transmit-delay 5
!
no interface GigabitEthernet0/0/0/0
```

Global Configuration Replace

Replace a pattern: IP address example

```
ipv4 access-list mylist
 10 permit tcp 10.20.30.40/16 host 1.2.4.5
 20 deny ipv4 any 1.2.3.6/16
!
interface GigabitEthernet0/0/0/0
  description first
  ipv4 address 10.20.30.40 255.255.0.0
  shutdown
!
interface GigabitEthernet0/0/0/2
  description 10.20.30.40
  shutdown
!
interface GigabitEthernet0/0/0/3
  description 1020304050607080
  shutdown
!
interface GigabitEthernet0/0/0/4
  description 1.2.3.4.5.6.7.8
  shutdown
!
route-policy temp
  if ospf-area is 10.20.30.40 or source in (2.3.4.5/20) then
    pass
  endif
end-policy
!
```

Original
Running
Configuration

```
RP/0/0/CPU0:fella(config)#replace pattern '10\.20\.30\.40' with
'100.200.250.225'
Building configuration...
Loading.
434 bytes parsed in 1 sec (430)bytes/sec

RP/0/0/CPU0:fella(config)#show configuration
Thu Feb 26 09:00:11.180 PST
Building configuration...
!! IOS XR Configuration 0.0.0
ipv4 access-list mylist
  no 10
  10 permit tcp 100.200.250.225/16 host 1.2.4.5
!
interface GigabitEthernet0/0/0/0
  no ipv4 address 10.20.30.40 255.255.0.0
  ipv4 address 100.200.250.225 255.255.0.0
!
interface GigabitEthernet0/0/0/2
  no description
  description 100.200.250.225
!
!
route-policy temp
  if ospf-area is 100.200.250.225 or source in (2.3.4.5/20) then
    pass
  endif
end-policy
```

Global Configuration Replace

Replace a pattern: interface range

```
interface GigabitEthernet0/1/0/0
  ipv4 address 20.0.0.10 255.255.0.0
!
interface GigabitEthernet0/1/0/1
  ipv4 address 21.0.0.11 255.255.0.0
!
interface GigabitEthernet0/1/0/2
  ipv4 address 22.0.0.12 255.255.0.0
!
interface GigabitEthernet0/1/0/3
  ipv4 address 23.0.0.13 255.255.0.0
!
interface GigabitEthernet0/1/0/4
  ipv4 address 24.0.0.14 255.255.0.0
!
interface TenGigE0/3/0/0
  shutdown
!
interface TenGigE0/3/0/1
  shutdown
!
interface TenGigE0/3/0/2
  shutdown
!
interface TenGigE0/3/0/3
  shutdown
!
interface TenGigE0/3/0/4
  shutdown
!
interface TenGigE0/3/0/5
  shutdown
!
interface TenGigE0/3/0/6
  shutdown
!
end
```

Original
Running Configuration

```
RP/0/0/CPU0:ios(config)#replace pattern 'GigabitEthernet0/1/0/([0-4])' with
'TenGigE0/3/0/\1'
Building configuration...
Loading.
485 bytes parsed in 1 sec (482)bytes/sec
RP/0/0/CPU0:ios(config-if)#show configuration
Fri Feb 27 16:52:56.549 PST
Building configuration...
!! IOS XR Configuration 0.0.0
no interface GigabitEthernet0/1/0/0
no interface GigabitEthernet0/1/0/1
no interface GigabitEthernet0/1/0/2
no interface GigabitEthernet0/1/0/3
no interface GigabitEthernet0/1/0/4
interface TenGigE0/3/0/0
  ipv4 address 20.0.0.10 255.255.0.0
!
interface TenGigE0/3/0/1
  ipv4 address 21.0.0.11 255.255.0.0
!
interface TenGigE0/3/0/2
  ipv4 address 22.0.0.12 255.255.0.0
!
interface TenGigE0/3/0/3
  ipv4 address 23.0.0.13 255.255.0.0
!
interface TenGigE0/3/0/4
  ipv4 address 24.0.0.14 255.255.0.0
```

Concurrent Config Sessions

Concurrent and exclusive



Enter Proposed Changes

```
interface gig 0/3/0/0
  ipv4 address 9.9.9.9/24
router ospf 100
  area 0
    interface gig 0/3/0/0
  area 1
    interface gig 0/4/0/0
```

First to Commit

Normal Commit
only first user's changes

Enter Proposed Changes

```
interface gig 0/3/0/0
  ipv4 address 9.9.9.7/24
router ospf 100
  area 2
    interface gig 0/3/0/0
  area 4
    interface gig 0/4/0/0
```

Second to Commit

Use config exclusive to block other users from committing

One or more commits have occurred from other configuration sessions since this session started or since the last commit was made from this session.
You can use the 'show configuration commit changes' command to browse the changes.
Do you wish to proceed with this commit anyway? [no] :

Configuration Consistency

If the system detects inconsistency: A downgrade example

```
RP/0/RSP0/CPU0:Jan 2 14:11:35.876 : cfgmgr-rp[161]: %MGBL-CONFIGCLI-3-BATCH_CONFIG_FAIL  
: 3 config(s) failed during startup. To view failed config(s) use the command - "show  
configuration failed startup"
```

```
RP/0/RSP0/CPU0:Jan 2 14:11:35.884 : cfgmgr-rp[161]: %MGBL-CONFIG-3-INCONSISTENCY_ALARM  
: A configuration inconsistency alarm has been raised. Configuration commits will be  
blocked until 'clear configuration inconsistency' command has been run to synchronize  
persistent configuration with running configuration.
```

```
RP/0/RSP0/CPU0:rusr9000-2w-b#configure  
Thu Jan 9 20:51:57.470 EST  
This SDR's running configuration is inconsistent with persistent configuration.  
No configuration commits for this SDR will be allowed until a 'clear configuration  
inconsistency' command is performed.
```

```
RP/0/RSP0/CPU0:rusr9000-2w-b#show configuration persistent diff  
Thu Jan 9 20:54:02.570 EST  
Building configuration...  
!! IOS XR Configuration 4.2.3  
End
```

Configuration Consistency

If the system detects inconsistency: A downgrade example

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show configuration failed startup
Thu Jan  9 21:00:33.389 EST
!!14:11:35 UTC Thu Jan 02 2014
!! SYNTAX/AUTHORIZATION ERRORS: This configuration failed due to
!! one or more of the following reasons:
!!   - the entered commands do not exist,
!!   - the entered commands have errors in their syntax,
!!   - the software packages containing the commands are not active,
!!   - the current user is not a member of a task-group that has
!!     permissions to use the commands.

router bgp 65001
12vpn
xconnect group PW-10
p2p PW-10
  neighbor ipv4 192.168.10.2 pw-id 10
    pw-class PW-GRE

RP/0/RSP0/CPU0:rasr9000-2w-b#clear configuration inconsistency
Thu Jan  9 20:54:46.435 EST
Creating any missing directories in Configuration File system...OK
Initializing Configuration Version Manager...OK
Syncing commit database with running configuration...OK
RP/0/RSP0/CPU0:Jan  9 20:54:48.946 : cfgmgr-rp[161]: cfgmgr_retry_mgr_sysdb_notification_fn Item is deleted
RP/0/RSP0/CPU0:Jan  9 20:54:48.948 : cfgmgr_cfs_check[65784]: %MGBL-CONFIG-3-INCONSISTENCY_ALARM : A
configuration inconsistency alarm has been cleared. Configuration commits within this SDR are no longer
blocked.
```

Monitoring Configuration

Configuration, commits, changes, sessions

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show running-config
```

```
Mon Jan  5 00:35:19.951 EST
Building configuration...
!! IOS XR Configuration 5.1.3
!! Last configuration change at Tue Dec  2 22:19:25 2014 by cisco
!
service unsupported-transceiver
hostname rasr9000-2w-b
clock timezone EST -5
```

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show configuration commit list
```

SNo.	Label/ID	User	Line	Client	Time Stamp
1	1000000033	cisco	con0_RSP0_CPU0	CLI	Tue Dec 2 22:19:25 2014
2	1000000032	cisco	con0_RSP0_CPU0	CLI	Tue Dec 2 22:15:54 2014
3	1000000031	cisco	con0_RSP0_CPU0	CLI	Tue Dec 2 22:14:18 2014

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show configuration commit changes last 5
```

```
Mon Jan  5 00:36:17.813 EST
Building configuration...
!! IOS XR Configuration 5.1.3
interface GigabitEthernet0/1/0/4
  ipv4 address 10.6.7.6 255.255.255.0
!
```

```
RP/0/RSP1/CPU0:viking-1# show config sessions
```

Current Configuration Session	Line	User	Date	Lock
00000051-004c4104-00000000	con0_RSP1_	ww	Tue Jul 21 16:58:22 2009	

Interface Configuration

Example

```
interface TenGigE0/0/0/1
  service-policy input ingress-qos1
  service-policy output e qos-2
  ipv4 address 10.1.2.1 255.255.255.0
  ipv6 address 2001:2::1/64
  flow ipv4 monitor perf-monitor-map sampler perf-sampler ingress
  flow ipv4 monitor perf-monitor-map sampler perf-sampler egress
  ipv4 access-group foo-v4-acl ingress
  ipv4 access-group foo-v4-acl egress
```

Routing Configuration Example

```
router bgp 100
bgp router-id 1.1.1.1
address-family ipv4 unicast
!
address-family vpnv4 unicast
!
address-family ipv6 unicast
!
address-family vpnv6 unicast
!
neighbor-group 6vpe-basic
address-family ipv4 unicast
  route-policy pass in
  maximum-prefix 5000000 75
  route-policy pass out
!
address-family ipv6 unicast
  route-policy pass in
  route-policy pass out
!
neighbor 10.1.2.2
remote-as 3021
address-family ipv4 unicast
  route-policy pass in
  maximum-prefix 5000000 75
  route-policy pass out
!
address-family ipv6 unicast
```

```
router ospf 1
area 0
  interface TenGigE0/0/0/0
  cost 3
!
  interface TenGigE0/0/0/1
!
area 1
  interface gig 0/4/0/0
  passive
!
  interface gig 0/4/0/1
!
router static
  address-family ipv4 unicast
    1.0.0.0/8 10.1.1.2
    7.7.7.77/32 7.1.9.1
    151.0.0.0/8 10.1.2.2
```

Configuration Sections

Reading a block: example

```
RP/0/0/CPU0:P103#show running-config router bgp
Mon Jan  5 15:06:29.774 EST
router bgp 65001
  bgp router-id 10.100.103.1
  bgp cluster-id 10.100.101.1
  bgp graceful-restart
  address-family ipv4 unicast
  !
  address-family vpng4 unicast
  !
  address-family ipv6 unicast
  !
  address-family l2vpn vpls-vpws
  !
neighbor-group iBGP
  remote-as 65001
  keychain CISCO
  update-source Loopback0
  address-family ipv4 unicast
    route-reflector-client
  !
  address-family vpng4 unicast
    route-reflector-client
  !
  address-family ipv6 unicast
    route-reflector-client
```

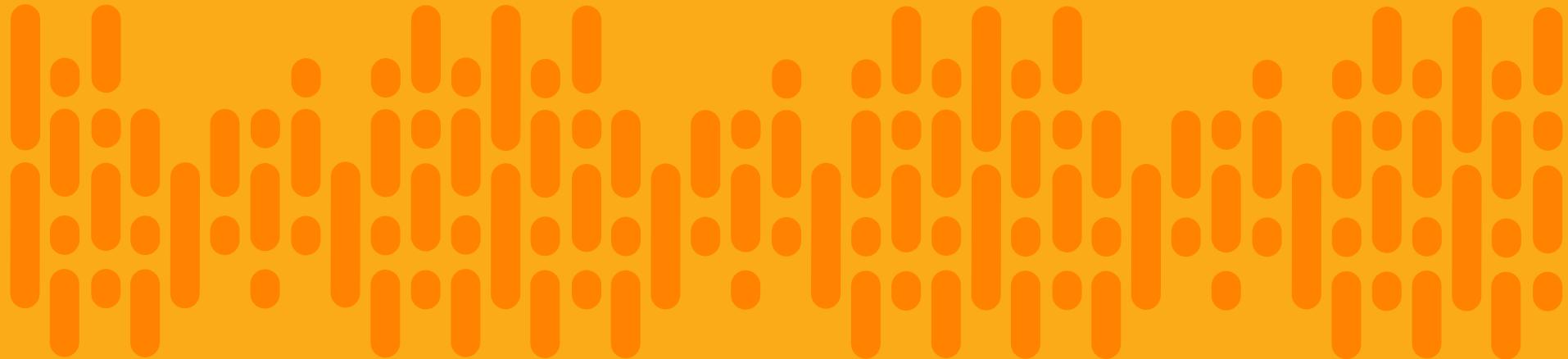
Agenda

- ✓ **System Architecture:** System anatomy and health
- ✓ **Operating System & Configuration:** IOS-XR & configuration models
- **Control, Management, & Security:** Processing of control & exceptions
- **Transit Packet/Frame Journey:** Life of L3/L2 unicast/multicast
- **MPLS Operation:** Processing, forwarding and L3/L2 service operation
- **Troubleshooting:** Diagnostics, counters, drops, and packet capture

3 Control, Management, & Security



You make security **possible**

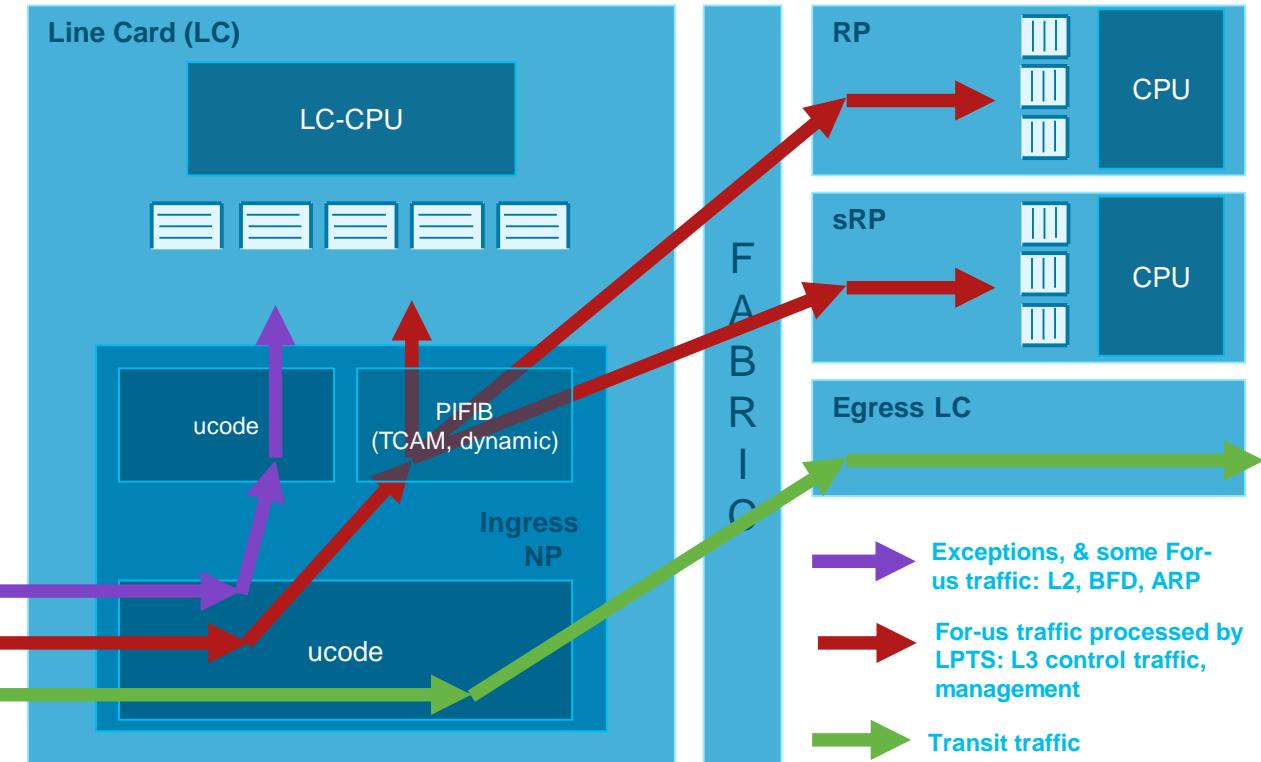


For Us, Exceptions, & Resource Protection

Traffic: Transit, For us, and Exceptions

Differentiate on ingress NP

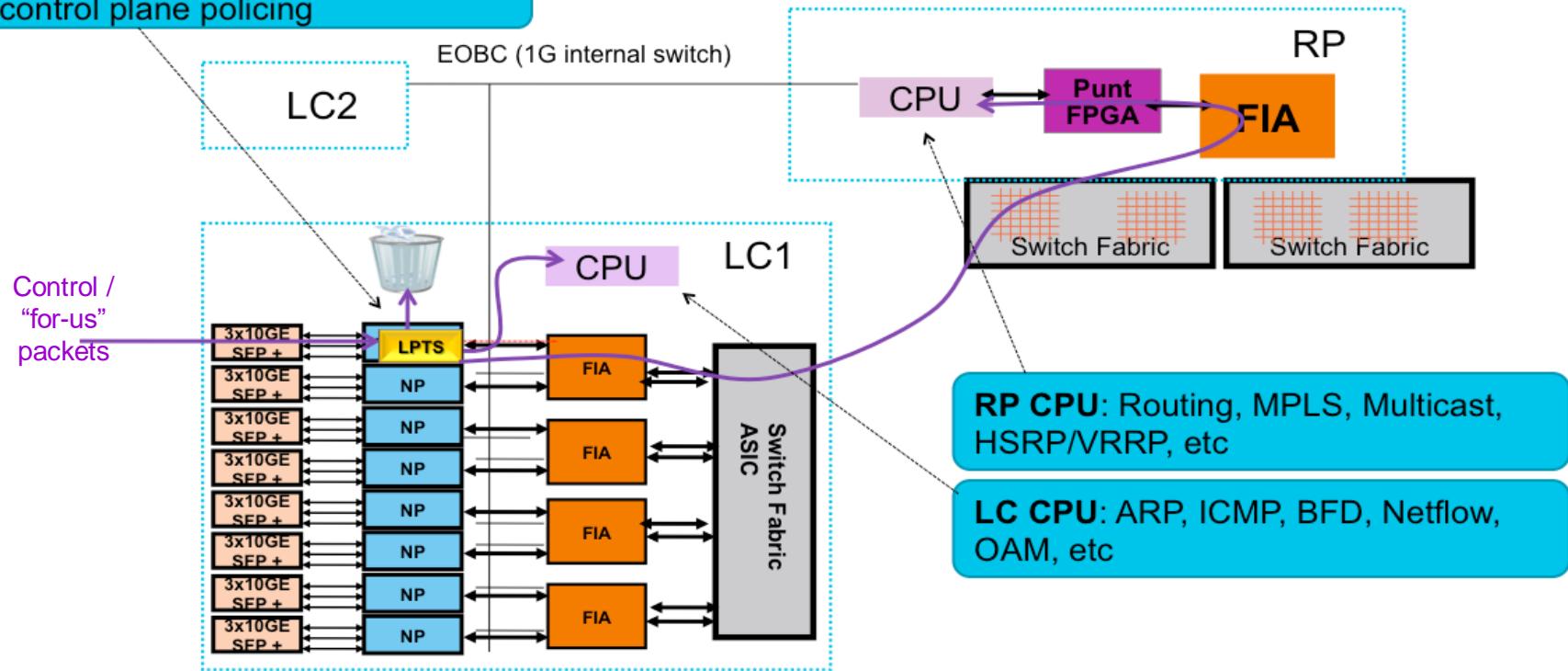
- Transit
 - Look up, re-write, forward
- For us
 - Destined to RP, or link local scope
 - Punt to RP or ingress LC CPU
- Exception
 - MTU failure, TTL failure, etc. Should have been transit
 - Punt to LC CPU



For Us Frame Path

From ingress NP to RP CPU or LC CPU

LPTS (local packet transport service):
control plane policing



For Us Frame Path

The internal FIB [IFIB]

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show lpts ifib brief
```

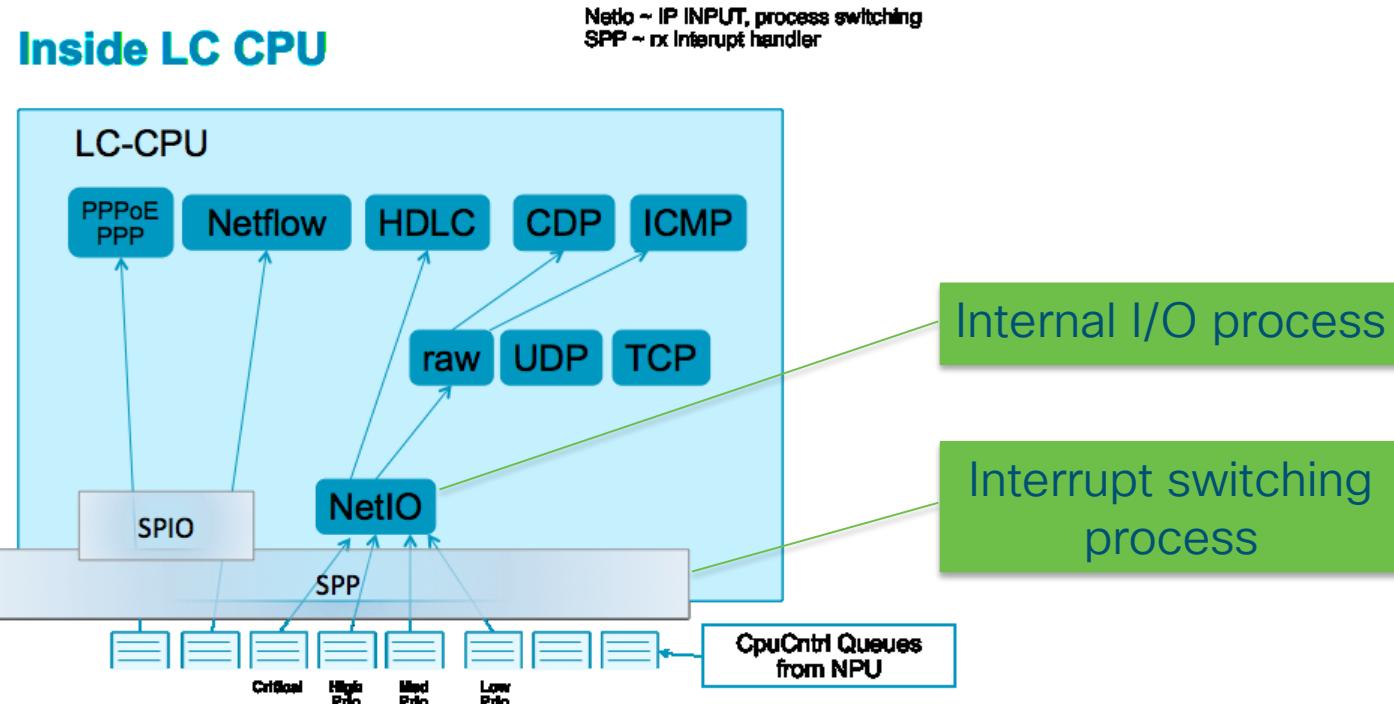
Mon Dec 9 11:58:43.726 EST

Slice	VRF-ID	L4	Interface	Dlvr	Local-Address, Port	Remote-Address, Port
RAWIP4	TRAFFIC	112	Te0/0/0/2.200	0/RSP0/CPU0	224.0.0.18	any
RAWIP4	default	RSVP	Gi0/1/0/3.400	[0x0003]	any	any
RAWIP4	default	RSVP	BE1	[0x0003]	any	any
RAWIP4	default	RSVP	Te0/0/0/4.100	[0x0003]	any	any
RAWIP4	default	IGMP	any	[0x0003]	any	any
BGP4	default	TCP	any	0/RSP0/CPU0	10.101.188.1,179	10.100.102.1,48462
BGP4	default	TCP	any	0/RSP0/CPU0	10.101.188.1,179	10.100.104.1,53724
BGP4	default	TCP	any	0/RSP0/CPU0	any,179	10.100.102.1
BGP4	default	TCP	any	0/RSP0/CPU0	any,179	10.100.104.1
UDP4	default	UDP	any	[0x0003]	10.101.188.1,646	10.100.108.1
UDP4	default	UDP	any	[0x0003]	10.101.188.1,646	10.101.111.1
TCP4	default	TCP	Mg0/RSP1/CPU0/0	0/RSP0/CPU0	any,23	any
TCP4	default	TCP	any	[0x0003]	10.101.188.1,59192	10.101.111.1,646
TCP4	default	TCP	Gi0/1/0/1	0/RSP0/CPU0	any,38751	any
TCP4	default	TCP	Mg0/RSP1/CPU0/0	0/RSP0/CPU0	any,38751	any
TCP4	default	TCP	any	[0x0003]	10.101.188.1,63675	10.100.108.1,646
ISIS	default	-	BE1	[0x0003]	--	--
ISIS	default	-	Te0/0/0/4.100	[0x0003]	--	--

Physical slot mask: 0003 is first
2 slots in 9006: RSP0 & RSP1

For Us Frame Path

From ingress NP to RP CPU or LC CPU



For Us Frame Path

Processes to watch on RP CPU

- netio on RP CPU
- Example for BGP from unknown
 - LPTS relaxed for simulation

```
RP/0/RSP0/CPU0:rasr9k-1y#show processes cpu location 0/RSP0/CPU0 | exclude " 0%      0%      0%"  
Wed Nov 28 01:36:52.203 UTC  
  
CPU utilization for one minute: 26%; five minutes: 25%; fifteen minutes: 22%  
  
PID    1Min     5Min     15Min Process  
94243    3%      3%      3% spp  
254074   23%     22%     19% netio  
  
RP/0/RSP0/CPU0:rasr9k-1y#show lpts pifib hardware police location 0/0/CPU0 | e$  
wed Nov 28 01:23:10.907 UTC  
-----  
          Node 0/0/CPU0:  
-----  
          Burst = 100ms for all flow types  
-----  


| FlowType | Policer     | Type | Cur. Rate | Def. Rate | Accepted | Dropped  |
|----------|-------------|------|-----------|-----------|----------|----------|
| -        |             |      |           |           |          |          |
| .        | BGP-default | 108  | Local     | 150000    | 1500     | 89395477 |
| .        | TCP-default | 164  | Local     | 150000    | 2000     | 49872016 |
| .        |             |      |           |           |          |          |

  
-----  
          statistics:  
          Packets accepted by deleted entries: 19477  
          Packets dropped by deleted entries: 0  
          Run out of statistics counter errors: 0
```

For Us Frame Path

Processes to watch on LC CPU

- netio and spp on LC CPU
 - netio for internal in/out (like ip input in IOS)
 - spp for software switched (similar to interrupt switching in IOS)
- Example for for-us fragments
 - LPTS relaxed for simulation

```
RP/0/RSP0/CPU0:rasr9k-1y#show processes cpu location 0/0/CPU0 |  
exclude " 0%      0%      0%"  
Wed Nov 28 01:28:52.281 UTC  
  
CPU utilization for one minute: 46%; five minutes: 48%; fifteen  
minutes: 39%  
  
PID    1Min     5Min     15Min Process  
45085   22%     23%     22% spp  
180316   23%     23%     23% netio  
  
RP/0/RSP0/CPU0:rasr9k-1y#show lpts pifib hardware police location 0/0/CPU0  
Wed Nov 28 01:23:10.907 UTC  
-----  
Node 0/0/CPU0:  
-----  
Burst = 100ms for all flow types  
-----  


| FlowType    | Policer | Type  | Cur. Rate | Def. Rate | Accepted  | Dropped    |
|-------------|---------|-------|-----------|-----------|-----------|------------|
| Fragment    | 101     | Local | 100000    | 2500      | 142076716 | 5033837819 |
| UDP-default | 163     | Local | 1000000   | 3500      | 38336274  | 2376859    |

  
-----  
statistics:  
Packets accepted by deleted entries: 19477  
Packets dropped by deleted entries: 0  
Run out of statistics counter errors: 0
```

For Us Frame Path

Traffic rate from/to each CPU

```
RP/0/RSP0/CPU0:rasr9k-1y#show netio rates  
Location 0/RSP0/CPU0
```

Thu Jan 3 06:56:28.745 UTC

Netio packet rate for node 0/RSP0/CPU0

Current rate (updated 0 seconds ago):

Input: 82811 pkts/s

Output: 100 pkts/s

Driver Output: 100 pkts/s

1 minute rate (updated 7 seconds ago):

Input: 82668 pkts/s

Output: 98 pkts/s

Driver Output: 98 pkts/s

5 minute rate (updated 7 seconds ago):

Input: 57073 pkts/s

Output: 65 pkts/s

Driver Output: 65 pkts/s

RSP: routing protocols,
management, etc.

```
RP/0/RSP0/CPU0:rasr9k-1y#show netio rates  
Location 0/0/CPU0
```

Thu Jan 3 06:56:20.329 UTC

Netio packet rate for node 0/0/CPU0

Current rate (updated 0 seconds ago):

Input: 14759 pkts/s

Output: 0 pkts/s

Driver Output: 14760 pkts/s

1 minute rate (updated 0 seconds ago):

Input: 14770 pkts/s

Output: 0 pkts/s

Driver Output: 14771 pkts/s

5 minute rate (updated 0 seconds ago):

Input: 10178 pkts/s

Output: 0 pkts/s

Driver Output: 0 pkts/s

LC: fragments, BFD, ARP, L2, etc.

Control Plane Protection

LPTS flow type polices

```
RP/0/RSP0/CPU0:rasr9k-1y#show lpts pifib hardware police location 0/0/CPU0
Sun Dec 2 06:07:36.931 UTC
```

Node 0/0/CPU0:

Burst = 100ms for all flow types

FlowType	Policer	Type	Cur. Rate	Def. Rate	Accepted	Dropped
unconfigured-default	100	Static	2500	2500	0	0
Fragment	101	Local	0	2500	0	0
OSPF-mc-known	102	Static	2000	2000	0	0
OSPF-mc-default	103	Local	0	1500	53	26
OSPF-uc-known	104	Static	2000	2000	0	0
OSPF-uc-default	105	Local	0	1000	0	0
ISIS-known	143	Static	2000	2000	20890	0
ISIS-default	144	Local	0	1500	0	0
.						
BGP-known	106	Static	2500	2500	4070	0
BGP-cfg-peer	107	Static	2000	2000	17	0
BGP-default	108	Local	0	1500	335787	15570288947
PIM-mcast-default	109	Local	0	2000	0	0
PIM-mcast-known	176	Static	2000	2000	0	0
PIM-ucast	110	Static	1500	1500	0	0
IGMP	111	Static	3000	3000	0	0

Control Plane Protection

LPTS flow type polices

FlowType	Policer	Type	Cur. Rate	Def. Rate	Accepted	Dropped
ICMP-local	112	Static	1500	1500	20044	0
ICMP-app	152	Local	100	1500	0	0
ICMP-control	140	Static	1000	1000	0	0
ICMP-default	153	Local	100	1500	0	0
ICMP-app-default	152	Local	100	1500	0	0
LDP-TCP-known	113	Static	2500	2500	0	0
LDP-TCP-cfg-peer	114	Static	2000	2000	0	0
LDP-TCP-default	115	Local	0	1500	0	0
LDP-UDP	116	Static	2000	2000	0	0
All-routers	117	Local	0	1000	0	0
LMP-TCP-known	168	Static	2500	2500	0	0
LMP-TCP-cfg-peer	169	Static	2000	2000	0	0
LMP-TCP-default	170	Local	0	1500	0	0
LMP-UDP	171	Local	0	2000	0	0
RSVP-UDP	118	Static	2000	2000	0	0
RSVP-default	154	Local	0	500	0	0
RSVP-known	177	Static	7000	7000	0	0
IKE	119	Static	100	100	0	0
IPSEC-known	120	Static	400	400	0	0
IPSEC-default	121	Local	0	100	0	0
MSDP-known	122	Static	300	300	0	0

Control Plane Protection

LPTS flow types: BGP example

Established session packets

```
RP/0/RSP0/CPU0:rasr9k-1y#show lpts pifib hardware police location 0/0/CPU0
Wed Nov 28 03:01:48.271 UTC
```

Node 0/0/CPU0:

Burst = 100ms for all flow types

Configured peer packets

BGP packets from unknown

FlowType	Policer	Type	Cur. Rate	Def. Rate	Accepted	Dropped		
Established session packets	0	BGP-known	106	Local	50000	2500	2590	0
Configured peer packets	0	BGP-cfg-peer	107	static	2000	2000	13	0
BGP packets from unknown	0	BGP-default	108	Local	400000	1500	138918630	3848639925

statistics:

Packets accepted by deleted entries: 19477
Packets dropped by deleted entries: 0
Run out of statistics counter errors: 0

Control Plane Protection

Customize LPTS flow rates

```
RP/0/RSP0/CPU0:rasr9k-1y(config)#lpts pifib hardware police location 0/0/CPU0
RP/0/RSP0/CPU0:rasr9k-(config-pifib-policer-per-node)# flow isis default rate 0
RP/0/RSP0/CPU0:rasr9k-(config-pifib-policer-per-node)#flow bgp configured rate 500
RP/0/RSP0/CPU0:rasr9k-(config-pifib-policer-per-node)# flow bgp default rate 0
RP/0/RSP0/CPU0:rasr9k-(config-pifib-policer-per-node)# flow pim multicast default rate 0
RP/0/RSP0/CPU0:rasr9k-(config-pifib-policer-per-node)# flow icmp application rate 100
RP/0/RSP0/CPU0:rasr9k-(config-pifib-policer-per-node)# flow icmp default rate 100
RP/0/RSP0/CPU0:rasr9k-(config-pifib-policer-per-node)# flow ldp tcp default rate 0
RP/0/RSP0/CPU0:rasr9k-(config-pifib-policer-per-node)# flow all-routers rate 0
RP/0/RSP0/CPU0:rasr9k-1y#show running-config lpts pifib hardware police location 0/0/CPU0
Sun Dec 2 06:29:11.493 UTC
lpts pifib hardware police location 0/0/CPU0
  flow bgp default rate 0
  flow pim multicast default rate 0
  flow icmp application rate 100
  flow icmp default rate 100
  flow ldp tcp default rate 0
  flow all-routers rate 0
  flow lmp tcp default rate 0
  flow lmp udp rate 0
  flow rsvp default rate 0
  flow ipsec default rate 0
  flow msdp default rate 0
  flow ssh known rate 0
  flow ssh default rate 0
```

Control Plane Protection

LPTS flow policers

```
RP/0/RSP0/CPU0:rasr9k-1y#show lpts pifib hardware police location 0/0/CPU0
Sun Dec 2 06:32:04.344 UTC
```

FlowType	Policer	Type	Cur. Rate	Def. Rate	Accepted	Dropped
unconfigured-default	100	Static	2500	2500	0	0
Fragment	101	Local	0	2500	0	0
OSPF-mc-known	102	Static	2000	2000	0	0
OSPF-mc-default	103	Local	0	1500	54	27
OSPF-uc-known	104	Static	2000	2000	0	0
OSPF-uc-default	105	Local	0	1000	0	0
ISIS-known	143	Static	2000	2000	21078	0
ISIS-default	144	Local	0	1500	0	0
TCP-known	156	Static	2500	2500	0	0
TCP-listen	157	Static	2500	2500	0	0
TCP-cfg-peer	158	Static	2000	2000	0	0
TCP-default	164	Local	0	2000	95977990	1995220219679
Mcast-known	159	Static	2500	2500	0	0
RADIUS	174	Local	0	2000	0	0
TACACS	175	Static	2000	2000	0	0
NTP-default	126	Local	0	200	0	0
NTP-known	180	Local	0	200	0	0

Control Plane Protection

LPTS PIFIB

- LPTS is the group of processes to transport for-us packets
 - Destination is either RP CPU's or ingress LC CPU
 - 5 queues of different priorities in Typhoon NP
- LPTS policers
 - Configured LC flow rate applied to LC, if not then configured global flow rate applied, if not then a default rate applied
 - Enforced by each NP
 - Flow entries created and installed based on: configuration and neighbor flow state [e.g. BGP TCP]

For Us Packet Forwarding Entries

LPTS flow entries

```
RP/0/RSP0/CPU0:ASR9006-2w-a.PE2#show lpts pifib hardware entry statistics location 0/0/CPU0
```

Offset	L3	VRD id	L4	Intf	Dest	Pkts/Drops	laddr,Port raddr,Port
8	IPV4	*	any	any	Local	0/0	any ,any any ,any
9	CLNS	*	-	BE1	LM[3]	0/0	- -
10	CLNS	*	-	Te0/0/0/1	LM[3]	59571/0	- -
11	CLNS	*	-	Te0/0/0/4.100	LM[3]	0/0	- -
12	CLNS	*	-	any	LU(30)	8/0	- -
13	IPV4	*	ICMP	any	Local	0/0	any ,any any ,ECHO
14	IPV4	default	RSVP	Te0/0/0/1	Local	15120/0	any ,any any ,any
15	IPV4	default	TCP	any	LM[3]	16991/0	any ,65264 10.10.1.1,179
16	IPV4	default	TCP	any	LU(30)	19377/0	any ,42370 10.10.1.1,646
.							

statistics:

Type	Num. Entries	Pkts
IPv4	58	151029/0
IPv6	39	0/0

Packets accepted by deleted entries: 5

Packets dropped by deleted entries: 0

Run out of statistics counter errors: 0

For Us Packet Forwarding Entries

LPTS flow entries

```
RP/0/RSP0/CPU0:rasr9k-1y#show lpts pifib  
hardware entry location 0/0/CPU0  
Sun Dec 2 00:46:50.573 UTC  
  
Node: 0/0/CPU0:  
-----  
M - Fabric Multicast;  
L - Listener Tag; T - Min TTL;  
F - Flow Type;  
DestNode - Destination Node;  
DestAddr - Destination Fabric queue;  
SID - Stream ID;  
Po - Policer; Ct - Stats Counter;  
Lp - Lookup priority; Sp - Storage  
Priority;  
Ar - Average rate limit; Bu - Burst;  
HAr - Hardware Average rate limit; HBu  
- Hardware Burst;  
Cir - Committed Information rate in  
HAL  
Rsp - Relative sorting position;  
Rtp - Relative TCAM position;  
na - Not Applicable or Not Available  
.
```

Show flow policers in
LC TCAM.

BGP-known
Session already
established. Flow
parameters in
hardware policer.

```
.  
-----  
VRF ID : 0x60000000  
Destination IP : any  
Source IP : 192.168.1.245  
IS Fragment : 0  
Interface : any  
M/L/T/F :  
1/IPv4_STACK/0/BGP-known  
DestNode : FGID 48  
DestAddr : 48  
SID : 7  
L4 Protocol : TCP  
TCP flag byte : any  
Source port : Port: 58549  
Destination Port : 179  
Ct : 0x5f0690  
Accepted/Dropped : 3189/0  
Lp/Sp : 1/255  
# of TCAM entries : 1  
HPo/HAr/HBu/Cir :  
15794309/2500pps/1250ms/2500pps  
State : Entry in TCAM  
Rsp/Rtp : 5/15  
-----  
.
```

For Us Packet Forwarding Entries

LPTS flow entries

```
VRF ID          : 0x60000000
Destination IP : any
Source IP       : 192.1.1.2
Is Fragment    : 0
Interface      : any
M/L/T/F        :
0/IPv4_STACK/255/BGP-known
DestNode        : 48
DestAddr        : 48
SID             : 7
L4 Protocol    : TCP
TCP flag byte  : any
Source port     : Port:179
Destination Port: 41243
Ct              : 0x5f0670
Accepted/Dropped: 0/0
Lp/Sp           : 1/255
# of TCAM entries: 1
HPo/HAr/HBu/Cir:
15794309/2500pps/1250ms/2500pps
State           : Entry in TCAM
Rsp/Rtp         : 6/16
```

BGP-known
Active session
with a configured
peer.

BGP-cfg-peer
Open to receiving
peer attempts to
establish.

```
VRF ID          : 0x60000000
Destination IP : any
Source IP       : 192.1.1.2
Is Fragment    : 0
Interface      : any
M/L/T/F        :
0/IPv4_LISTENER/255/BGP-cfg-peer
DestNode        : 48
DestAddr        : 48
SID             : 8
L4 Protocol    : TCP
TCP flag byte  : any
Source port     : Port:any
Destination Port: 179
Ct              : 0x5f0340
Accepted/Dropped: 0/0
Lp/Sp           : 1/255
# of TCAM entries: 1
HPo/HAr/HBu/Cir:
15794310/2000pps/1000ms/2000pps
State           : Entry in TCAM
Rsp/Rtp         : 7/17
```

For Us Packet Forwarding Entries

LPTS flow entries

VRF ID	:	any
Destination IP	:	any
Source IP	:	any
Is Fragment	:	0
Interface	:	any
M/L/T/F	:	0/BGP4_FM/0/ BGP-default
DestNode	:	48
DestAddr	:	48
SID	:	9
L4 Protocol	:	TCP
TCP flag byte	:	any
Source port	:	Port: 179
Destination Port	:	any
Ct	:	0x5f01b0
Accepted/Dropped	:	300890/13952472426
Lp/Sp	:	1/0
# of TCAM entries	:	1
HPo/HAr/HBu/Cir	:	
15794311/0pps/750ms/ 1pps	:	
State	:	Entry in TCAM
Rsp/Rtp	:	13/23

BGP-default
Any TCP from
port 179 not
matching
previous entries.

BGP-default
Any TCP to port
179 not matching
previous entries.

VRF ID	:	any
Destination IP	:	any
Source IP	:	any
Is Fragment	:	0
Interface	:	any
M/L/T/F	:	0/BGP4_FM/0/ BGP-default
DestNode	:	48
DestAddr	:	48
SID	:	9
L4 Protocol	:	TCP
TCP flag byte	:	any
Source port	:	Port: any
Destination Port	:	179
Ct	:	0x5f01a0
Accepted/Dropped	:	0/0
Lp/Sp	:	1/0
# of TCAM entries	:	1
HPo/HAr/HBu/Cir	:	
15794311/0pps/750ms/ 1pps	:	
State	:	Entry in TCAM
Rsp/Rtp	:	15/25

For Us Packet Forwarding Entries

LPTS flow entries

```
VRF ID          : any
Destination IP : any
Source IP       : any
Is Fragment    : 0
Interface       : any
M/L/T/F        : 0/TCP4_FM/0/TCP-
default
DestNode       : 48
DestAddr       : 48
SID             : 9
L4 Protocol    : TCP
TCP flag byte  : any
Source port     : Port:any
Destination Port: any
Ct              : 0x5f0170
Accepted/Dropped :
95947801/1817465391676
Lp/Sp           : 1/0
# of TCAM entries : 1
HPo/HAr/HBu/Cir :
15794367/0pps/1000ms/1pps
State           : Entry in TCAM
Rsp/Rtp         : 24/34
```

TCP-default
Any IPv4 TCP not matched by previous entries.

Raw-default
Any IPv4 not matched by previous entries.

```
VRF ID          : any
Destination IP : any
Source IP       : any
Is Fragment    : 0
Interface       : any
M/L/T/F        : 0/RawIP4_FM/0/Raw-
default
DestNode       : 48
DestAddr       : 48
SID             : 9
L4 Protocol    : any
Source port     : any
Destination Port: any
Ct              : 0x5f01f0
Accepted/Dropped : 10272/18857
Lp/Sp           : 1/0
# of TCAM entries : 1
HPo/HAr/HBu/Cir :
15794370/0pps/1250ms/1pps
State           : Entry in TCAM
Rsp/Rtp         : 28/38
```

Control Plane Protection

LPTS: PIFIB ACL-Based Policers

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show running-config
ip4 access-list
Thu Apr 3 18:21:35.034 EDT
ip4 access-list PE
10 remark PE LOOPBACKS
20 permit ipv4 10.101.0.1 0.0.255.0 any
40 deny ipv4 any any
!
ip4 access-list CORE
10 permit ipv4 10.100.0.0/16 any
20 deny ipv4 any any
!
ip4 access-list OFFENDERS
10 permit ipv4 host 172.19.19.1 any
20 permit ipv4 host 172.19.19.15 any
30 permit ipv4 172.19.19.224/29 any
40 deny ipv4 any any
!
```

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show running-config
lpts pifib hardware police
Thu Apr 3 18:25:22.831 EDT
lpts pifib hardware police
acl PE rate 11000
flow bgp known rate 6000
flow bgp configured rate 1000
flow bgp default rate 0
acl CORE rate 33000
acl OFFENDERS rate 0
!
```

“per-ACL” PPS
rate

Control Plane Protection

LPTS: PIFIB ACL-Based Policers

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show lpts pifib hardware entry brief location 0/1/CPU0
```

Thu Apr 3 18:28:57.713 EDT

Node: 0/0/CPU0:

L3 - L3 Protocol; L4 - Layer4 Protocol; Intf - Interface;

Dest - Destination Node; V - Virtual;

na - Not Applicable or Not Available;

LU - Local chassis fabric unicast;

LM - Local chassis fabric multicast;

RU - Multi chassis fabric unicast;

RM - Multi chassis fabric multicast;

def - default

Offset	L3	VRF id	L4	Intf	Dest	laddr,Port raddr,Port	acl name
18	IPV4	default	RSVP	Gi0/1/0/3.400	Local	any,any any,any	
19	IPV4	default	TCP	any	LU(30)	any,179 10.100.104.1,28603	CORE
20	IPV4	default	TCP	any	LU(30)	any,40607 10.100.102.1,179	CORE
21	IPV4	default	TCP	any	LM[3]	any,38362 10.100.108.1,646	CORE
22	IPV4	default	UDP	any	LM[3]	any,646 192.168.10.2,any	
23	IPV4	default	UDP	any	LM[3]	any,646 10.100.108.1,any	CORE
24	IPV4	default	TCP	any	LU(30)	any,179 10.100.102.1,any	CORE
25	IPV4	default	TCP	any	LU(30)	any,179 10.100.104.1,any	CORE
26	IPV4	default	TCP	any	LU(30)	any,23 any,any	
.							

Control Plane Protection

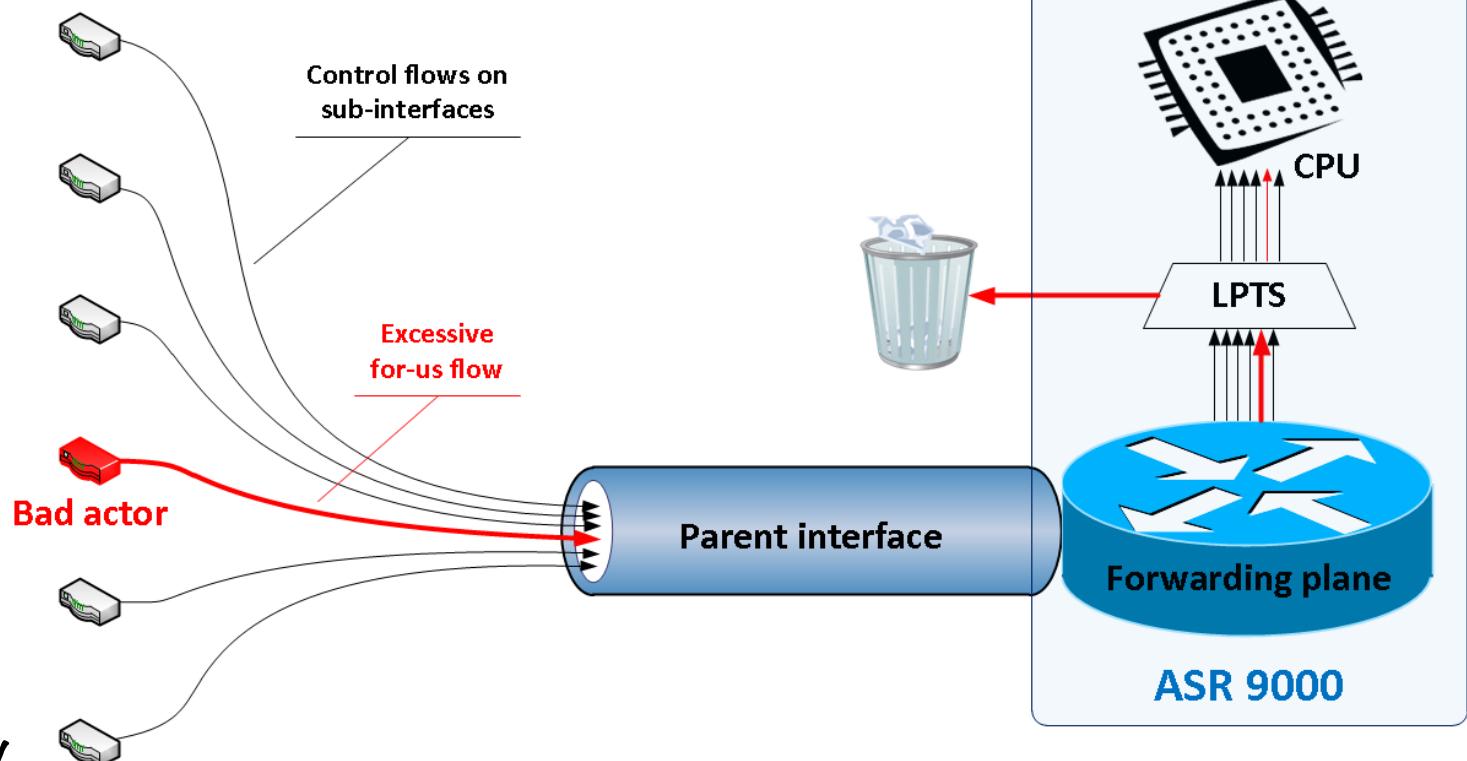
LPTS: PIFIB ACL-Based Policers

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show lpts pifib hardware entry
type ipv4 start-index 12 num-entries 7 location 0/1/CPU0
Thu Apr  3 18:40:54.467 EDT
VRF ID          : 0x60000000
Destination IP : any
Source IP       : 10.100.104.1
Is Fragment     : 0
Interface       : any
M/L/T/F         : 0/IPv4_STACK/0/BGP-known
DestNode        : 48
DestAddr        : 48
SID              : 7
L4 Protocol    : TCP
TCP flag byte   : any
Source port      : Port:28603
Destination Port: 179
Ct               : 0x612050
Accepted/Dropped: 5058/0
Lp/Sp             : 1/255
# of TCAM entries: 1
HPo/HAr/HBu/Cir/acl:
14876914/33000pps/33000ms/33000pps/CORE
```

```
VRF ID          : 0x60000000
Destination IP : any
Source IP       : 10.100.108.1
Is Fragment     : 0
Interface       : any
M/L/T/F         : 1/IPv4_LISTENER/0/LDP-UDP
DestNode        : FGID 3
DestAddr        : 3
SID              : 7
L4 Protocol    : UDP
Source port      : Port:any
Destination Port: 646
Ct               : 0x612060
Accepted/Dropped: 16214/0
Lp/Sp             : 1/255
# of TCAM entries: 1
HPo/HAr/HBu/Cir/acl:
14876914/33000pps/33000ms/33000pps/CORE
State            : Entry in TCAM
Rsp/Rtp          : 16/30
-----
--
```

Control Plane Protection

LPTS Excessive Flow Trap



Control Plane Protection

LPTS Excessive Flow Trap: Configuration

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show running-config lpts punt excessive-flow-trap
Tue Mar 11 11:47:47.820 EDT
lpts punt excessive-flow-trap
penalty-rate arp 50
penalty-rate icmp 50
penalty-rate igmp 100
penalty-rate ip 100
penalty-timeout arp 5
penalty-timeout icmp 5
penalty-timeout igmp 2
penalty-timeout ip 4
non-subscriber-interfaces mac
!
```

- Policing per Src MAC on main interfaces
- Policing per Src MAC on BNG sub-interfaces
- Policing per sub-int on non-BNG
 - Change with “non-subscriber-interfaces mac”

- Policing for-us from offending source instead of dropping for flow type from all peers
- Penalizing “bad actor” on major protocols: IP, IGMP, ICMP, ARP, DHCP, PPP, PPPoE, L2TP. Potentially impacting several protocols from offending peer
- Not enabled by default
- Check if default penalty rates and timeouts are acceptable in your case

Control Plane Protection

LPTS Excessive Flow Trap: Default & Configured Penalties

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show lpts punt excessive-flow-trap information
```

Protocol	Police		Penalty		Punt Reasons	
	Rate (pps)	Default	Timeout (mins)	Default	Config	
ARP	10	50	15	5		ARP Reverse ARP Dynamic ARP Inspection (DAI)
ICMP	10	50	15	5		ICMP
IGMP	10	100	15	2		IGMP IGMP Snoop MLD Snoop
IPv4/v6	10	100	15	4		IP Subscriber (IPSUB) IPv4 options IPv4 FIB IPv4 TTL exceeded IPv4 fragmentation needed IPv4/v6 adjacency IPv4/v6 unknown IFIB UDP-known

Control Plane Protection

LPTS Excessive Flow Example: A VRRP Flooding

```
LC/0/0/CPU0:Mar 11 12:52:09.059 : flowtrap[187]: %OS-FLOWTRAP-4-BAD_ACTOR_INTF_DETECTED : Excessive VRRP flow detected on interface TenGigE0/0/0/5.511. The interface will be penalty-policed at 10 pps for 15 minutes.
```

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show lpts pifib hardware police location 0/0/CPU0
```

FlowType	Policer	Type	Cur. Rate	Def. Rate	Accepted	Dropped	TOS Value
.
VRRP	148	Static	1000	1000	804133	40681182	01234567

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show lpts punt excessive-flow-trap all location 0/0/CPU0
```

```
Tue Mar 11 13:04:35.545 EDT
```

```
    Interface: TenGigE0/0/0/5.511
    Intf Handle: 0x04001740
    Protocol: ****
    Penalty Rate: 10 pps
    Time Remaining: 8 mins 22 secs
                                         Location: 0/0/CPU0
                                         Punt Reason: VRRP
                                         Penalty Timeout: 15 mins
```

```
LC/0/0/CPU0:Mar 11 13:24:33.899 : flowtrap[187]: %OS-FLOWTRAP-4-BAD_ACTOR_INTF_CLEARED : Interface TenGigE0/0/0/5.511 cleared from penalty-policing by timeout.
```

Control Plane Protection

LPTS Excessive Flow Example: A VRRP Flooding

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show vrrp
```

```
Tue Mar 11 13:07:23.623 EDT
```

```
IPv4 Virtual Routers:
```

A indicates IP address owner
| P indicates configured to preempt
| |

Interface	vrID	Prio	A	P	State	Master addr	VRouter addr
Te0/0/0/5.500	100	100	P	Master	local	172.24.1.1	
Te0/0/0/5.501	101	90	P	Backup	172.24.1.2	172.24.1.1	
Te0/0/0/5.502	102	100	P	Master	local	172.24.1.1	
Te0/0/0/5.503	103	90	P	Backup	172.24.1.2	172.24.1.1	
Te0/0/0/5.504	104	100	P	Master	local	172.24.1.1	
Te0/0/0/5.505	105	90	P	Backup	172.24.1.2	172.24.1.1	
Te0/0/0/5.506	106	100	P	Master	local	172.24.1.1	
Te0/0/0/5.507	107	90	P	Backup	172.24.1.2	172.24.1.1	
Te0/0/0/5.508	108	100	P	Master	local	172.24.1.1	
Te0/0/0/5.509	109	90	P	Backup	172.24.1.2	172.24.1.1	
Te0/0/0/5.510	110	100	P	Master	local	172.24.1.1	
Te0/0/0/5.511	111	90	P	Master	local	172.24.1.1	
Te0/0/0/5.512	112	100	P	Master	local	172.24.1.1	
Te0/0/0/5.513	113	90	P	Backup	172.24.1.2	172.24.1.1	
Te0/0/0/5.514	114	100	P	Master	local	172.24.1.1	
Te0/0/0/5.515	115	90	P	Backup	172.24.1.2	172.24.1.1	
Te0/0/0/5.516	116	100	P	Master	local	172.24.1.1	
Te0/0/0/5.517	117	90	P	Backup	172.24.1.2	172.24.1.1	

Control Plane Protection

LPTS exception punt

- Handles transit exceptions, some protocols, and snooping
 - Exceptions are transit that needs special processing [examples: MTU failure, TTL exhaustion]
 - Some protocols handled by LC CPU [BFD, ARP, CDP]
 - IGMP snooping
- Punted to LC CPU
 - Exception is IGMP snooping, punted to RSP CPU's
- Policers
 - Configured LC rate applied to LC, if not then a default rate applied
 - No global rate configuration option. But a pre-configuration per LC option
 - Enforced by each NP's microcode
 - More policers are added in newer releases

Control Plane Protection

Exception punt policers

```
RP/0/RSP0/CPU0:rasr9k-1y#show lpts pifib hardware static-police location 0/0/CPU0
Sun Dec 2 06:42:23.474 UTC
```

Node 0/0/CPU0:						
Burst = 100ms for all flow types						
Punt Reason	SID	Flow Rate	Burst Rate	Accepted	Dropped	Destination
PUNT_INVALID	NETIO_LOW	400	400	0	0	Local
PUNT_ALL	NETIO_HI	1000	200	0	0	Local
CDP	NETIO_CRUCIAL	50	50	11763	0	Local
ARP	ARP	5000	5000	75	0	Local
RARP	NETIO_CRUCIAL	1000	200	0	0	Local
LOOP	NETIO_LOW	1000	200	33448	0	Local
BUNDLE_PROTO_PUNT	LACP	1000	200	0	0	Local
UNKNOWN_OSI	NETIO_LOW	1000	200	0	0	Local
IGMP_SNOOP	NETIO_MED	4000	2000	0	0	0x0030 (0/RSP0/CPU0)
DIAGS	DIAG	1000	200	11132	0	Local
PUNT_NO_MATCH	NETIO_LOW	200	200	0	0	Local
IPV4_TTL_ERROR	NETIO_LOW	500	500	0	0	Local
IPV4_FRAG_NEEDED_PUNT	NETIO_LOW	10000	10000	0	0	Local
IPV4_BFD	BFD	500000	500000	0	0	Local
DROP_PACKET	NETIO_LOW	100	20	0	0	Local
PUNT_ADJ	NETIO_LOW	300	300	3	0	Local
IPV6_LINK_LOCAL	NETIO_HI	2000	2000	1000	0	Local

Control Plane Protection

Customize punt policer rates

```
RP/0/RSP0/CPU0:rasr9k-1y(config)#lpts punt police location 0/0/CPU0
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# protocol cdp rate 50
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# protocol arp rate 5000
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# protocol ipv4 options rate 100
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# exception icmp rate 200
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# exception ipv4 ttl-error rate 500
.
RP/0/RSP0/CPU0:rasr9k-1y#show running-config lpts punt police location 0/0/CPU0
Sun Dec 2 07:05:30.358 UTC
lpts punt police location 0/0/CPU0
exception invalid rate 400
protocol cdp rate 50
protocol arp rate 5000
protocol ipv4 options rate 100
exception icmp rate 200
exception ipv4 ttl-error rate 500
exception ipv4 fragment rate 10000
exception adjacency rate 300
exception acl-deny rate 50
exception ipv6 ttl-error rate 500
exception ipv6 fragment rate 10000
exception mpls fragment rate 10000
exception mpls ttl-error rate 500
!
```

Control Plane Protection

Customize punt policer rates – pre-configure

```
RP/0/RSP0/CPU0:rasr9k-1y(config)#lpts punt police location preconfigure 0/4/CPU0
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# protocol cdp rate 50
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# protocol arp rate 5000
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# protocol ipv4 options rate 100
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# exception icmp rate 200
RP/0/RSP0/CPU0:rasr9k-1(config-punt-policer-per-node)# exception ipv4 ttl-error rate 500
.
RP/0/RSP0/CPU0:rasr9k-1y#show running-config lpts punt police location 0/4/CPU0
Sun Dec 2 07:05:30.358 UTC
lpts punt police location 0/4/CPU0
exception invalid rate 400
protocol cdp rate 50
protocol arp rate 5000
protocol ipv4 options rate 100
exception icmp rate 200
exception ipv4 ttl-error rate 500
exception ipv4 fragment rate 10000
exception adjacency rate 300
exception acl-deny rate 50
exception ipv6 ttl-error rate 500
exception ipv6 fragment rate 10000
exception mpls fragment rate 10000
!
```

Control Plane Protection

Monitoring Hints

- A TCL script to periodically check and log excessive drops:
https://supportforums.cisco.com/sites/default/files/legacy/1/5/2/116251-IOS-XR_LPTS_Alerting.tar.gz
 - lpts-threshold-alerting.tcl[65755]: LPTS threshold (80%) exceeded for flow type Raw-default on 0/2/0, 102.513333333% of 250 pps in last 60 seconds
- To clear punt/exception Accepted/Dropped counters:
 - #clear controller np counters all location ...

A decorative header element consisting of a repeating pattern of red and dark red vertical bars and dots, resembling a stylized barcode or a series of signal bars.

Management

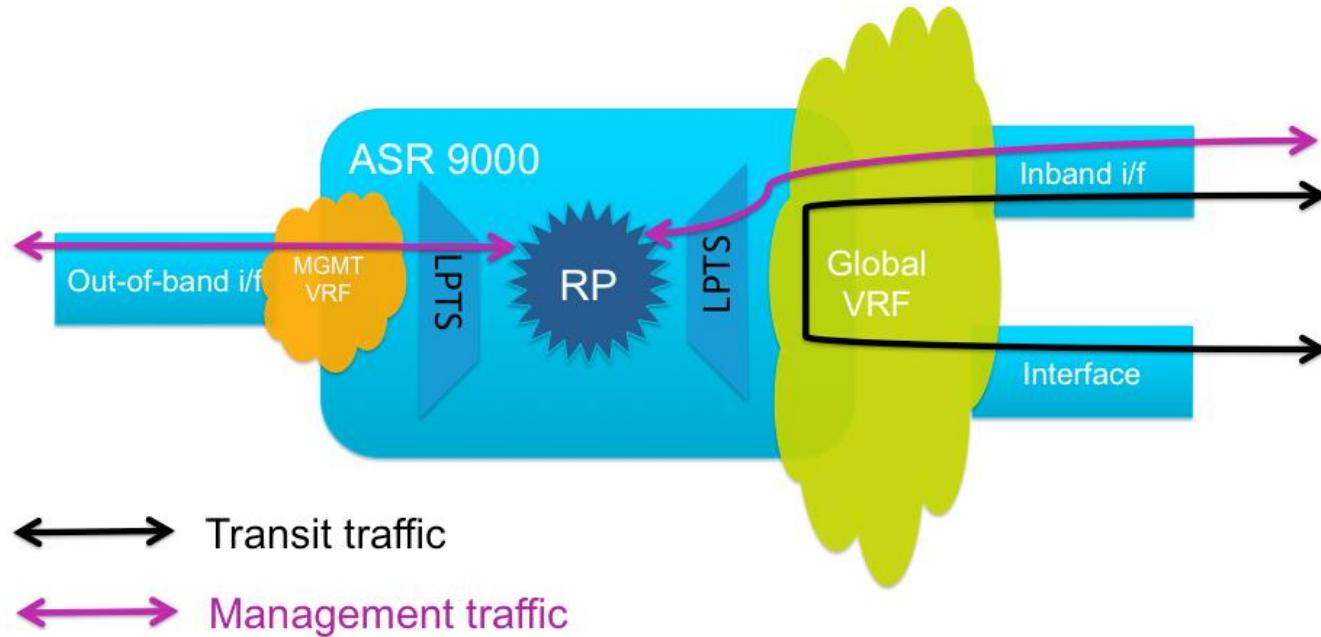
Management

Management Plane Protocols

- FTP
- NETCONF SSH
- NetFlow (also used by the Data Plane as that is where the traffic comes from)
- NTP
- RADIUS
- SCP
- SFTP
- SNMP
- SSH
- Syslog
- TACACS+
- Telnet
- TFTP
- XML

Management Traffic

Management interfaces: Out-of-band, in-band, and “global”



- No communication permitted between inband and out-of-band
- Management VRF is not necessary, but looks cleaner

Management Traffic

Out-of-Band: Virtual address, interfaces, and protocols

```
RP/0/RSP0/CPU0:rasr9k-1y#show running-config
!
vrf MGMT
  address-family ipv4 unicast
!
rp mgmtethernet forwarding ! If LC<>Mgmt
forwarding is needed
!
ipv4 virtual address vrf MGMT 172.16.111.110
255.255.0.0
ipv4 virtual address use-as-src-addr
!
interface Loopback1 ! If needed
  vrf MGMT
    ipv4 address 172.24.100.100 255.255.255.255
!
interface MgmtEth0/RSP0/CPU0/0
  vrf MGMT
    ipv4 address 172.16.111.111 255.255.0.0
!
interface MgmtEth0/RSP0/CPU0/1
  shutdown
!
interface MgmtEth0/RSP1/CPU0/0
  vrf MGMT
    ipv4 address 172.16.111.112 255.255.0.0
!
```

```
!
key chain OSPF-MGMT
  key 1
    accept-lifetime 00:00:00 january 01 2012 23:59:59
december 31 2014
    key-string password 153B382537
    send-lifetime 00:00:00 january 01 2012 23:59:59
december 31 2014
    cryptographic-algorithm HMAC-MD5
  !
  accept-tolerance 90000
!
router ospf OSPF
  vrf MGMT
    router-id 172.24.100.100
    area 0
      authentication message-digest keychain OSPF-MGMT
      interface Loopback1
    !
    interface MgmtEth0/RSP0/CPU0/0
    !
    interface MgmtEth0/RSP1/CPU0/0
    !
!
```

Management Traffic

Out-of-Band: Virtual address, interfaces, and protocols

```
RP/0/RSP0/CPU0:rasr9k-1y#show running-config  
control-plane management-plane out-of-band  
Wed Dec 5 00:45:07.132 UTC  
control-plane  
management-plane  
out-of-band  
vrf MGMT  
interface MgmtEth0/RSP0/CPU0/0  
allow SSH peer  
address ipv4 172.16.1.0/24  
!  
allow SNMP peer  
address ipv4 172.16.1.98  
!  
interface MgmtEth0/RSP1/CPU0/0  
allow SSH peer  
address ipv4 172.16.1.0/24  
!  
allow SNMP peer  
address ipv4 172.16.1.98  
!
```

```
RP/0/RSP0/CPU0:rasr9k-1y#show mgmt-plane  
wed Dec 5 00:46:26.162 UTC  
  
Management Plane Protection  
  
inband interfaces  
-----  
interface - TenGigE0_0_0_2/  
ssh configured -  
peer v4 allowed - 192.168.1.0/24  
  
outband interfaces  
-----  
interface - MgmtEth0_RSP0_CPU0_0/  
ssh configured -  
peer v4 allowed - 172.16.1.0/24  
snmp configured -  
peer v4 allowed - 172.16.1.98  
interface - MgmtEth0_RSP1_CPU0_0/  
ssh configured -  
peer v4 allowed - 172.16.1.0/24  
snmp configured -  
peer v4 allowed - 172.16.1.98
```

Management Traffic

In-band: If OOB is not available

```
RP/0/RSP0/CPU0:rasr9k-1y#show running-config  
control-plane management-plane inband
```

Tue Dec 11 23:05:11.597 UTC

```
control-plane  
management-plane
```

```
inband
```

```
  interface TenGigE0/0/0/2  
    allow SSH peer  
    address ipv4 192.168.1.0/24
```

```
RP/0/RSP0/CPU0:rasr9k-1y#show mgmt-plane  
wed Dec  5 00:46:26.162 UTC
```

Management Plane Protection

inband interfaces

```
-----  
interface - TenGigE0_0_0_2/  
  ssh configured -  
    peer v4 allowed - 192.168.1.0/24
```

outband interfaces

```
-----  
interface - MgmtEth0_RSP0_CPU0_0/  
  ssh configured -  
    peer v4 allowed - 172.16.1.0/24  
  snmp configured -  
    peer v4 allowed - 172.16.1.98
```

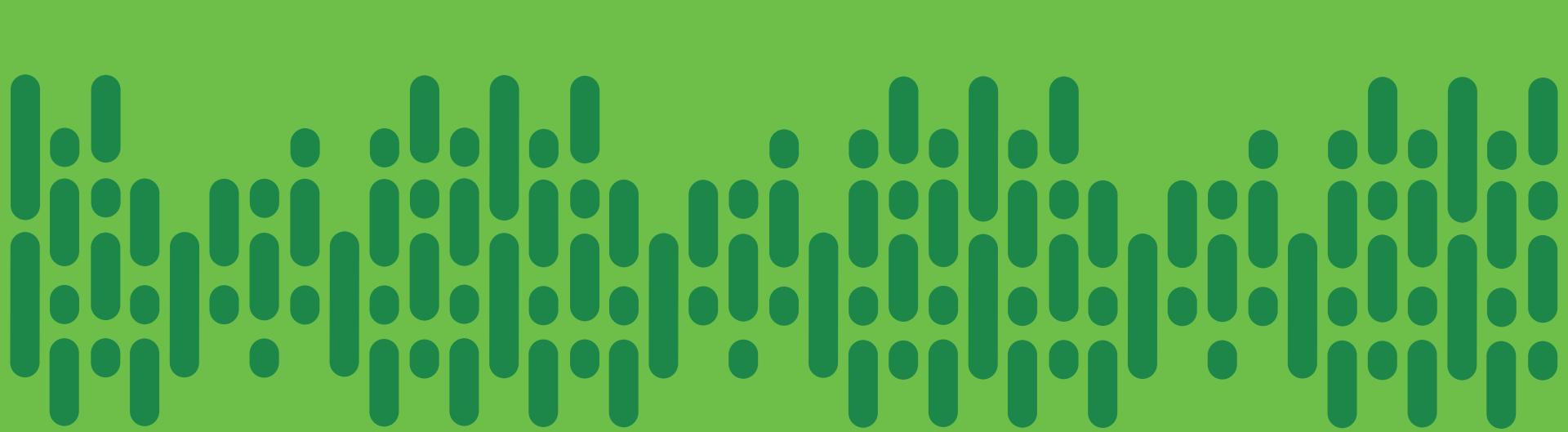
```
interface - MgmtEth0_RSP1_CPU0_0/  
  ssh configured -  
    peer v4 allowed - 172.16.1.0/24  
  snmp configured -  
    peer v4 allowed - 172.16.1.98
```

Management Protection

Authentication, authorization, and accounting

```
tacacs source-interface Loopback1 vrf MGMT
tacacs-server host 172.16.1.98 port 49
key 7 13061E010803
!
taskgroup operation
  task read bgp
  task read isis
  task write ospf
  inherit taskgroup operator
!
taskgroup provisioning
  inherit taskgroup netadmin
  description PROVISIONING GROUP
!
usergroup PROVISIONING
  taskgroup netadmin
  taskgroup provisioning
!
aaa authentication login default local
aaa accounting exec default start-stop group tacacs+ none
aaa authorization exec default group tacacs+
local none
aaa authorization commands default group tacacs+
none
aaa authentication login default group tacacs+
local
```

```
RP/0/RSP0/CPU0:rasr9k-1y(config)#do show aaa
taskgroup
Wed Dec 5 01:40:50.022 UTC
Task group 'operation'
  Inherits from task group 'operator'
  Task IDs included directly by this group:
  Task:          bgp : READ
  Task:          isis : READ
  Task:          ospf : READ      WRITE
  Task group 'operation' has the following combined
set
  of task IDs (including all inherited groups):
  Task:          basic-services : READ      WRITE
  EXECUTE DEBUG
  Task:          bgp : READ
  Task:          cdp : READ
  Task:          diag : READ
  Task:          ext-access : READ
  EXECUTE
  Task:          isis : READ
  Task:          logging : READ
  Task:          ospf : READ      WRITE
  Task group 'provisioning'
    Inherits from task group 'netadmin'
.
```



More Control Plane Security

What's at stake?

Security is CIA

- Confidentiality:
 - SP info
 - Customer info
 - Traffic

- Integrity:
 - SP traffic
 - Customer traffic
 - Control information

- Availability:
 - Operating environment
 - Operating parameters

- Threats are: environmental/natural/physical – human – technical

Control Plane Protection

Some Essential & Easy Protections

Global

Limit TCP syn wait time

!
tcp synwait-time 10 ! Default is 30 sec!

Accept only up to 200 connections per sec

tcp accept-rate 200 ! Default is 500

Max no. of for-us packets in assembler

ipv6 assembler max-packets 5 ! Default is 1000 packets

Discard timer for for-us frags in assembler

ipv6 assembler timeout 5

Max no. of for-us packets in assembler

ipv4 assembler max-packets 5 ! Default is 1000 packets

Discard timer for for-us frags in assembler

ipv4 assembler timeout 5

Disable IPv6 source route

no ipv6 source-route ! Default

Send up to 20 every 100 ms

ipv6 icmp error-interval 100 20

Send up to 1 every 600 ms

icmp ipv4 rate-limit unreachable 600 ! Default is 500 ms

Disable IPv4 source route

no ipv4 source-route ! Default

Control Plane Protection

Some Essential & Easy Protections

Interface

Disable proxy ARP

Disable IPv4 redirects

Disable IPv4 ICMP unreachable

Disable IPv6 router advertisements

Disable IPv6 ICMP unreachable

```
!
interface GigabitEthernet0/0/1/0
no proxy-arp ! Default
no ipv4 redirects ! Default
ipv4 unreachable disable ! Breaks PMTUD!
ipv6 nd suppress-ra ! RA only needed on host nets
ipv6 unreachable disable
```

Control Plane Protection

Routing & MPLS Protocol Security

```
key chain ISIS
key 1
accept-lifetime 00:00:00 january 01 2012
23:59:59 december 31 2014
key-string password 153B382537
send-lifetime 00:00:00 january 01 2012
23:59:59 december 31 2014
cryptographic-algorithm HMAC-MD5
!
router isis ISIS
is-type level-2-only
net 49.6539.1291.6800.1240.00
nsf ietf
lsp-password keychain ISIS
address-family ipv4 unicast
metric-style wide
!
interface TenGigE0/0/0/2
circuit-type level-2-only
hello-padding disable
hello-password keychain ISIS
address-family ipv4 unicast
metric 20
```

```
router ospf OSPF
vrf MGMT
router-id 172.24.100.100
area 0
authentication message-digest keychain
OSPF-MGMT
interface Loopback1
!
interface MgmtEth0/RSP0/CPU0/0
!
interface MgmtEth0/RSP1/CPU0/0
!
!
!
rsvp
interface TenGigE0/0/0/2
!
authentication
key-source key-chain RSVP-KEY
```

```
router bgp 6539
nsr
bgp router-id 192.168.1.240
!
neighbor 192.1.1.2
remote-as 64000
password encrypted 1511021F0725
ttl-security
address-family ipv4 unicast
route-policy CUSTOMER-A in
maximum-prefix 200 70
remove-private-AS
!
```

Control Plane Protection

VPLS Control Security: MAC LIMIT

- MAC learning limit per bridge domain & per AC
 - BD limit = OR > aggregate for AC's
 - Default is 4K, but no action
- “No-flood” to prevent learning & flooding
 - Traffic from known MAC sources continues to be forwarded/flooded. Unicast From **unknown** (new) is dropped
 - Protection to both **Control** and **Data** planes
- Notification both: Syslog and SNMP

```
RP/0/RSP0/CPU0:rasr9k-1y#show running-config I2vpn
Fri Dec 7 23:23:15.872 UTC
I2vpn
bridge group BRIDGES
bridge-domain DOMAIN-A
mac
limit
maximum 2000
action no-flood
notification both
!
secure
action none
logging
!
!
interface GigabitEthernet0/0/1/10.100
mac
limit
maximum 1000
action no-flood
notification both
```

Control Plane Protection

VPLS Control Security: MAC LIMIT

Notification: Limit exceeded and action being taken

```
RP/0/RSP0/CPU0:Dec 9 05:34:45.987 : l2vpn_mgr[1126]: %L2-L2VPN-6-MAC_LIMIT_AC_SET :  
Number of MAC addresses in AC 'Gi0/0/1/19.101' has reached the configured MAC limit maximum,  
MAC learning and unicast flooding disabled
```

AC showing configured limit/action and status

```
RP/0/RSP0/CPU0:rasr9k-1y#show l2vpn bridge-domain interface GigabitEthernet  
0/0/1/19.101 detail
```

Sun Dec 9 06:10:10.934 UTC

Legend: pp = Partially Programmed.

Bridge group: BRIDGES, bridge-domain: DOMAIN-A, id: 0, state: up, ShgId: 0, MSTi: 0

ACs: 2 (2 up), VFI: 1, PWs: 0 (0 up), PBBs: 0 (0 up)

List of ACs:

AC: GigabitEthernet0/0/1/19.101, state is up

MAC learning: disabled (MAC-limit action)

Flooding:

Broadcast & Multicast: enabled

Unknown unicast: disabled (MAC-limit action)

MAC aging time: 300 s, Type: inactivity

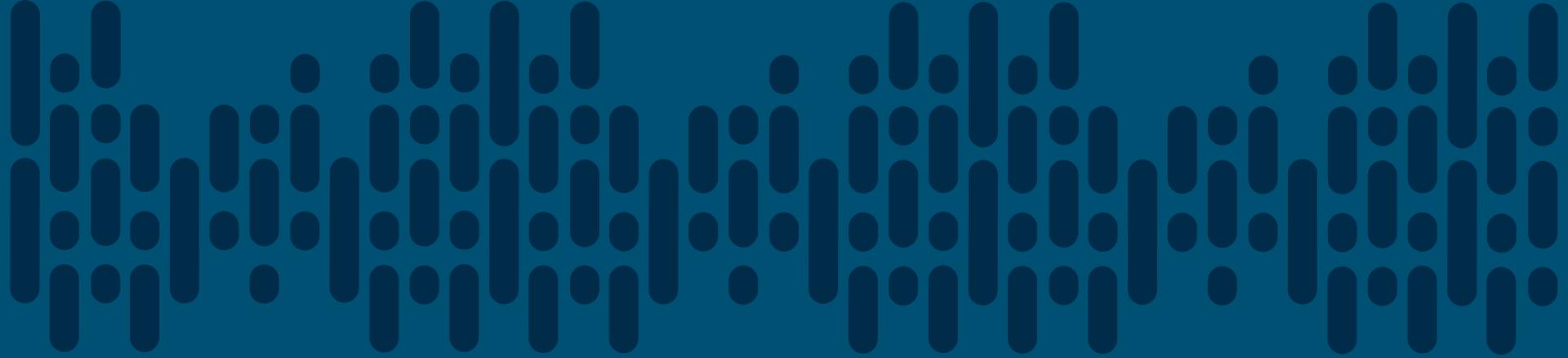
MAC limit: 1000, Action: limit, no-flood, Notification: syslog, trap

MAC limit reached: yes

MAC port down flush: enabled

Back within limit

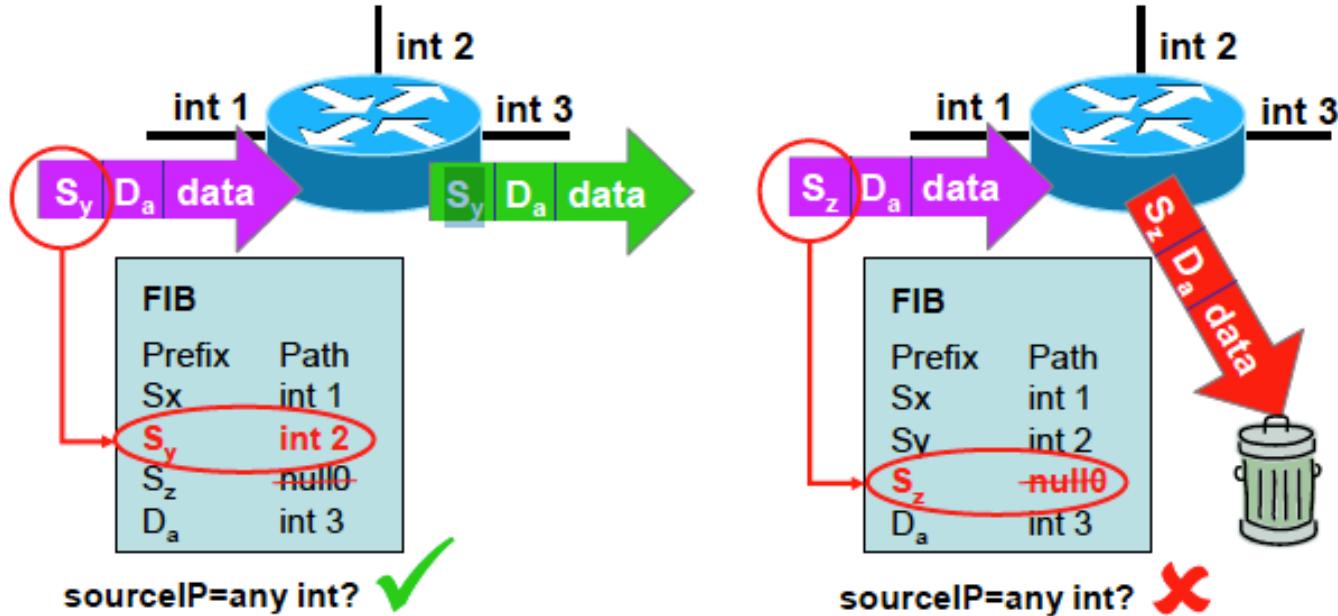
```
RP/0/RSP0/CPU0:Dec 9 08:00:17.577 : l2vpn_mgr[1126]: %L2-L2VPN-6-MAC_LIMIT_AC_CLEAR :  
Number of MAC addresses in AC 'Gi0/0/1/19.101' has gone below 75 percent of the configured MAC  
limit maximum, MAC learning and unicast flooding re-enabled
```

A decorative header element consisting of a repeating pattern of dark blue vertical bars of varying heights, creating a visual texture.

Securing the Data Plane

Data Plane Protection

Reverse Path Forwarding Verification: uRPF Loose



- Defense against spoofed and bogus source packets.

Data Plane Protection

Reverse Path Forwarding Verification: uRPF Loose

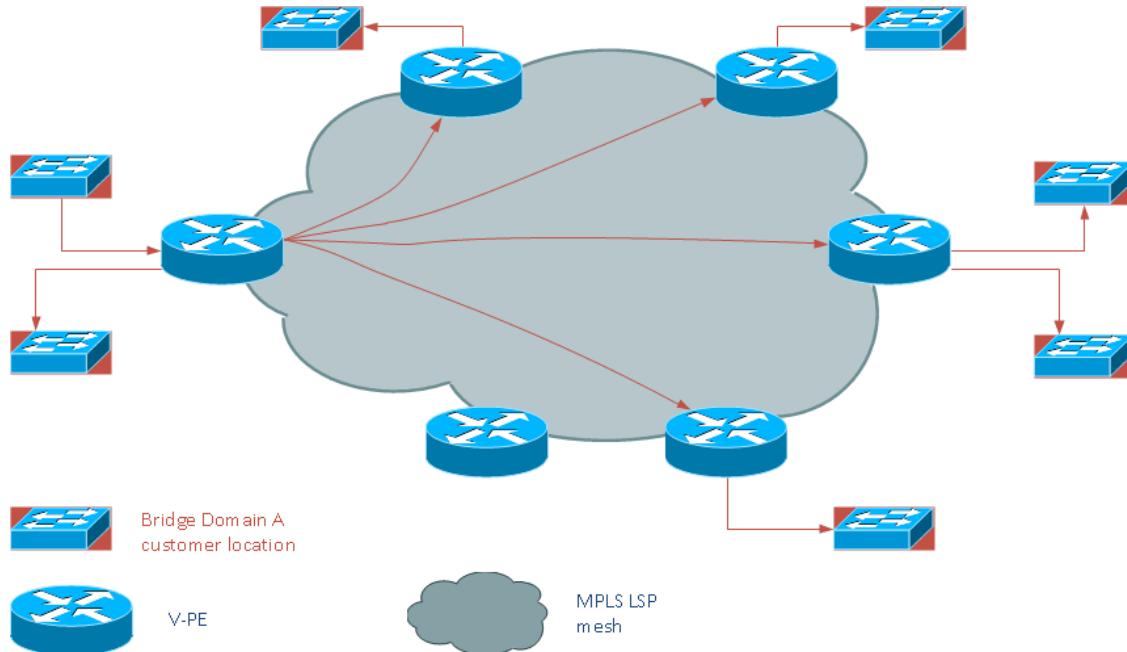
Routing to **null0** (e.g.
Bogons) results in
source drops

Loose uRPF [via any]
to account for
asymmetric traffic
and multi-homed
customers

```
RP/0/RSP0/CPU0:rasr9k-1y#show running-config router static
Thu Dec 6 22:40:58.625 UTC
router static
address-family ipv4 unicast
10.0.0.0/8 Null0
172.16.0.0/12 Null0
192.168.0.0/16 Null0
!
RP/0/RSP0/CPU0:rasr9k-1y#show running-config interface TenGigE 0/0/0/2
Thu Dec 6 22:30:17.910 UTC
interface TenGigE0/0/0/2
ipv4 address 172.29.1.1 255.255.255.252
ipv4 verify unicast source reachable-via any
ipv6 verify unicast source reachable-via any
!
RP/0/RSP0/CPU0:rasr9k-1y#show ipv4 interface TenGigE 0/0/0/2
Thu Dec 6 22:30:45.242 UTC
TenGigE0/0/0/2 is Up, ipv4 protocol is Up
Vrf is default (vrfid 0x60000000)
Internet address is 172.29.1.1/30
Table Id is 0xe0000000
IP unicast RPF check is enabled
RPF mode loose
```

Data Plane Protection

VPLS Storm Control: Flooding is Costly



- Frame copies of unknown destination, multicast, and broadcast are flooded.

Data Plane Protection

VPLS Storm Control

- Sets the PPS limit per AC for forwarding/flooding ingress L2:
 - Broadcast [dest MAC FFFF.FFFF.FFFF]
 - Multicast [dest MAC DNDD.DDDD.DDDD where D=any, and N is odd]
 - Unknown unicast [dest unicast MAC is not in MAC table]
- Does not impact unicast with dest MAC in cache/table

```
RP/0/RSP0/CPU0:rasr9k-1y#show running-config |2vpn
Mon Dec 10 08:10:39.712 UTC
I2vpn
bridge group BRIDGES
bridge-domain DOMAIN-A

interface GigabitEthernet0/0/1/10.100
!
storm-control unknown-unicast pps 2000
storm-control multicast pps 6000
storm-control broadcast pps 5000
!
interface GigabitEthernet0/0/1/19.101
!
storm-control unknown-unicast pps 2000
storm-control multicast pps 6000
storm-control broadcast pps 5000
!
vfi VFI-A
vpn-id 65000
autodiscovery bgp
rd auto
route-target 65000:1
```

Data Plane Protection

VPLS Storm Control

- For Data Centers:
broadcast and
unknown unicast rate
is influenced by **ARP**
and **MAC aging** on
hosts and network
devices
- To clear counters:
“clear l2vpn forwarding
counters”

```
RP/0/RSP0/CPU0:rasr9k-1y#show l2vpn bridge-domain interface GigabitEthernet
0/0/1/19.101 detail
Mon Dec 10 07:15:42.544 UTC
Legend: pp = Partially Programmed.
Bridge group: BRIDGES, bridge-domain: DOMAIN-A, id: 0, state: up, ShgId: 0, MSTi: 0
List of ACs:
AC: GigabitEthernet0/0/1/19.101, state is up
MAC aging time: 300 s, Type: inactivity
Storm Control:
Broadcast: enabled(5000)
Multicast: enabled(6000)
Unknown unicast: enabled(2000)
Static MAC addresses:
Statistics:
packets: received 4303565, sent 0
bytes: received 258213900, sent 0
Storm control drop counters:
packets: broadcast 0, multicast 0, unknown unicast 108388233
bytes: broadcast 0, multicast 0, unknown unicast 6503293980
Dynamic ARP inspection drop counters:
packets: 0, bytes: 0
```

Data Plane Protection

VPLS ARP Inspection

- Perform ARP/RARP checks:
 - All: `Sender_MAC == Source_MAC`
 - Replies: `Target_MAC == Dest_MAC`
 - ARP request source IPv4 is `unicast`
 - ARP reply dest IPv4 is `unicast`
- Configure at the BD level [Applies to all AC's] or the AC level

```
RP/0/RSP0/CPU0:rasr9k-1y#show running-config I2vpn
Tue Dec 11 03:50:31.612 UTC
I2vpn
bridge group BRIDGES
bridge-domain DOMAIN-A
dynamic-arp-inspection
logging
address-validation
src-mac
dst-mac
ipv4
!
interface GigabitEthernet0/0/1/10.100
dynamic-arp-inspection
logging
address-validation
src-mac
dst-mac
ipv4
!
storm-control unknown-unicast pps 2000
```

Data Plane Protection

VPLS ARP Inspection

- Violations are logged and dropped

```
RP/0/RSP0/CPU0:rasr9k-1y#show l2vpn forwarding interface GigabitEthernet 0/0/1/10.100 detail
location 0/0/CPU0
Tue Dec 11 06:29:08.357 UTC
Local interface: GigabitEthernet0/0/1/10.100, Xconnect id: 0x40001, Status: up

Flooding:
Broadcast & Multicast: enabled
Unknown unicast: enabled
MAC aging time: 300 s, Type: inactivity
MAC limit: 1000, Action: limit, no flood, Notification: syslog, trap
MAC limit reached: no
MAC Secure: enabled, Logging: disabled, Action: restrict
DHCPv4 snooping: profile not known on this node, disabled
Dynamic ARP Inspection: enabled, Logging: enabled
Dynamic ARP Inspection Address Validation:
    IPv4 verification: enabled
    Source MAC verification: enabled
    Destination MAC verification: enabled
IP Source Guard: disabled, Logging: disabled
IGMP snooping profile: profile not known on this node
```

```
LC/0/0/CPU0:Jun 16 13:28:28.697 : l2fib[188]: %L2-L2FIB-5-SECURITY_DAI_VIOLATION_AC :
Dynamic ARP inspection in AC GigabitEthernet0_0_0_7.1000 detected violated packet - source MAC:
0000.0000.0065, destination MAC: 0000.0040.0000, sender MAC: 0000.0000.0064, target MAC:
0000.0000.0000, sender IP: 5.6.6.6, target IP: 130.10.3.2
```

Data Plane Protection

VPLS MAC Security

- If a cached MAC appears as frame source on another AC:
 - Log
 - Do not learn MAC
 - Drop frame
- A bridge domain level options is to shut down “offending” AC

```
RP/0/RSP0/CPU0:rasr9k-1y#show running-config l2vpn
Fri Dec 14 02:52:41.373 UTC
l2vpn
bridge group BRIDGES
bridge-domain DOMAIN-A
mac
limit
!
secure
action none
logging
!
!
interface GigabitEthernet0/0/1/0.200
mac
limit
maximum 1000
action no-flood
notification both
!
secure
action restrict
logging
!
```

Data Plane Protection

VPLS MAC Security

To see the MAC table

```
RP/0/RSP0/CPU0:rasr9k-1y#show l2vpn forwarding bridge-domain mac-address location 0/0/CPU0  
Fri Dec 14 02:48:57.535 UTC
```

To Resynchronize MAC table from the Network Processors, use the command...
l2vpn resynchronize forwarding mac-address-table location <r/s/i>

Mac Address	Type	Learned from/Filtered on	LC learned	Resync	Age	Mapped to
0000.c001.0102	dynamic	Gi0/0/1/19.101	0/0/CPU0	0d 0h 0m 15s		N/A
0000.c001.0103	dynamic	Gi0/0/1/19.101	0/0/CPU0	0d 0h 0m 0s		N/A
.						
0000.c001.015f	dynamic	Gi0/0/1/19.101	0/0/CPU0	0d 0h 0m 3s		N/A
0000.c001.0160	dynamic	Gi0/0/1/19.101	0/0/CPU0	0d 0h 0m 3s		N/A
0000.c001.0161	dynamic	Gi0/0/1/19.101	0/0/CPU0	0d 0h 0m 13s		N/A
.						
0000.c001.0164	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m 20s		N/A
0000.c001.0166	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m 10s		N/A
0000.c001.0167	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m 17s		N/A
0000.c001.0168	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m 15s		N/A
0000.c001.0169	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m 0s		N/A

Violation detected,
action taken

```
LC/0/0/CPU0:Dec 14 03:00:12.138 : l2fib[249]: %L2-L2FIB-5-  
SECURITY_MAC_SECURE_VIOLATION_AC : MAC secure in AC  
GigabitEthernet0_0_1_0.200 detected violated packet - source MAC: 0000.c001.0160,  
destination MAC: 6c9c.ed2b.57dc; action: restrict
```

Data Plane Protection

Other Protections to Consider

- Routing:
 - Perimeter ACL [Also protects control and management planes]
 - Policing and admission control
 - No default route
 - Routing to Null0
 - BGP source/destination RTBH, and sinkholing
 - CSC label security
- Ethernet services:
 - DHCP snooping
 - IP source guard

Agenda

- ✓ **System Architecture:** System anatomy and health
- ✓ **Operating System & Configuration:** IOS-XR & configuration models
- ✓ **Control, Management, & Security:** Processing of control & exceptions
- **Transit Packet/Frame Journey:** Life of L3/L2 unicast/multicast
- **MPLS Operation:** Processing, forwarding and L3/L2 service operation
- **Troubleshooting:** Diagnostics, counters, drops, and packet capture

4 Transit Packet/Frame Journey

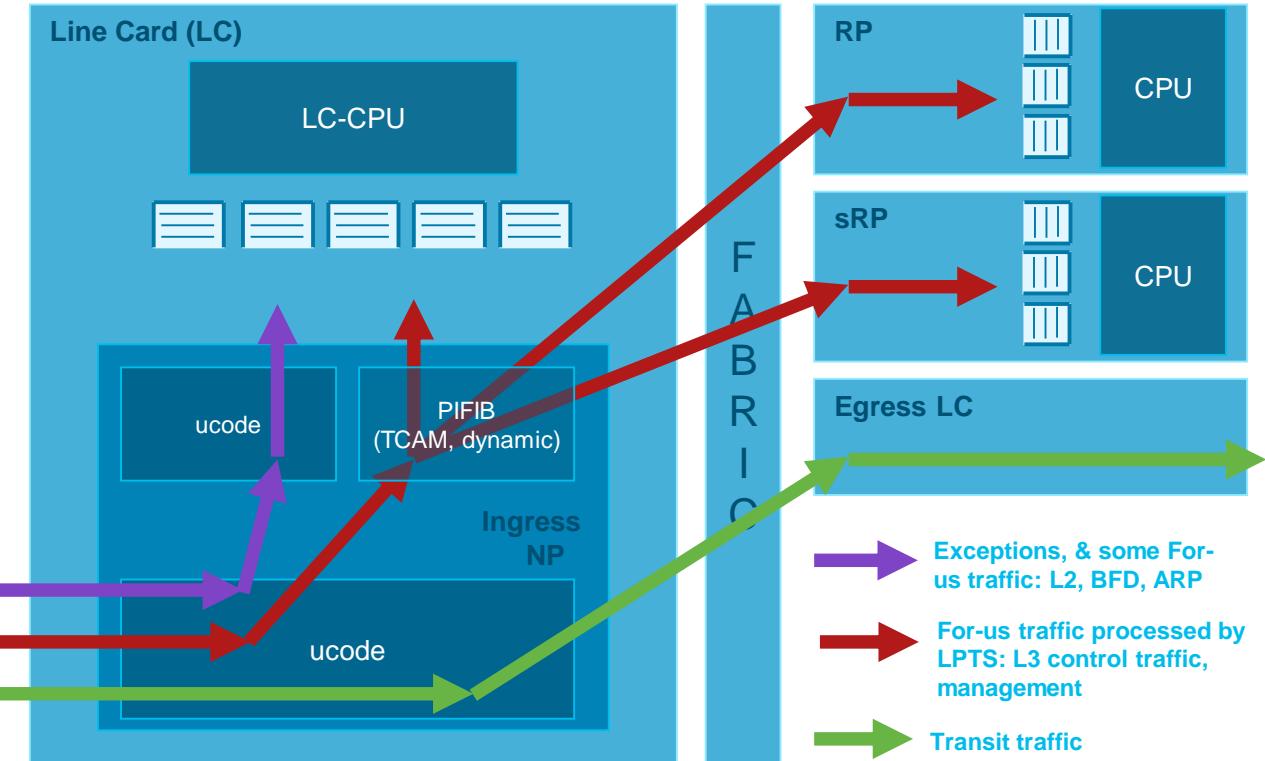


You make the power of data **possible**

Traffic: Transit, For us, and Exceptions

Differentiate on ingress NP

- **Transit**
 - Look up, re-write, forward
- **For us**
 - Destined to RP, or link local scope
 - Punt to RP or ingress LC CPU
- **Exception**
 - MTU failure, TTL failure, etc. Should have been transit
 - Punt to LC CPU

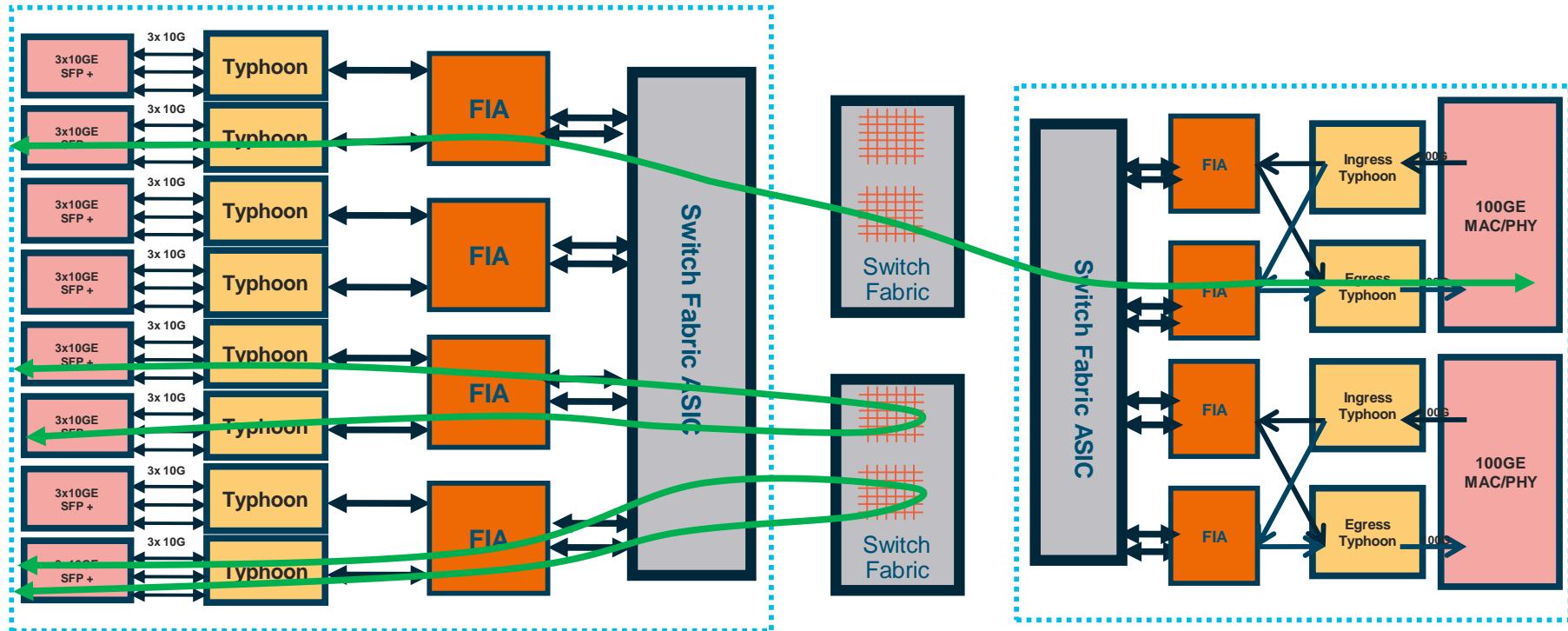




L3 Unicast Packet Forwarding

Unicast Transit Frame Path

Physical > NP > FIA > Fabric > FIA > NP > Physical



A9K-24X10GE

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#CLUS

TECSPG-3001

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246

Unicast Transit Frame Path

Forwarding

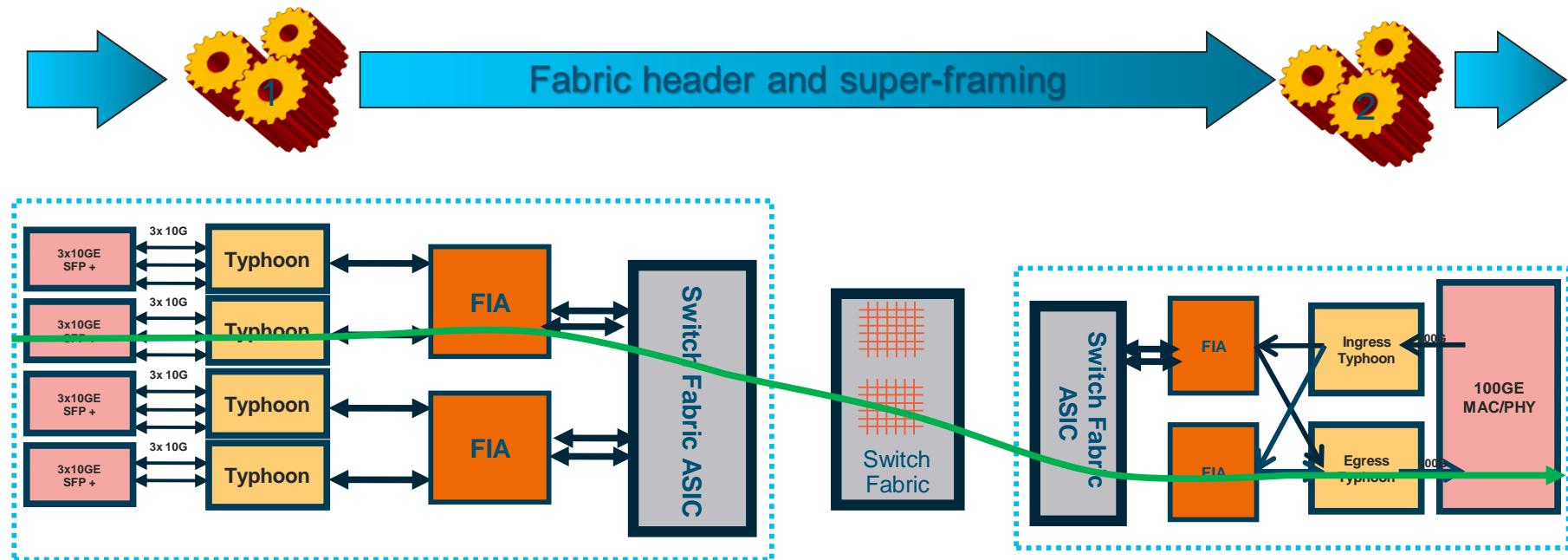
- All frames take same path stages
 - Ingress physical => ingress NP => FIA => fabric => FIA => egress NP => egress physical
 - Super-framing in fabric, and per super-frame load sharing
- Two stage forwarding
 - Ingress NP: to which egress port, ingress encap (if tunneling) and ingress features
 - Egress NP: Adjacency, encap, and egress features
- VOQ, and back-pressure signaling
 - Each FIA has a VQ per each egress 10 Gbps port. More VQs per 40 and 100 G ports
 - Back pressure is signaled backwards from egress NP to ingress FIA for buffering

Unicast Two Stage Forwarding

By ingress NP and egress NP

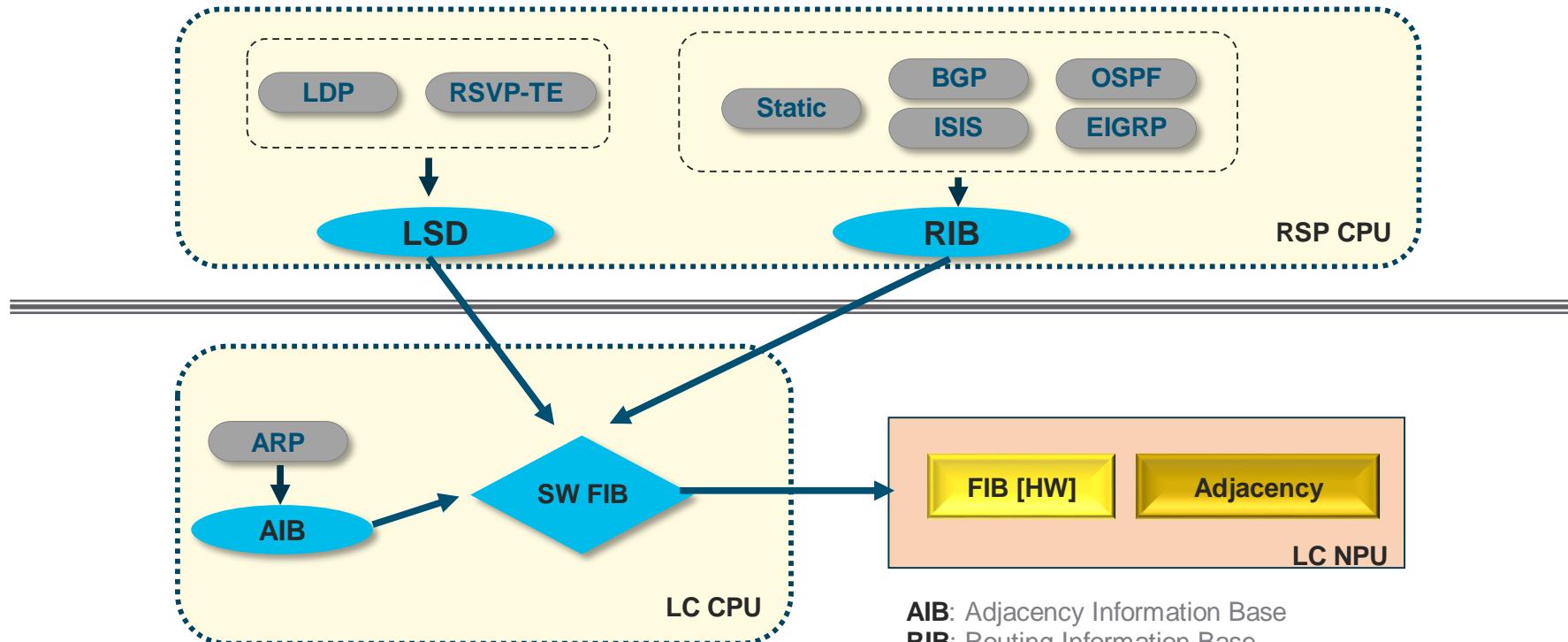
First stage: lookup on **ingress NPU** →
Egress NPU (or **SFP**: switch fabric port)

Second stage: lookup on **egress NPU** →
Egress port and rewrite information



The NP FIB

From RP control plane to data plane NP



AIB: Adjacency Information Base

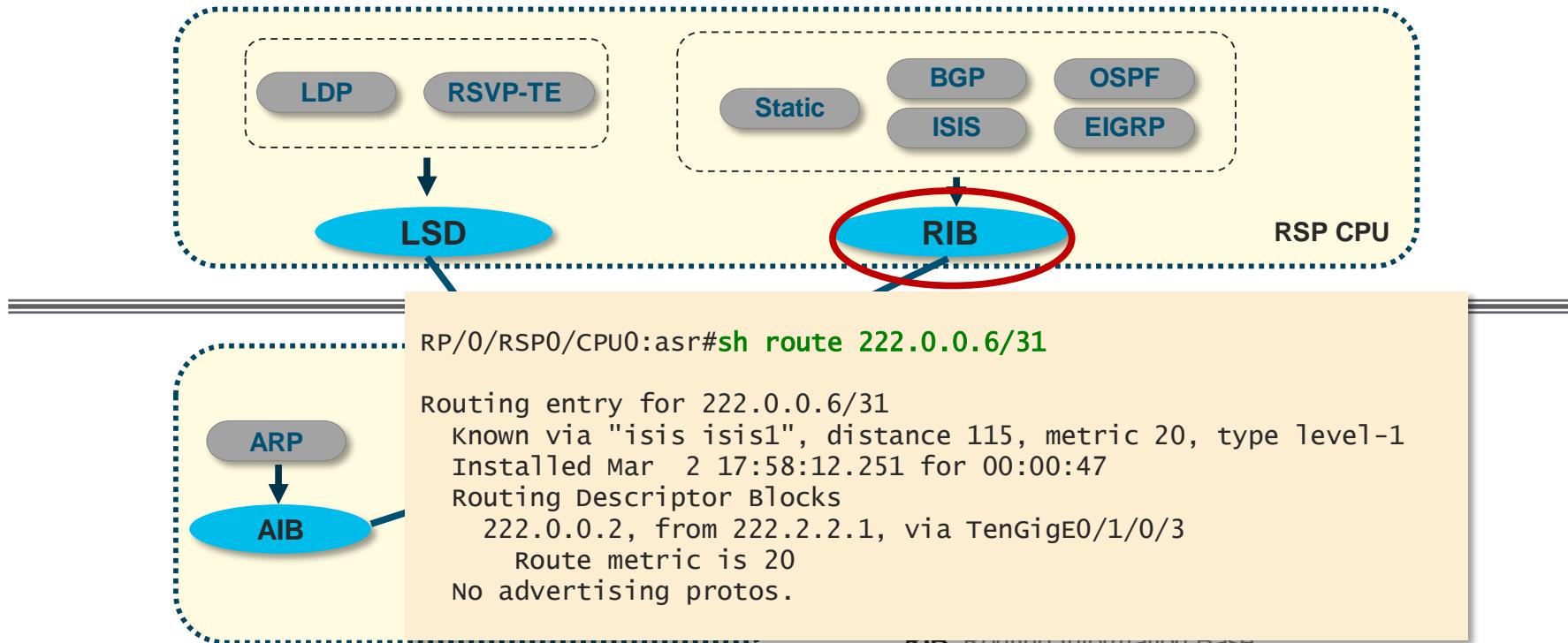
RIB: Routing Information Base

FIB: Forwarding Information Base

LSD: Label Switch Database

The NP FIB

RIB info: example



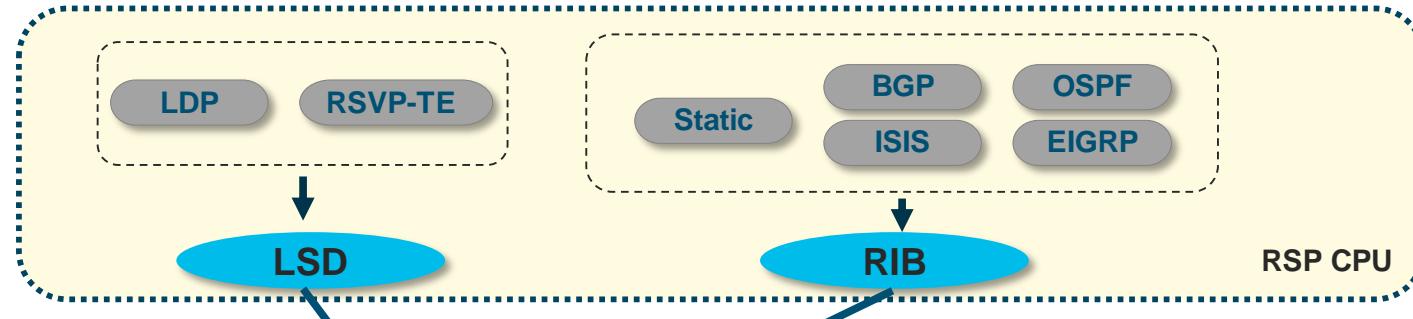
RIB: Routing Information Base

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The NP FIB

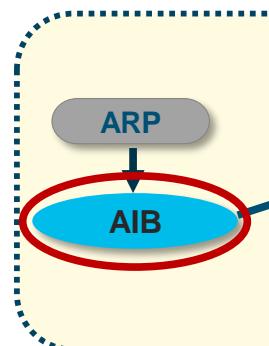
Line card adjacency



```
RP/0/RSP0/CPU0:asr#show adjacency summary Location 0/1/CPU0
```

Adjacency table (version 26) has 19 adjacencies:

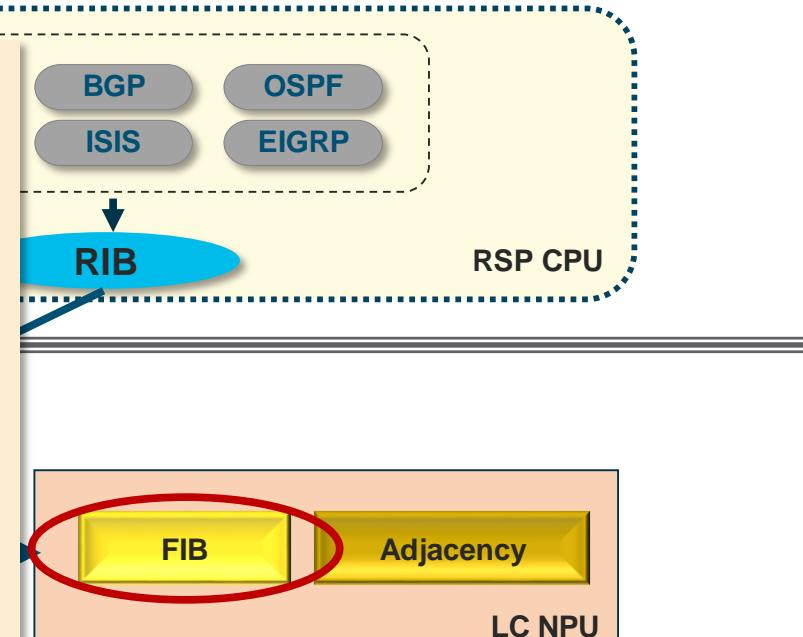
11 complete adjacencies
8 incomplete adjacencies
0 deleted adjacencies in quarantine list
8 adjacencies of type IPv4
 8 complete adjacencies of type IPv4
 0 incomplete adjacencies of type IPv4
 0 deleted adjacencies of type IPv4 in quarantine
 0 interface adjacencies of type IPv4
 4 multicast adjacencies of type IPv4



The NP FIB

FIB entry in NP: example

```
RP/0/RSP0/CPU0:asr#sh cef 222.0.0.6 hardware ingress loc 0/1/CPU0
222.0.0.6/31, version 1, internal 0x40000001 (0xb1d66c6c) [1], 0x0
(0xb1b4f758), 0x0 (0x0)
Updated Mar 2 17:58:11.987
local adjacency 222.0.0.2
Prefix Len 31, traffic index 0, precedence routine (0)
via 222.0.0.2, TenGigE0/1/0/3, 5 dependencies, weight 0, class 0
next hop 222.0.0.2
local adjacency
EZ:0 Leaf
=====
Search ctrl-byte0: 0x3 ctrl-byte1: 0x8 ctrl-byte2:0x5
Leaf Action : FORWARD
prefix length : 31
Search Control Flags :
    match      : 1      valid: 1
    done       : 0      ifib_lookup: 0
    ext_lsp_array : 0   match_all_bit: 0
    recursive   : 0   nonrecursive : 1
    default_action: 1
Non Recursive Leaf:
-----
ldi ptr : 10936 (0x2ab8)      igp statsptr:0
rpf ptr : 0x0000
```



AIB: Adjacency Information Base

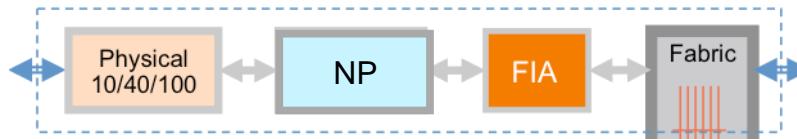
RIB: Routing Information Base

FIB: Forwarding Information Base

LSD: Label Switch Database

L3 Unicast Packet Journey

Mapping the port to NP and FIA



! Example: Path from GigabitEthernet0/0/1/0 192.3.1.2 TO TenGigE0/4/0/20.6 192.6.1.2

```
RP/0/RSP0/CPU0:rasm9k-1y#show controllers NP ports all location 0/0/CPU0
```

Fri Feb 22 15:57:32.307 UTC

Node: 0/0/CPU0:

NP	Bridge	Fia	Ports
0	--	0	TenGigE0/0/0/0, TenGigE0/0/0/1, TenGigE0/0/0/2, TenGigE0/0/0/3, TenGigE0/0/0/4, TenGigE0/0/0/5, TenGigE0/0/0/6, TenGigE0/0/0/7, TenGigE0/0/0/8, TenGigE0/0/0/9, TenGigE0/0/0/10, TenGigE0/0/0/11, TenGigE0/0/0/12, TenGigE0/0/0/13, TenGigE0/0/0/14, TenGigE0/0/0/15, TenGigE0/0/0/16, TenGigE0/0/0/17, TenGigE0/0/0/18, TenGigE0/0/0/19, TenGigE0/0/0/20, TenGigE0/0/0/21, TenGigE0/0/0/22, TenGigE0/0/0/23
1	--	1	GigabitEthernet0/0/1/0 - GigabitEthernet0/0/1/19

Map the port to NP
and FIA

```
RP/0/RSP0/CPU0:rasm9k-1y#show controllers NP ports all location 0/4/CPU0
```

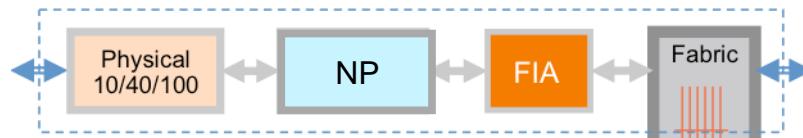
Fri Feb 22 15:55:22.370 UTC

Node: 0/4/CPU0:

NP	Bridge	Fia	Ports
0	--	0	TenGigE0/4/0/0, TenGigE0/4/0/1, TenGigE0/4/0/2
1	--	0	TenGigE0/4/0/3, TenGigE0/4/0/4, TenGigE0/4/0/5
2	--	1	TenGigE0/4/0/6, TenGigE0/4/0/7, TenGigE0/4/0/8
3	--	1	TenGigE0/4/0/9, TenGigE0/4/0/10, TenGigE0/4/0/11
4	--	2	TenGigE0/4/0/12, TenGigE0/4/0/13, TenGigE0/4/0/14
5	--	2	TenGigE0/4/0/15, TenGigE0/4/0/16, TenGigE0/4/0/17
6	--	3	TenGigE0/4/0/18, TenGigE0/4/0/19, TenGigE0/4/0/20
7	--	3	TenGigE0/4/0/21, TenGigE0/4/0/22, TenGigE0/4/0/23

L3 Unicast Packet Journey

The egress interface identifier



```
RP/0/RSP0/CPU0:rasr9k-1y#show controllers pm interface tenGigE 0/4/0/20.6
```

Fri Feb 22 16:45:22.404 UTC

Ifname(1): TenGigE0_4_0_20.6, ifh: 0xc001340 :

iftype 0x19

egress_uidb_index 0x1d

ingress_uidb_index 0x1d

port_num 0x14

subslot_num 0x0

phy_port_num 0x14

channel_id 0x6

channel_map 0x0

lag_id 0x0

virtual_port_id 0x0

switch_fabric_port 0x136

in_tm_qid_fid0 0x0

in_tm_qid_fid1 0x0

in_qos_drop_base 0x0

out_tm_qid_fid0 0x0

0x0

out_tm_qid_fid1 0x0

0x0

out_qos_drop_base 0x0

bandwidth 10000000 kbps

Get internal
identifiers

Interface handle: unique to
logical sub-interface

Fabric port, shared between all port
sub-interfaces. The fabric
destination.

L3 Unicast Packet Journey

Ingress NP FIB

```
RP/0/RSP0/CPU0:rasr9k-1y#show cef ipv4 192.6.1.2
hardware ingress location 0/0/CPU0
Fri Feb 22 17:40:35.887 UTC
192.6.1.0/24, version 364, attached, connected,
internal 0xc0000c1 (ptr 0x8856b534) [1], 0x0
(0x873dde50), 0x0 (0x0)
    Updated Feb 22 16:09:42.862
    remote adjacency to TenGigE0/4/0/20.6
    Prefix Len 24, traffic index 0, precedence
    routine (0), priority 0
        via TenGigE0/4/0/20.6, 2 dependencies, weight
    0, class 0 [flags 0x8]
        path-idx 0 [0x8a60a7bc 0x0]
        remote adjacency
    LEAF - HAL pd context :
        sub-type : IPV4, ecd_marked:0,
        has_collapsed_ldi:0, collapse_bwalk_required:0,
        ecdv2_marked:0
    Leaf H/W Result:
        Physical Result: 0x11dd0600 (LE)
        Raw Data0: 0x91ad1000 00000001 360c0013
        40000000
        Raw Data1: 0x00000000 00000136 00180000
        00000000
.
```

RX H/W Result on **NP:1** [Adj ptr:0x3a (BE)]:

```
Raw_Data0: 0x91000000 00000136 0c001340 00000000
adj_resolve_control_byte0
    match: 1
valid: 1
    iptunl_adj: 0
    remote_rack: 0
    adj_resolve_control_byte1
        adj_down: 0
mgscp_en: 0
    rx_lag_hash_en: 0
    rx_lag_adj: 0
    adj_resolve_control_byte2
        rx_lag_adj: 0
rx_adj_null0: 0
    rp_destined: 0
rx_punt: 0
    rx_drop: 0
    sfp/vqi : 0x136
    if_handle : 0xc001340
.
```

L3 Unicast Packet Journey

Egress NP FIB

```
RP/0/RSP0/CPU0:rasr9k-1y#show cef ipv4 192.6.1.2
hardware egress location 0/4/CPU0
Fri Feb 22 17:55:28.494 UTC
192.6.1.2/32, version 0, internal 0x4080001 (ptr
0x8efc2704) [1], 0x0 (0x8e0f2210), 0x0 (0x0)
Updated Feb 22 16:13:35.351
local adjacency 192.6.1.2
Prefix Len 32, traffic index 0, Adjacency-
prefix, precedence routine (0), priority 0
via 192.6.1.2, TengGigE0/4/0/20.6, 3
dependencies, weight 0, class 0 [flags 0x0]
path-idx 0 [0x91a2cef8 0x0]
next hop 192.6.1.2
local adjacency
LEAF - HAL pd context :
  sub-type : IPV4, ecd_marked:0,
has_collapsed_ldi:0, collapse_bwalk_required:0,
ecdv2_marked:0
Leaf H/W Result:
  Physical Result: 0x11e80300 (LE)
  Raw Data0: 0x91ad1000 8a030001 360c0013
40400000
.
```

```
TX H/W Result for NP:6 (index: 0x38a (BE)):
  Raw Data0: 0x91080000 1d000000 dc050000 400b5f00
  Raw Data1: 0x0000c006 01020000 00000000 00000000
    adj_resolve_control_byte0
      reserved: 0
  egr_uidb_internal: 1
      match: 1
  valid: 1
    iptun1_adj: 0
    adj_resolve_control_byte1
      tx_adj_null0: 0
  tx_punt: 0
      tx_drop: 0
      default_action: 1
  spare: 0
    adj_resolve_control_byte2
      spare: 0
  spare_cb: 0
    flags
      gre_adj : 0
    uidb_index : 0x1d00 (LE)
    reserve_pad_word: 0
    13_mtu : 1500
    reserve_pad_1 : 0
    adj_stats_index : 0x400b5f00
    dest_mac : 0x0000.c006.0102
    ether reserved : 0000000000000000
```

L3 Unicast Packet Journey

GRE encap case

```
RP/0/RSP0/CPU0:rasr9k-1y#show cef vrf DEF ipv4
172.25.25.2 hardware ingress location 0/4/CPU0
Sat Feb 23 14:35:00.017 UTC
172.25.25.0/24, version 1, attached, connected,
internal 0xc0000c1 (ptr 0x8e154de4) [1], 0x0
(0x8e0ec7c0), 0x0 (0x0)
Updated Feb 21 16:28:04.573
local adjacency point2point
Prefix Len 24, traffic index 0, precedence
routine (0), priority 0
via tunnel-ip25, 3 dependencies, weight 0,
class 0 [flags 0x8]
path-idx 0 [0x90fdd3b4 0x0]
local adjacency
LEAF - HAL pd context :
sub-type : IPV4, ecd_marked:0,
has_collapsed_ldi:0, collapse_bwalk_required:0,
ecdv2_marked:0
Leaf H/W Result:
Physical Result: 0x11be0200 (LE)

Raw Data0: 0x11a50000 c9020000 00000000 00000000
Raw Data1: 0x00000000 00000000 00180000 0000a2ff
leaf_resolve_control_byte0
```

```
TX H/W Result for NP:6 (index: 0x28a (BE)):
.
adj_resolve_control_byte0
    reserved: 0
egr_uidb_internal: 1
                                match: 1
valid: 1
iptunl_adj: 1
.
flags
gre_adj : 1
uidb_index : 0x1b00 (LE)
reserve_pad_word: 0
13_mtu : 1476
reserve_pad_1 : 0
adj_stats_index : 0x18005f00
GRE Adj
ip_src : 172.20.20.1 ip_dst : 172.20.20.2
tos : 0 ttl : 0xff
df : 1 tos_reflect : 1
rsrvd_flag_bits: 0 encaps_checksum: 0x40a3
vrf_id : 0
reserved : 0
```

L3 Unicast Packet Journey

GRE encap case: GRE adjacency

```
RP/0/RSP0/CPU0:rasr9k-1y#show cef vrf DEF
adjacency tunnel-ip 25 hardware ingress location
0/4/CPU0
Sat Feb 23 14:44:52.239 UTC
Display protocol is ipv4
Interface      Address
Type          Refcount
ti25          Prefix: 0.0.0.0/32
local         3
            Adjacency: PT:0x8aa0c0c8 0.0.0.0/32
            Interface: ti25
            GRE header:
0000004500400000a2fb2fff011414ac021414ac00080000
            GRE tunnel adjacency
            GRE tunnel info: 0x91b3b050 (0x1 3),
tos-propagate is set
            Interface Type: 0x25, Base Flags:
0x2001 (0x90fdd3b4)
            Nhinfo PT: 0x90fdd3b4, Idb PT:
0x8d8f8898, If Handle: 0x8000120
            Dependent adj type: remote
(0x90fdd460)
            Dependent adj intf: ti25
            Ancestor If Handle: 0x0
```

```
TX H/W Result for NP:6 (index: 0x28a (BE)):
.
adj_resolve_control_byte0
    reserved: 0
    egr_uidb_internal:
1
    match: 1
    valid:
1
    iptunl_adj: 1
.
flags
    gre_adj : 1
uidb_index : 0x1b00 (LE)
reserve_pad_word: 0
13_mtu : 1476
reserve_pad_1 : 0
adj_stats_index : 0x18005f00
.
GRE Adj
    ip_src : 172.20.20.1
    ip_dst : 172.20.20.2
    tos : 0
    ttl : 0xff
    df : 1
    rsrvd flag bits : 0
    tos_reflect : 1
    encaps_checksum :
0x40a3
    vrf_id : 0
    reserved: 0
```

L3 Unicast Packet Journey

IP to MPLS-TE case

```
RP/0/RSP0/CPU0:rasr9k-1y#show cef ipv4 172.29.2.1
hardware ingress location 0/4/CPU0
Sat Feb 23 15:22:57.224 UTC
172.29.2.0/24, version 259, internal 0x4004001
(ptr 0x8efba154) [1], 0x0 (0x8e0ece00), 0x440
(0x90dca470)
    Updated Feb 22 11:03:15.593
    Prefix Len 24, traffic index 0, precedence
    routine (0), priority 3
        via 192.168.20.242, tunnel-te200, 5
dependencies, weight 0, class 0 [flags 0x0]

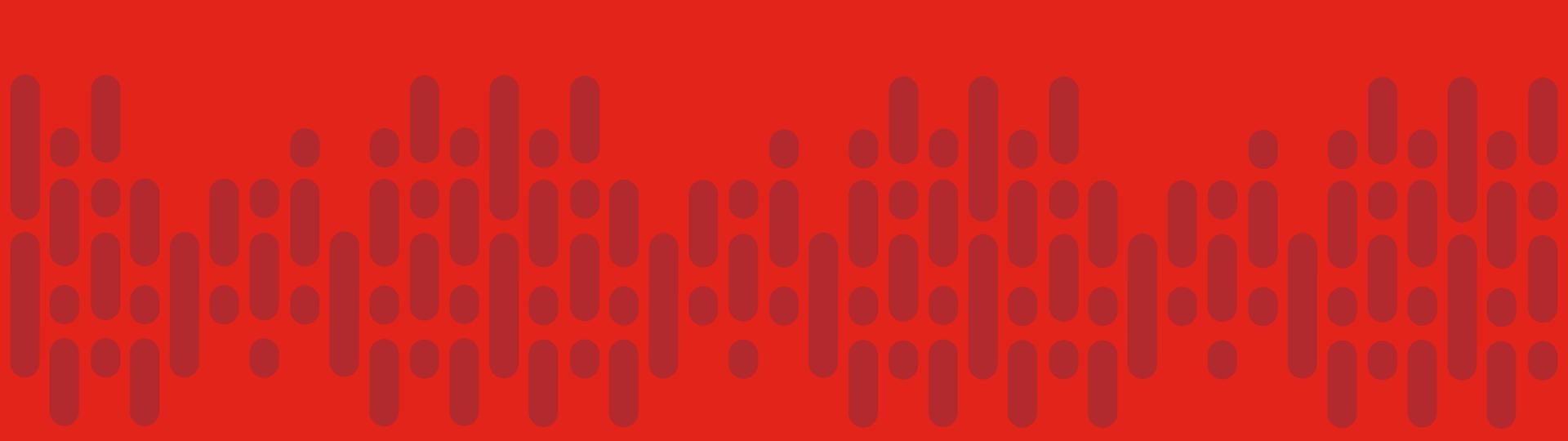
TE-NH H/W Result for 1st NP:0 (index: 0x3 (BE)):
.
    tunnel_over_tunnel: 0
spare: 0
.
    TE_local_label:
        label: 16012
        exp: 0
eos: 1
    TE_tunnel_label:
        label: 0
        exp: 0
eos: 1
    te_nh_stats_ptr: 0x880a5f
```

```
RX H/W Result for 1st NP:0 (index: 0x38 (BE)):

    Raw Data0: 0x91000000 0000005c 00000640
00000000
        adj_resolve_control_byte0
            match: 1
valid: 1
            iptunl_adj: 0
            remote_rack: 0

        adj_resolve_control_byte1
            adj_down: 0
mgscp_en: 0
            rx_lag_hash_en: 0
            rx_lag_adj: 0

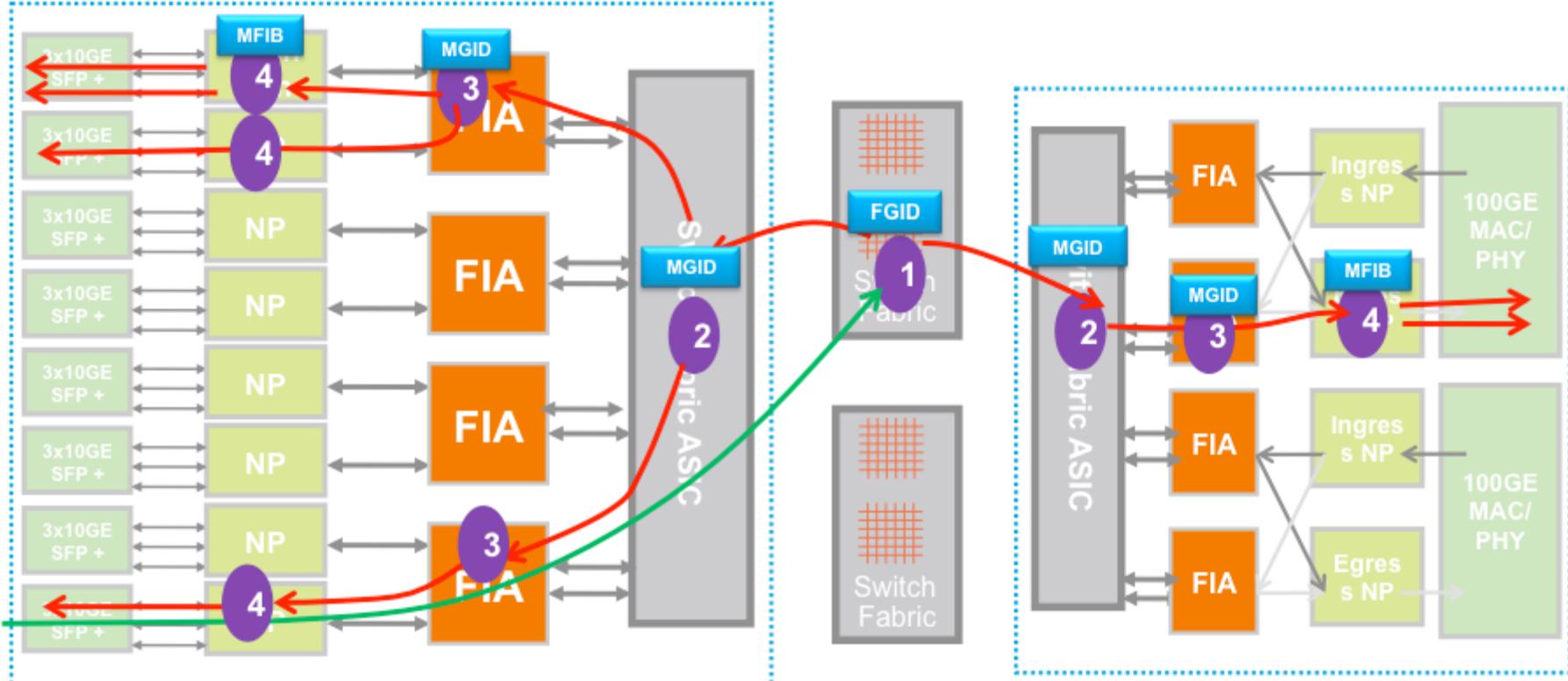
        adj_resolve_control_byte2
            rx_lag_adj: 0
rx_adj_null0: 0
            rp_destined: 0
rx_punt: 0
            rx_drop: 0
            sfp/vqi : 0x5c
            if_handle : 0x640
.
```



L3 Multicast Packet Replication

Multicast Transit Frame Path

Replication stages: per LC, per FIA, per NP, per interface



Multicast Transit Frame Path

Lookups and replications

- Two MFIB lookups
 - Ingress NP tags frame with FGID and MGID, and ingress feature processing
 - FGID [Fabric Group ID]: to which LC's
 - MGID [Multicast Group ID]: Entry index to egress NP's
 - Egress NP replicates to egress interfaces, and egress feature processing
- Egress replication
 - 1st replication is at RSP switch fabric. Replicates to 1 copy per egress line card [FGID]
 - 2nd replication at each egress LC switch fabric. Replicates to 1 copy per egress FIA [MGID]
 - 3rd replication at each egress FIA. Replicates to 1 copy per egress NP [MGID]
 - 4th replication at each egress NP. Replicates to 1 copy for each egress interface [MFIB]
- Per flow load sharing
 - Ingress NP hashes to ingress FIA (like on a 100 Gbps interface)
 - FIA hashes to LC fabric links
 - LC fabric hashes to RSP fabric links
 - Similar per-flow load sharing over 2 links RSP fabric=>LC, LC fabric=>FIA, FIA=>NP

Multicast Fabric Group ID

FGID = destination card

Slot		Slot Mask	
Logical	Physical	Binary	Hex
LC7	9	1000000000	0x0200
LC6	8	0100000000	0x0100
LC5	7	0010000000	0x0080
LC4	6	0001000000	0x0040
RSP0	5	0000100000	0x0020
RSP1	4	0000010000	0x0010
LC3	3	0000001000	0x0008
LC2	2	0000000100	0x0004
LC1	1	0000000010	0x0002
LC0	0	0000000001	0x0001

9906

9010

9910/12/22

Slot		Slot Mask	
Logical	Physical	Binary	Hex
LC3	5	0000100000	0x0020
LC2	4	0000010000	0x0010
LC1	3	0000001000	0x0008
LC0	2	0000000100	0x0004
RSP1	1	0000000010	0x0002
RSP0	0	0000000001	0x0001

Slot		Slot Mask	
Logical	Physical	Binary	Hex
LC19	21	10000 00000000 00000000	0x10 0000
LC1-18	3-20		
LC0	2	0000000100	0x0004
RP1	1	0000000010	0x0002
RP0	0	0000000001	0x0001

- Follows the sequence of slots in chassis

L3 Multicast Packet Journey

Reading the mRIB

```
RP/0/RSP0/CPU0:rasr9k-1y#show mrib route 232.1.1.1 172.30.1.1 detail
```

```
Tue Feb 26 17:15:05.039 UTC
```

```
IP Multicast Routing Information Base
```

```
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
```

```
.
```

```
(172.30.1.1,232.1.1.1) ver: 0x5180 RPF nbr: 172.29.1.2 Flags:,
```

```
PD: Slotmask: 0x41
```

```
MGID: 16903
```

```
Up: 5d09h
```

```
Incoming Interface List
```

```
TenGigE0/0/0/2 Flags: A IC II LI, Up: 5d09h
```

```
Outgoing Interface List
```

```
TenGigE0/0/0/0 Flags: F IC NS II LI, Up: 4d08h
```

```
TenGigE0/0/0/1 Flags: F IC NS II LI, Up: 4d08h
```

```
TenGigE0/4/0/2.2 Flags: F NS LI, Up: 5d09h
```

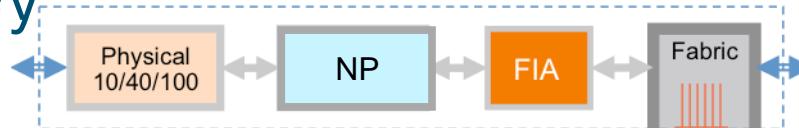
```
TenGigE0/4/0/20.6 Flags: F IC NS II LI, Up: 00:59:25
```

```
GigabitEthernet0/0/1/19 Flags: F IC NS II LI, Up: 01:08:45
```

0x41 = 0100 0001:
LC0 & LC4 in 9010
[physical slots 0, 6]

L3 Multicast Packet Journey

Reading the NP mFIB



```
RP/0/RSP0/CPU0:rasr9k-1y#show mfib hardware route detail 232.1.1.1 172.30.1.1 location 0/4/CPU0
```

Tue Feb 26 18:09:54.515 UTC

LC Type: Typhoon A9K-24x10GE-TR

Source: 172.30.1.1 Group: 232.1.1.1 Mask: 64 RPF Int: Te0/0/0/2
MGID: 16903 MLI: 5 Fabric Slotmask: 0x41 **FGID: 0x41**

Route Information

NP	B	S	DC	PL	PR	PF	DR	RI	T	OC	MF	TR	TE	TD	CD	MI	Base
0	F	F	F	F	F	F	F	0x640	0	1	F	F	F	F	F	0x0	0x5100d4
1	F	F	F	F	F	F	F	0x640	0	0	F	F	F	F	F	0x0	0x5100d4
2	F	F	F	F	F	F	F	0x640	0	0	F	F	F	F	F	0x0	0x5100d4
3	F	F	F	F	F	F	F	0x640	0	0	F	F	F	F	F	0x0	0x5100d4
4	F	F	F	F	F	F	F	0x640	0	0	F	F	F	F	F	0x0	0x5100d4
5	F	F	F	F	F	F	F	0x640	0	0	F	F	F	F	F	0x0	0x5100d4
6	F	F	F	F	F	F	F	0x640	1	1	F	F	F	F	F	0x0	0x5100d4
7	F	F	F	F	F	F	F	0x640	0	0	F	F	F	F	F	0x0	0x5100d4

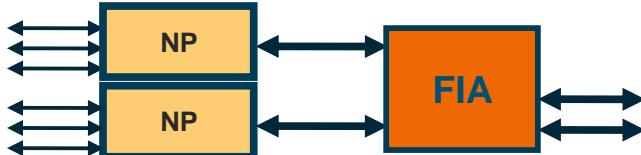
Outgoing interface
count per NP

Software MGID Information

```
MGID: 16903 Mask: 0x41 old MGID: 0 old Mask: 0x1
```

L3 Multicast Packet Journey

Reading egress LC Fabric and FIA replication



```
RP/0/RSP0/CPU0:rasr9k-1y#show controllers mgidprgm mgidindex 16903 location 0/0/CPU0
Tue Feb 26 17:35:10.026 UTC
```

Device	MGID-BITS	Client-Last-Modified
XBAR-0	11	MFIBV4
FIA-0	10	MFIBV4
FIA-1	10	MFIBV4

Fabric to 1st & 2nd FIA
FIA to 2nd NP

MGID

Egress LC

```
RP/0/RSP0/CPU0:rasr9k-1y#show controllers mgidprgm mgidindex 16903 location 0/4/CPU0
Tue Feb 26 17:35:15.417 UTC
```

Device	MGID-BITS	Client-Last-Modified
XBAR-0	1001	MFIBV4
FIA-0	1	MFIBV4
FIA-1	0	MFIBV4
FIA-2	0	MFIBV4
FIA-3	1	MFIBV4

Fabric to 1st & 4th FIA
None
FIA to 1st NP

L3 Multicast Packet Journey

Reading the hardware counters

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show mfib vrf TRAFFIC hardware route statistics 232.1.1.100  
192.5.1.100 location 0/1/CPU0
```

Thu Jan 9 22:09:04.997 EST

LC Type: Typhoon A9K-MOD80-SE

Legend:

N:	NP ID	R:	Received
F:	Forwarded	P:	Punted to CPU
ID:	Ingress Drop	ED:	Egress Drop

Source: 192.5.1.100 Group: 232.1.1.100 Mask:64

NP R(packets:bytes)/F(packets:bytes)/P(packets)/ID(packets)/ED(packets)

0 18326252:4948100612 / 0:0 / 0 / 0 / 0

1 0:0 / 18212304:4917314359 / 0 / 0 / 0

Received on NP0

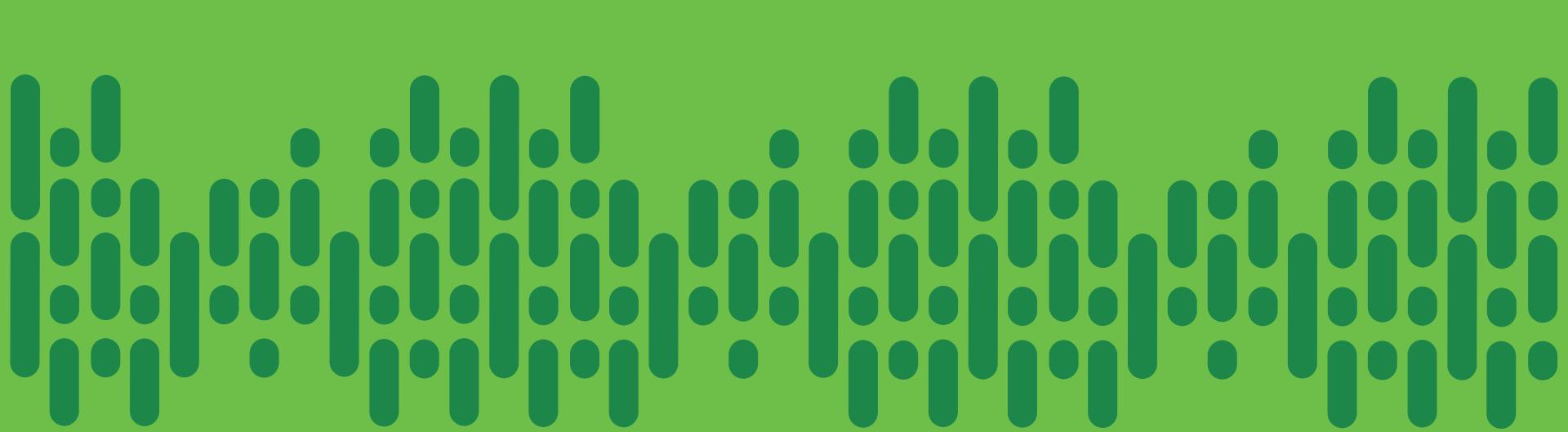
Interface Statistics:

C Interface F/P/D (packets:bytes)

1 Gi100/0/0/9 18212651:4917382603 / 0:0 / 0:0

Forwarded on NP1

Forwarded on interface [satellite]



L2 Frame Forwarding & Flooding

L2 Frame Journey

L2 frame forwarding/flooding

```
RP/0/RSP0/CPU0:rasr9k-1y#show l2vpn forwarding
bridge-domain BRIDGES:DOMAIN-A hardware ingress
detail location 0/4/CPU0
Sun Feb 24 13:53:34.530 UTC

Bridge-domain name: BRIDGES:DOMAIN-A, id: 0,
state: up
MAC learning: enabled
MAC port down flush: enabled
Flooding:
    Broadcast & Multicast: enabled
    Unknown unicast: enabled
MAC aging time: 300 s, Type: inactivity
MAC limit: 2000, Action: limit, no flood,
Notification: syslog, trap
MAC limit reached: no
MAC Secure: enabled, Logging: enabled, Action: none
DHCPv4 snooping: profile not known on this node
Dynamic ARP Inspection: enabled, Logging: enabled
Dynamic ARP Inspection Address Validation:
    IPv4 verification: enabled
    Source MAC verification: enabled
    Destination MAC verification: enabled
IP Source Guard: disabled, Logging: disabled
IGMP snooping: disabled, flooding: enabled
Bridge MTU: 1500 bytes
Number of bridge ports: 4
Number of MAC addresses: 2002
```

```
Bridge Domain: 0 NP 0
Flags: Virtual Table, Multicast Flooding, Learn
Enable, No Learn, Learn Drop
Num Members: 0, Learn Key: 0x00, Half Age: 5
fgid shg0: 0x0001, fgid shg1: 0x0041, fgid
shg2: 0x0041
PBB Core BD: 0, ISID: 0
Bridge Domain: 0 NP 1
Flags: Virtual Table, Multicast Flooding, Learn
Enable, No Learn, Learn Drop
Num Members: 0, Learn Key: 0x00, Half Age: 5
fgid shg0: 0x0001, fgid shg1: 0x0041, fgid
shg2: 0x0041
PBB Core BD: 0, ISID: 0
Bridge Domain: 0 NP 6
Flags: Virtual Table, Multicast Flooding, Learn
Enable, No Learn, Learn Drop
Num Members: 1, Learn Key: 0x00, Half Age: 5
fgid shg0: 0x0001, fgid shg1: 0x0041, fgid
shg2: 0x0041
PBB Core BD: 0, ISID: 0
Bridge Port 0
    XID: 0x09b00001, Active
        virtual
    XID: 0x09b00001, Active
```

L2 Frame Journey

L2 frame forwarding/flooding

! CONTINUED

```
TenGigE0/4/0/20.101, state: oper up
Number of MAC: 0
Statistics:
    packets: received 36731752, sent 14772099
    bytes: received 2203905120, sent 886325940
    Storm control drop counters:
        packets: broadcast 0, multicast 0, unknown
        unicast 2961034169
        bytes: broadcast 0, multicast 0, unknown unicast
177662050140
        Dynamic arp inspection drop counters:
            packets: 0, bytes: 0
        IP source guard drop counters:
            packets: 0, bytes: 0
Platform Bridge Port context:
Ingress State: Bound
    Flags: DAI, DAI-ipv4, DAI-src-MAC, DAI-dst-MAC, DAI-log,
MAC-SEC, MAC-SEC-log,
        MAC-learn-disabled
    MAC Security Actions: Drop, No Notify
Platform AC context:
Ingress AC: VPLS, State: Bound
    Flags: Learn Limit - No Learn, Learn Limit - Drop, Storm
Control BCast,
        Storm Control MCast, Storm Control UCast, Port
Level MAC Limit
    XID: 0x09b00001, SHG: None
    Ingress uIDB: 0x001c, Egress uIDB: 0x001c, NP: 6,
Port Learn Key: 0
.
```

NP6

```
Ingress uIDB:
    Flags: DAI, DAI Notification, Dest MAC validation,
IP Addr Validation,
    L2PT, L2, Source MAC validation, Status, Ext
Required, VLAN Ops,
    VPLS
    Stats Ptr: 0x000000, uIDB index: 0x001c, Wire Exp
Tag: 1
    BVI Bridge Domain: 0, BVI Source XID: 0x00000000
    VLAN1: 0, VLAN1 etype: 0x0000, VLAN2: 0, VLAN2
    etype: 0x0000
    L2 ACL Format: 0, L2 ACL ID: 0, IPV4 ACL ID: 0,
IPV6 ACL ID: 0
    QOS ID: 0, QOS Format ID: 0
    Local Switch dest XID: 0x09b00001
    UIDB IF Handle: 0x0c000042, Source Port: 0, Num
    VLANs: 0
    Xconnect ID: 0x09b00001, NP: 6
    Type: AC
    Flags: Learn enable, Type 5, Learn limit no learn,
Learn limit drop,
        Broadcast storm control, Multicast storm
control, Unknown unicast storm control,
        VPLS
    uIDB Index: 0x001c
    Bridge Domain ID: 0, Stats Pointer: 0xf78122
    Storm Control enabled for: Broadcast, Multicast,
Unknown Unicast, Pointer: 0x00001801
.
```

L2 MAC

MAC learning and synchronization

```
RP/0/RSP0/CPU0:rasr9k-1y#show 12vpn forwarding bridge-domain BRIDGES:DOMAIN-A mac-address  
hardware ingress location 0/4/CPU0
```

Fri Feb 22 18:50:08.433 UTC

To Resynchronize MAC table from the Network Processors, use the command...
12vpn resynchronize forwarding mac-address-table location <r/s/i>

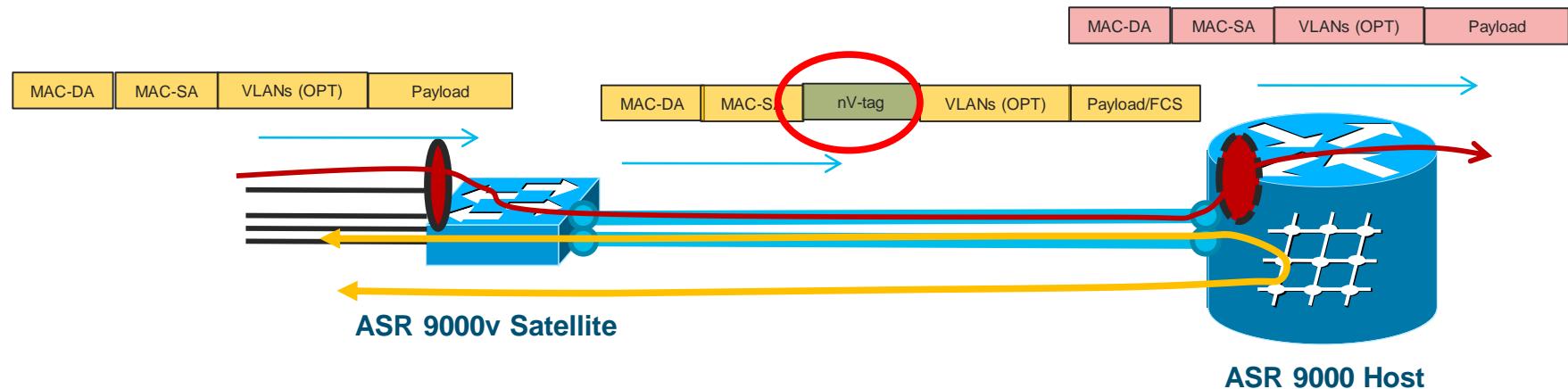
Mac Address	Type	Learned from/Filtered on	LC learned	Resync	Age	Mapped to
0000.c001.0167	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m	18s	N/A
0000.c001.016b	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m	11s	N/A
0000.c001.016c	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m	9s	N/A
0000.c001.016d	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m	18s	N/A
0000.c001.016e	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m	20s	N/A
0000.c001.016f	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m	8s	N/A
0000.c001.0171	dynamic	Gi0/0/1/0.200	0/0/CPU0	0d 0h 0m	17s	N/A
0000.c001.0102	dynamic	Te0/4/0/20.101	0/4/CPU0	0d 0h 0m	16s	N/A
0000.c001.0104	dynamic	Te0/4/0/20.101	0/4/CPU0	0d 0h 0m	20s	N/A
0000.c001.0105	dynamic	Te0/4/0/20.101	0/4/CPU0	0d 0h 0m	8s	N/A
0000.c001.0106	dynamic	Te0/4/0/20.101	0/4/CPU0	0d 0h 0m	9s	N/A
0000.c001.0107	dynamic	Te0/4/0/20.101	0/4/CPU0	0d 0h 0m	18s	N/A
0000.c001.0108	dynamic	Te0/4/0/20.101	0/4/CPU0	0d 0h 0m	15s	N/A
0000.c001.0109	dynamic	Te0/4/0/20.101	0/4/CPU0	0d 0h 0m	3s	N/A
0000.c001.010a	dynamic	Te0/4/0/20.101	0/4/CPU0	0d 0h 0m	4s	N/A
.						



ASR 9000 Satellite to/from Host

ASR 9000v “Satellite”

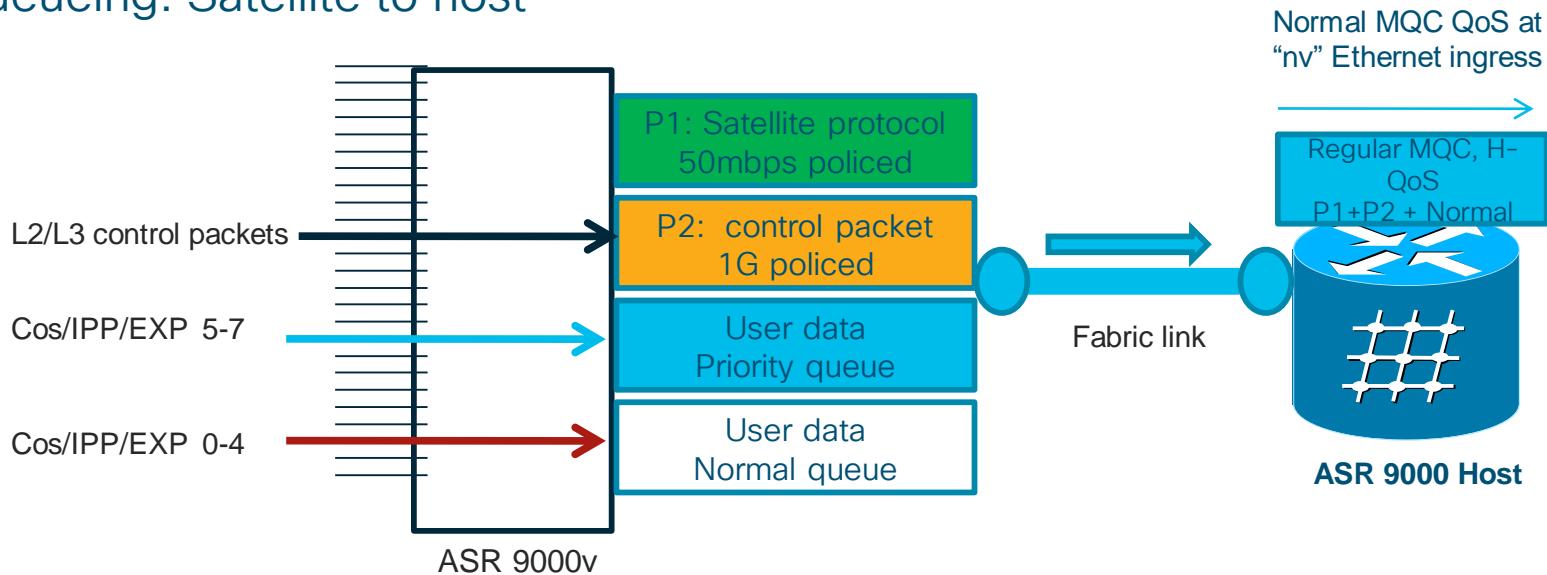
Traffic flow



- “nV” tag identifies the satellite port traffic
- No learning or switching on satellite
- L2/3/4 and ingress/egress QoS done on host

ASR 9000v “Satellite”

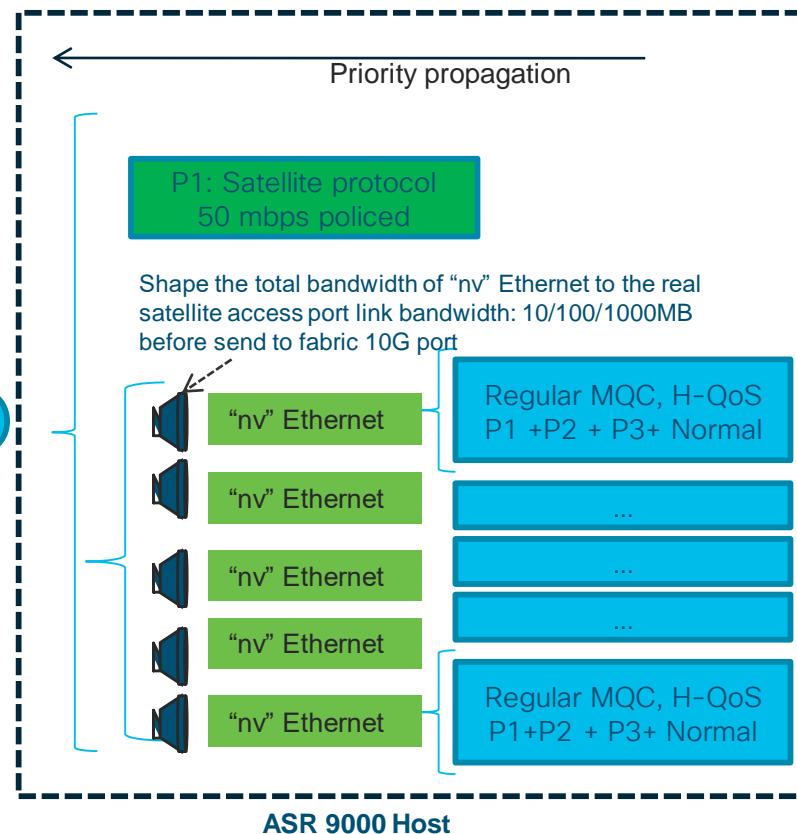
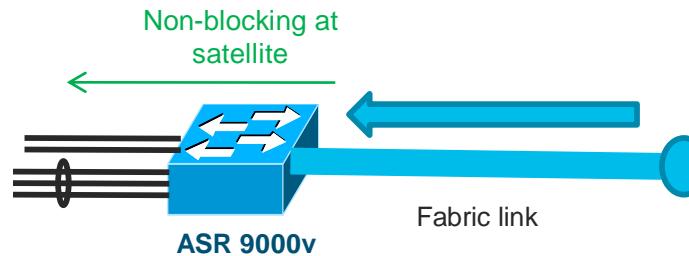
Queueing: Satellite to host

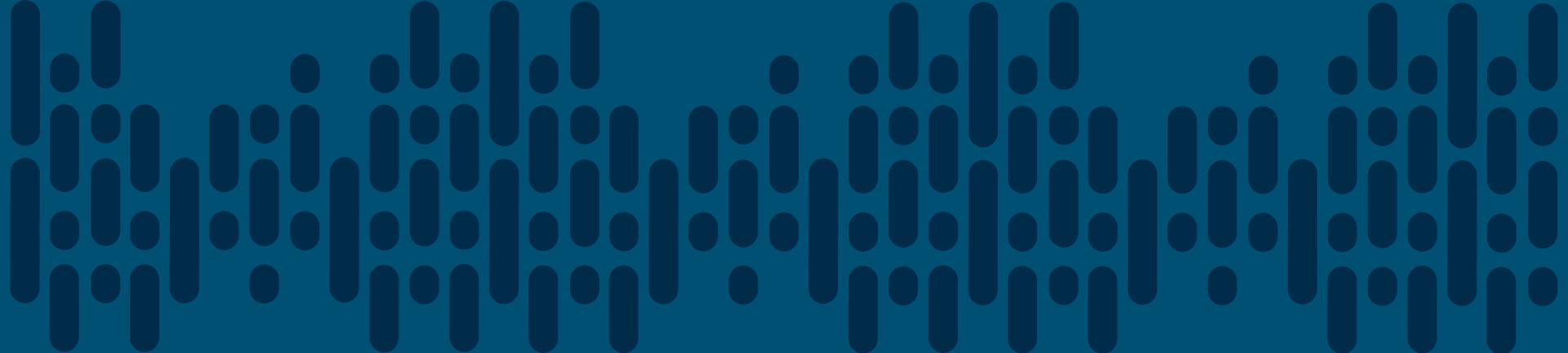


- Implicit classification
- P1 and P2 are strict priority
- User data priority:normal 100:1 bandwidth

ASR 9000v “Satellite”

Queueing: Host to satellite

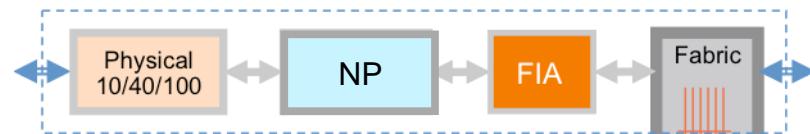




Under the Hood: Inside NP, FIA, and Fabric

Frame Path: Stats & Drops

Reading the physical counters

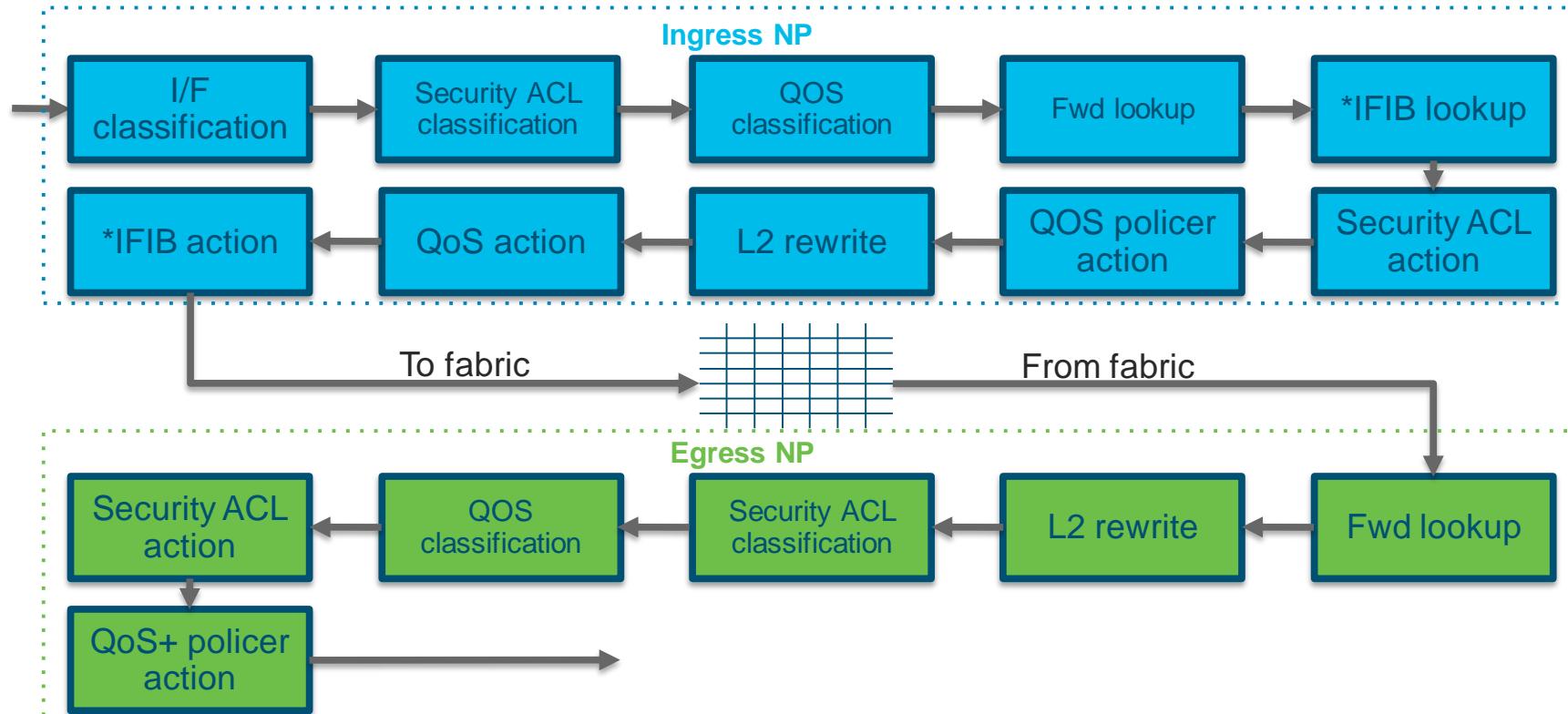


```
RP/0/RSP0/CPU0:rusr9k-1y#show controllers
TenGigE0/4/0/20 stats
Sun Feb 24 14:44:18.899 UTC
Statistics for interface TenGigE0/4/0/20 (cached values):
Ingress:
Input total bytes      = 3081227904920
Input good bytes       = 3081227904920
Input total packets    = 23220024479
Input 802.1Q frames   = 0
Input pause frames    = 0
Input pkts 64 bytes   = 7143534733
Input pkts 65-127 bytes = 2888766549
Input pkts 128-255 bytes = 13124923916
Input pkts 256-511 bytes = 62799261
Input pkts 512-1023 bytes = 0
Input pkts 1024-1518 bytes = 0
Input pkts 1519-Max bytes = 0
Input good pkts        = 23220024479
Input unicast pkts     = 23220023458
Input multicast pkts   = 62
Input broadcast pkts   = 959
Input drop overrun      = 0
```

Egress:	
Output total bytes	= 1345771624
Output good bytes	= 1345771624
Output total packets	= 21895707
Output 802.1Q frames	= 0
Output pause frames	= 0
Output pkts 64 bytes	= 21665536
Output pkts 65-127 bytes	= 21179
Output pkts 128-255 bytes	= 168767
Output pkts 256-511 bytes	= 40225
Output pkts 512-1023 bytes	= 0
Output pkts 1024-1518 bytes	= 0
Output pkts 1519-Max bytes	= 0
Output good pkts	= 21895707
Output unicast pkts	= 21870499
Output multicast pkts	= 25195
Output broadcast pkts	= 13
Output drop underrun	= 0
Output drop abort	= 0
Output drop other	= 0
Output error other	= 0

NP Feature Processing

Order of processing by ingress and egress NP's



Inside NP

Processing pipelines



Inside NP

Reading pipeline counters



```
RP/0/RSP0/CPU0:rasr9000-2w-a#show controllers NP counters np0 location 0/1/CPU0
Wed Nov 27 21:09:07.635 EST
```

```
Node: 0/1/CPU0:
```

```
Show global stats counters for NP0, revision v2
```

```
Read 64 non-zero NP counters:
```

```
Offset Counter
```

```
FrameValue Rate (pps)
```

16	MDF_TX_LC_CPU	6722114	10
17	MDF_TX_WIRE	1826039	3
21	MDF_TX_FABRIC	1635541	2
29	PARSE_FAB_RECEIVE_CNT	1837406	3
33	PARSE_INTR_RECEIVE_CNT	5083364	7
37	PARSE_INJ_RECEIVE_CNT	1228130	2
499	RSV_ING_L2_SMAC_MISS	60	0
502	RSV_ING_L2_LEARN	60	0
541	RSV_REFRESH_FROM_NOTIFY_CNT	62	0
584	RSV_L2BC_BVI	2	0
604	RESOLVE_REMOTE_RACK_PREP_CNT	5539915	8
708	LRN_PERIODIC_AGING_DELETE_ENTRY	60	0
774	ARP	119	0
848	PUNT_ADJ	2	0
852	PUNT_ACL_DENY	161	0
900	PUNT_STATISTICS	5083356	7
902	PUNT_DIAGS_RSP_ACT	11419	0
904	PUNT_DIAGS_RSP_STBY	11427	0

List of NP counters:

<https://supportforums.cisco.com/docs/DOC-26566>

NP Counters and Rates

Example: Ingress NP, no drops



```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP counters np0 location 0/0/CPU0
Mon Dec  9 15:16:34.889 EST
```

```
Node: 0/0/CPU0:
```

```
Show global stats counters for NP0, revision v2
```

```
Read 59 non-zero NP counters:
```

Offset	Counter	FrameValue	Rate (pps)
16	MDF_TX_LC_CPU	10255120	8
17	MDF_TX_WIRE	6382883323428	1
21	MDF_TX_FABRIC	8903307706961	31250074
29	PARSE_FAB_RECEIVE_CNT	6382883151049	0
33	PARSE_INTR_RECEIVE_CNT	8653828	8
37	PARSE_INJ_RECEIVE_CNT	744943	1
41	PARSE_ENET_RECEIVE_CNT	8910925981070	31250074
45	PARSE_TM_LOOP_RECEIVE_CNT	8035316	5
49	PARSE_TOP_LOOP_RECEIVE_CNT	61	0
57	PARSE_ING_DISCARD	2344591	0
195	PRS_HEALTH_MON	8035316	5
204	INTR_FRAME_TYPE_7	8653827	8
214	DBG_PRS_EP_L_PRS_VPLS_PW_IMPOSE	10	0
233	PARSE_RSP_INJ_FAB_CNT	70634	0
235	PARSE_RSP_INJ_DIAGS_CNT	55255	0
236	PARSE_EGR_INJ_PKT_TYP_UNKNOWN	66847	0
237	PARSE_EGR_INJ_PKT_TYP_IPV4	3787	0
246	PARSE_LC_INJ_FAB_CNT	101092	0

To FIA

From Phy

NP Counters and Rates

NP drops, rate and direction



```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP counters np0 location 0/0/CPU0
Tue Dec 10 14:18:39.195 EST
```

Node: 0/0/CPU0:

Show global stats counters for NP0, revision v2

Read 59 non-zero NP counters:

Offset Counter

		FrameValue	Rate (pps)
16	MDF_TX_LC_CPU	11004363	9
17	MDF_TX_WIRE	8712222364719	29761820
21	MDF_TX_FABRIC	11063035007386	27714366
29	PARSE_FAB_RECEIVE_CNT	8712222113330	29761820
33	PARSE_INTR_RECEIVE_CNT	9401470	9
37	PARSE_INJ_RECEIVE_CNT	832185	1
41	PARSE_ENET_RECEIVE_CNT	11070653296959	27714366
45	PARSE_TM_LOOP_RECEIVE_CNT	8437075	5
359	PARSE_MAC_NOTIFY_RCV	183	0
367	PARSE_FAST_DISCARD_LOW_PRIORITY_DROP_0	106211394050	883832
368	PARSE_FAST_DISCARD_LOW_PRIORITY_DROP_1	106210662138	883856
369	PARSE_FAST_DISCARD_LOW_PRIORITY_DROP_2	106211061617	883943
370	PARSE_FAST_DISCARD_LOW_PRIORITY_DROP_3	106211474043	883922
373	DBG_RSV_EP_L_RSV_ING_L3_IFIB	3707021673	0
830	PUNT_NO_MATCH	4746	0
831	PUNT_NO_MATCH_EXCD	464963896	0
849	PUNT_ADJ_EXCD	273406	0
852	PUNT_ACL_DENY	1479378	0
853	PUNT_ACL_DENY_EXCD	1163570900	0

To egress

To fabric

From fabric

From interface

NP catching up

NP Counters and Rates

Traffic Manager drops



```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP tm counters np1 location 0/0/CPU0
Tue Dec 10 14:40:47.210 EST
```

Node: 0/0/CPU0:

```
==== TM Counters (NP 1 TM 0) ====
```

```
TM Counters:
```

```
xmt paks: 897837659243, xmt bytes: 62718673698431
drop paks: 29447137293, drop_bytes: 2002405351616
```

```
RP/0/RSP0/CPU0:rasr9000-2w-b#
```

```
RP/0/RSP0/CPU0:rasr9000-2w-b#
```

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP tm counters np1 location 0/0/CPU0
```

```
Tue Dec 10 14:40:49.816 EST
```

Node: 0/0/CPU0:

```
==== TM Counters (NP 1 TM 0) ====
```

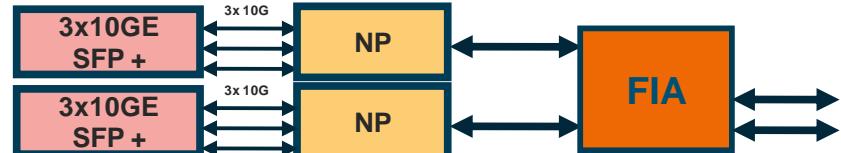
```
TM Counters:
```

```
xmt paks: 897909308598, xmt bytes: 62723686013270
drop paks: 29466027670, drop_bytes: 2003689898884
```

FIA Counters

FIA counts, drops and direction

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers fabric  
fia instance 0 stats location 0/0/CPU0  
Tue Dec 10 14:49:58.704 EST  
  
***** FIA-0 *****  
Category: count-0  
From Unicast Xbar[0] 733461306331  
From Unicast Xbar[1] 733460650405  
From Unicast Xbar[2] 0  
From Unicast Xbar[3] 0  
From MultiCast Xbar[0] 233068  
From MultiCast Xbar[1] 0  
From MultiCast Xbar[2] 0  
From MultiCast Xbar[3] 0  
To Unicast Xbar[0] 933450146675  
To Unicast Xbar[1] 932066610046  
To Unicast Xbar[2] 0  
To Unicast Xbar[3] 0  
To MultiCast Xbar[0] 451799  
To MultiCast Xbar[1] 0  
To MultiCast Xbar[2] 0  
To MultiCast Xbar[3] 0  
To Line Interface[0] 8759312354291  
To Line Interface[1] 457138023968  
From Line Interface[0] 11117127781061  
From Line Interface[1] 489302108080  
Ingress drop: 97191712670  
Egress drop: 0  
Total drop: 97191712670
```



```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers fabric fia  
instance 0 drops ingress location 0/0/CPU0  
Tue Dec 10 15:33:37.655 EST
```

***** FIA-0 *****

Category: in_drop-0

From Spauि Drop-0	0
acctp tble-0	0
ctl len-0	0
short pkt-0	0
max pkt len-0	0
min pkt len-0	0
From Spauि Drop-1	0
acctp tble-1	0
ctl len-1	0
short pkt-1	0
max pkt len-1	0
min pkt len-1	0
Tail drp	125787328841
Vqi drp	0
Header parsing drp	0
pw to ni drp	0
ni from pw drp	0
sp0 crc err	0
sp0 bad align	0
sp0 bad code	0
sp0 align fail	3
sp0 prot err	0
sp1 crc err	0

Back pressure
from egress NP

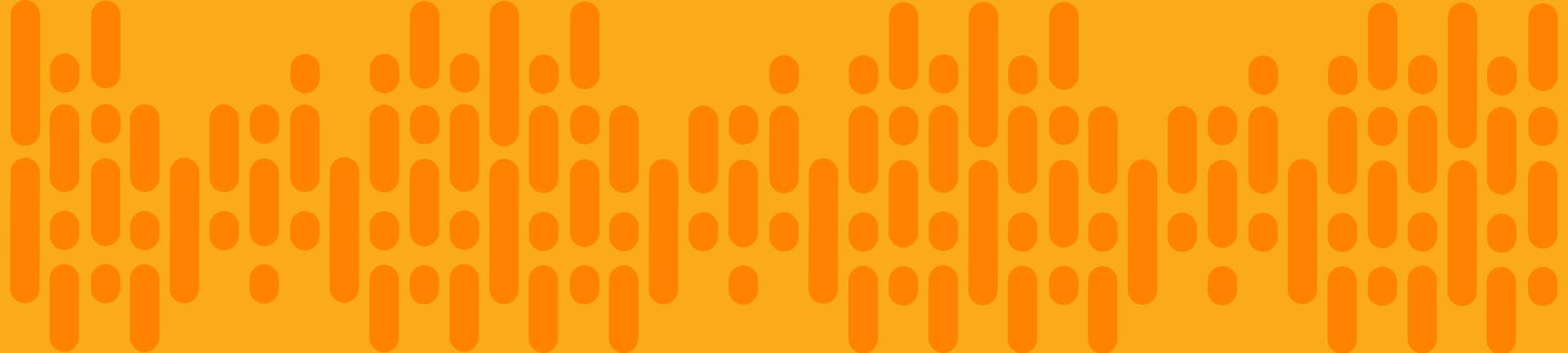
Agenda

- ✓ **System Architecture:** System anatomy and health
- ✓ **Operating System & Configuration:** IOS-XR & configuration models
- ✓ **Control, Management, & Security:** Processing of control & exceptions
- ✓ **Transit Packet/Frame Journey:** Life of L3/L2 unicast/multicast
- **MPLS Operation:** Processing, forwarding and L3/L2 service operation
- **Troubleshooting:** Diagnostics, counters, drops, and packet capture

5 MPLS Operation



You make multi-cloud **possible**



MPLS in the Data Plane

Main Label Uses

- Forwarding
 - The destination for this label is ... [FEC]. Usually a host address of an LER
 - A path to a label destination is an LSP
 - Intermediate nodes may not know much about payload or the basis for its forwarding
 - Ultimate destination may not need the label [PHP]
- Service
 - How to handle this payload [IP, L3VPN VRF, L2VPN, PW, CEoP, control]
 - Significant to edge nodes. Forwarding nodes along the path may not know what it means

Forwarding

- Without label

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show cef ipv4 10.101.188.1
```

```
remote adjacency to GigabitEthernet0/1/0/1  
Prefix Len 32, traffic index 0, precedence routine (0), priority 1  
via 10.100.11.1, GigabitEthernet0/1/0/1, 4 dependencies, weight 0, class 0 [flags 0x0]  
path-idx 0 [0x721f30e0 0x0]  
next hop 10.100.11.1  
remote adjacency
```

- With label

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show cef ipv4 10.101.188.1
```

```
remote adjacency to GigabitEthernet0/1/0/1  
Prefix Len 32, traffic index 0, precedence routine (0), priority 1  
via 10.100.11.1, GigabitEthernet0/1/0/1, 20 dependencies, weight 0, class 0 [flags  
0x0]  
path-idx 0 [0x723990b4 0x0]  
next hop 10.100.11.1  
remote adjacency  
local label 111012
```

The diagram illustrates the forwarding process. It starts with a blue speech bubble labeled "IP in". An arrow points from this bubble to a blue oval labeled "MPLS in". Another arrow points from the "MPLS in" oval to a blue oval labeled "MPLS out". Below the "MPLS in" oval, the text "labels imposed {101000}" is written.

Label Operations

```
RP/0/0/CPU0:P101#show cef ipv4 10.101.188.1/32
```

Prefix Len 32, traffic index 0, precedence n/a, priority 1
via 10.100.108.1, tunnel-te181, 3 dependencies, weight 0, class 0 [flags 0x0]
path-idx 0 [0xaccc9d674 0x0]
next hop 10.100.108.1
Local adjacency
local label 101000 Labels imposed {108000} Push

```
RP/0/0/CPU0:P101#show mpls forwarding
```

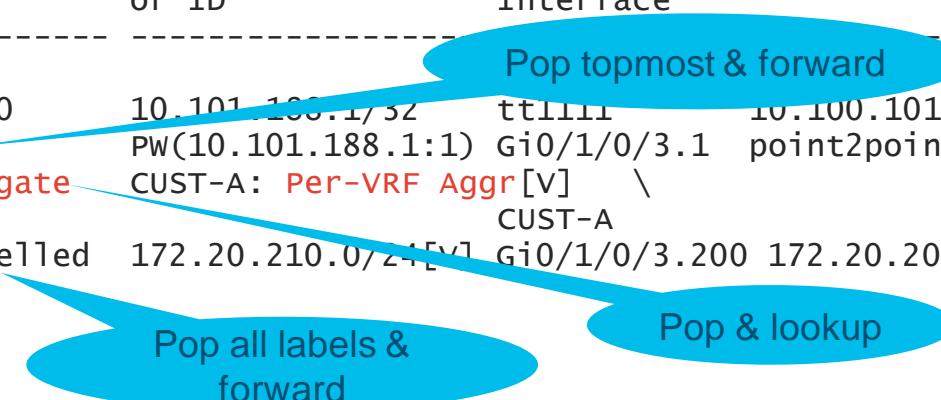
Thu Jun 6 09:16:22.581 EDT

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
101000	108000	10.101.188.1/32	tt181	10.100.108.1	0
101001	102000	11210	Gi0/0/0/0.112	10.100.112.2	0
101005	Pop	10.101.111.1/32	tt1111	10.101.111.1	0
101007	Exp-Null-v4	11211	Gi0/0/0/1	10.100.11.11	0
101039	Unlabelled	10.101.124.1/32	Gi0/0/0/0.112	10.100.112.2	0
101040	Unlabelled	10.101.125.1/32	Gi0/0/0/0.112	10.100.112.2	4591105

Aggregate Label

- Bottom of stack label not sufficient for forwarding decision
- Payload header has to be used for forwarding

RP/0/RSP0/CPU0:rasr9000-2w-a#show mpls forwarding						
Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched	
.						
111007	101000	10.101.100.1/32	tt1111	10.100.101.1	375048	
111014	Pop	PW(10.101.188.1:1)	Gi0/1/0/3.1	point2point	314906	
111015	Aggregate	CUST-A: Per-VRF Aggr [v]	\			
		CUST-A				
111016	unlabelled	172.20.210.0/24	E1	Gi0/1/0/3.200	172.20.200.2	6320
						0



Aggregate Label vs. Non-Aggregate

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show mpls forwarding vrf CUST-A detail
```

Mon Jun 17 21:31:10.474 EDT

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
111015	Aggregate	CUST-A: Per-VRF Aggr[v]	\ CUST-A		8240

Updated Jun 17 20:03:20.046

Path Flags: 0x10 []

MAC/Encaps: 0/0, MTU: 0

Label Stack (Top -> Bottom): { }

Packets Switched: 65

Pop & lookup

```
111016 Unlabelled 172.20.210.0/24[v] Gi0/1/0/3.200 172.20.200.2 0
```

Updated Jun 17 21:23:42.495

Version: 47, Priority: 3

MAC/Encaps: 18/18, MTU: 1500

Label Stack (Top -> Bottom): { unlabelled }

Packets Switched: 0

Pop & forward

Aggregate Label: Example

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show route vrf CUST-A ipv4 connected  
Mon Jun 17 21:34:49.647 EDT
```

```
C 172.20.200.0/24 is directly connected, 00:56:39, GigabitEthernet0/1/0/3.200
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show mpls forwarding vrf CUST-A detail
```

```
Mon Jun 17 21:31:10.474 EDT
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
-------------	----------------	--------------	--------------------	----------	----------------

```
111015 Aggregate CUST-A: Per-VRF Aggr[V] \  
CUST-A
```

```
Updated Jun 17 20:03:20.046
```

```
Path Flags: 0x10 [ ]
```

```
MAC/Encaps: 0/0, MTU: 0
```

```
Label Stack (Top -> Bottom): { }
```

```
Packets Switched: 65
```



Pop & lookup

Non-Aggregate Label: Example

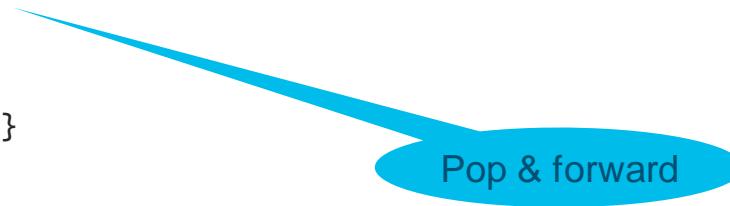
```
RP/0/RSP0/CPU0:rasr9000-2w-a#show route vrf CUST-A ipv4 static  
Mon Jun 17 21:34:57.549 EDT
```

```
S 172.20.210.0/24 [1/0] via 172.20.200.2, 00:11:45
```

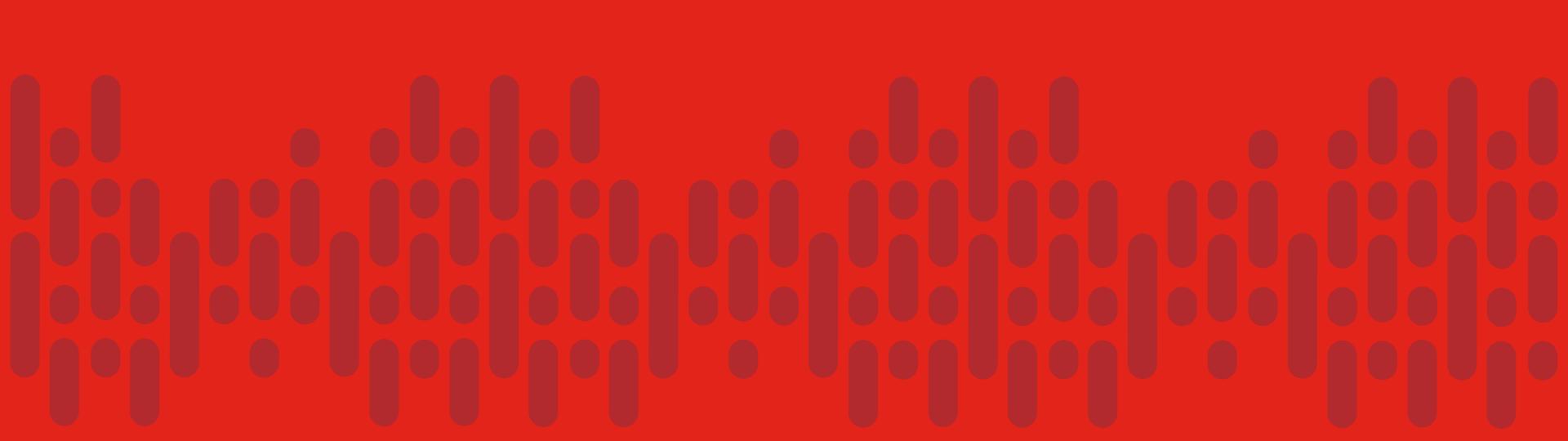
```
RP/0/RSP0/CPU0:rasr9000-2w-a#show mpls forwarding vrf CUST-A detail  
Mon Jun 17 21:31:10.474 EDT
```

```
.
```

111016	Unlabelled	172.20.210.0/24[v]	Gi0/1/0/3.200	172.20.200.2	0
Updated Jun 17 21:23:42.495					
Version: 47, Priority: 3					
MAC/Encaps: 18/18, MTU: 1500					
Label Stack (Top -> Bottom): { unlabelled }					
Packets Switched: 0					

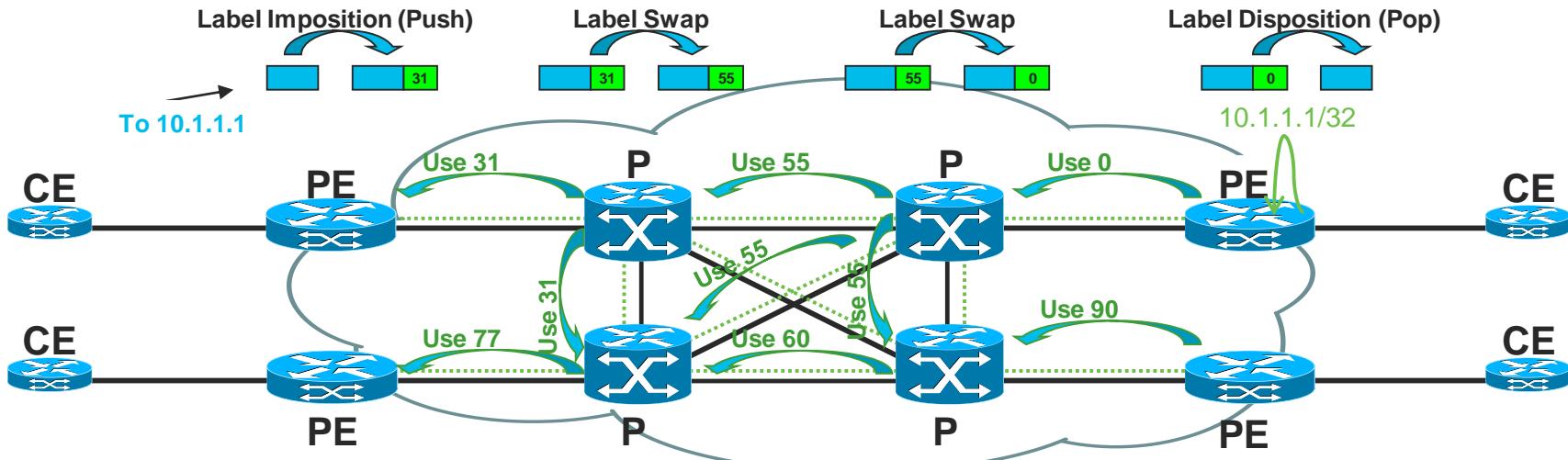


Pop & forward

The background of the slide features a repeating pattern of the Cisco logo, which consists of a series of red vertical bars of varying heights, creating a stylized bar chart effect across the entire slide.

Forwarding Labels

LDP: Label Distribution Protocol



- Binds and advertises labels for all IGP prefixes [Cisco default]
- Multicast hellos for neighbor discovery. TCP 646 for session.
- Hop by hop. No guarantee for end to end LSP.

LDP: Control Plane: Neighbor Sessions

```
RP/0/0/CPU0:P101#show mpls ldp neighbor
```

Thu Jun 6 10:41:01.283 EDT

Peer LDP Identifier: 10.100.108.1:0

TCP connection: 10.100.108.1:31207 - 10.100.101.1:646; MD5 on

Graceful Restart: Yes (Reconnect Timeout: 120 sec, Recovery: 180 sec)

Session Holdtime: 180 sec

State: Oper; Msgs sent/rcvd: 27745/27777; Downstream-Unsolicited

Up time: 2w2d

LDP Discovery Sources:

Targeted Hello (10.100.101.1 -> 10.100.108.1, active)

Addresses bound to this peer:

10.100.87.8 10.100.108.1 10.100.168.8 10.100.178.8

My potential dest prefixes through this neighbor as next hop

10.100.188.8

Peer LDP Identifier: 10.101.111.1:0

TCP connection: 10.101.111.1:35863 - 10.100.101.1:646; MD5 on

Graceful Restart: Yes (Reconnect Timeout: 120 sec, Recovery: 0 sec)

Session Holdtime: 180 sec

State: Oper; Msgs sent/rcvd: 3024/3020; Downstream-Unsolicited

Up time: 1d19h

LDP Discovery Sources:

Targeted Hello (10.100.101.1 -> 10.101.111.1, active)

GigabitEthernet0/0/0/1

Addresses bound to this peer:

10.100.11.11 10.101.111.1 172.16.200.150 172.16.200.151 192.168.2.2

LDP: Control Plane: Label Binding

```
RP/0/0/CPU0:P101#show mpls ldp bindings
.
10.101.111.1/32, rev 161
  Local binding: label: 101005
  Remote bindings: (1 peers)
    Peer          Label
    -----
    10.100.108.1:0      108009
10.101.112.1/32, rev 116
  Local binding: label: 101041
  Remote bindings: (2 peers)
    Peer          Label
    -----
    10.100.108.1:0      108038
    10.101.111.1:0      111006
10.101.124.1/32, rev 117
  Local binding: label: 101039
  Remote bindings: (2 peers)
    Peer          Label
    -----
    10.100.108.1:0      108031
    10.101.111.1:0      111007
```

10.101.125.1/32, rev 118	Local binding: label: 101040
	Remote bindings: (2 peers)
Peer	Label
-----	-----
10.100.108.1:0	108032
10.101.111.1:0	111008
10.101.135.1/32, rev 119	Local binding: label: 101042
	Remote bindings: (2 peers)
Peer	Label
-----	-----
10.100.108.1:0	108033
10.101.111.1:0	111009
37.1/32, rev 120	Local binding: label: 101043
	Remote bindings: (2 peers)
Peer	Label
-----	-----
10.100.108.1:0	108034
10.101.111.1:0	111010

Use the one matching IGP route, if any

LDP: Forwarding: FIB and LFIB

```
RP/0/RSPO/CPU0:rasr9000-2w-b#show cef ipv4 10.101.111.1/32
Wed Mar 19 12:25:01.496 EDT
10.101.111.1/32, version 272, internal 0x4004001 0x0 (ptr 0x7238643c) [1], 0x0 (0x71e26460)
(0x71e26460)
Updated Mar 19 12:23:44.913
remote adjacency to GigabitEthernet0/1/0/1
Prefix Len 32, traffic index 0, precedence n/a, priority 3
via 10.100.188.8, GigabitEthernet0/1/0/1, 20 dependencies, weight 0, class 0 [flags 0x0]
path-idx 0 NHID 0x0 [0x719ea954 0x0]
next hop 10.100.188.8
remote adjacency
local label 188017      labels imposed {108002}
```

IPv4 in

```
RP/0/RSPO/CPU0:rasr9000-2w-b#show mpls forwarding labels 188017 detail
```

MPLS in

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
188017	108002	10.101.111.1/32	Gi0/1/0/1	10.100.188.8	1558

Updated Mar 19 12:23:44.913
Version: 272, Priority: 3
MAC/Encaps: 14/18, MTU: 1386
Label Stack (Top -> Bottom): { 108002 }
NHID: 0x5
Packets Switched: 19

LDP: Forwarding: In the Forwarding Plane

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show cef ipv4  
10.101.111.1/32 hardware ingress location 0/1/CPU0  
  
local adjacency 10.100.188.8  
Prefix Len 32, traffic index 0, precedence n/a,  
priority 3  
via 10.100.188.8, GigabitEthernet0/1/0/1, 21  
dependencies, weight 0, class 0 [flags 0x0]  
path-idx 0 NHID 0x5 [0x8b15d134 0x0]  
next hop 10.100.188.8  
local adjacency  
local label 188017      labels imposed {108002}  
  
NR-LDI H/W Result for path 0 [index: 0x34c7 (BE),  
common to all NPs]:  
  
    output_label: 108002  
    label_msb: 0x1a5e          label_lsb: 0x2  
                           exp: 0x0           eos: 0x1  
  
RX H/W Result for 1st NP:0 (index: 0x3b (BE)):  
  
    if_handle     : 0x3e0  
  
TX H/W Result for NP:0 (index: 0x33d3 (BE)):  
  
    uidb_index     : 0x900 (LE)  
    l3_mtu        : 1386  
    adj_stats_index: 0x381f61  
    dest_mac       : 0x000c.29f4.90c6
```

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show mpls forwarding labels  
188017 hardware ingress location 0/1/CPU0  
Wed Mar 19 13:01:00.202 EDT  
Local Outgoing Prefix      Outgoing Next Hop   Bytes  
Label Label or ID          Interface      Switched  
-----  
188017 108002 10.101.111.1/32 Gi0/1/0/1 10.100.188.8 N/A  
  
NR-LDI H/W Result for path 0 [index: 0x34c7 (BE), common  
to all NPs]:  
  
    output_label: 108002  
    label_msb: 0x1a5e  
    label_lsb: 0x2  
    exp: 0x0  
    eos: 0x1  
  
RX H/W Result for 1st NP:0 (index: 0x3b (BE)):  
  
    if_handle     : 0x3e0  
  
TX H/W Result for NP:0 (index: 0x33d3 (BE)):  
  
    uidb_index     : 0x900 (LE)  
    l3_mtu        : 1386  
    adj_stats_index: 0x381f61  
    dest_mac       : 0x000c.29f4.90c6  
    ether_reserved : 0000000000000000
```

Segment Routing: Control Plane: LFIB

```
RP/0/0/CPU0:P103#show mpls forwarding
```

```
Fri Dec 15 10:44:16.905 EST
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16101	Exp-Null-v4	No ID	Gi0/0/0/0.113	10.100.113.1	14772872
16102	Exp-Null-v4	No ID	Gi0/0/0/0.123	10.100.123.2	948365600
16105	Exp-Null-v4	No ID	Gi0/0/0/0.135	10.100.135.5	26746300
16107	17107	No ID	Gi0/0/0/0.135	10.100.135.5	3853248
16108	Unlabelled	No ID	Gi0/0/0/0.134	10.100.134.4	0
16112	16112	No ID	Gi0/0/0/0.113	10.100.113.1	410866200
16124	16124	No ID	Gi0/0/0/0.123	10.100.123.2	9676882
16125	16125	No ID	Gi0/0/0/0.123	10.100.123.2	27336101
16135	Exp-Null-v4	No ID	Gi0/0/0/0.1335	10.100.35.35	12462352
16137	17137	No ID	Gi0/0/0/0.135	10.100.135.5	321434400
16178	17178	No ID	Gi0/0/0/0.135	10.100.135.5	2861539
16206	Unlabelled	No ID	Gi0/0/0/0.134	10.100.134.4	0

Out label may change based on policy or PHP

Segment Routing: Forwarding: FIB and LFIB

```
RP/0/0/CPU0:P103#show cef ipv4 10.101.178.1/32
```

Fri Dec 15 11:37:11.028 EST

10.101.178.1/32, version 205075, internal 0x1000001 0x3 (ptr 0xa13dbe74) [1], 0x0 (0xa13a719c), 0xa28 (0xa1534320)

Updated Dec 15 06:26:49.304

local adjacency 10.100.135.5

Prefix Len 32, traffic index 0, precedence n/a, priority 1

via 10.100.135.5, GigabitEthernet0/0/0/0.135, 14 dependencies, weight 0, class 0 [flags 0x0]

path-idx 0 NHID 0x0 [0xa0e8f598 0x0]

next hop 10.100.135.5

local adjacency

local label 16178 labels imposed {17178}

IPv4 in

```
RP/0/0/CPU0:P103#show mpls forwarding labels 16178 detail
```

Fri Dec 15 11:37:14.297 EST

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16178	17178	No ID	Gi0/0/0/0.135	10.100.135.5	2870087

MPLS in

Updated Dec 15 06:26:49.303

Version: 205075, Priority: 1

MAC/Encaps: 18/22, MTU: 7986

Label Stack (Top -> Bottom): { 17178 }

NHID: 0

Packets Switched: 28277

Segment Routing: Forwarding: In the Forwarding Plane

```
RP/0/0/CPU0:P103#show cef ipv4 10.101.178.1/32 hardware ingress location 0/0/CPU0
Fri Dec 15 11:42:31.786 EST
10.101.178.1/32, version 205201, internal 0x1000001 0x3 (ptr 0xa13dbe74) [1], 0x0 (0xa13a719c),
0xa28 (0xa1534320)
Updated Dec 15 11:40:36.394
local adjacency 10.100.135.5
Prefix Len 32, traffic index 0, precedence n/a, priority 1
via 10.100.135.5, GigabitEthernet0/0/0/0.135, 14 dependencies, weight 0, class 0 [flags 0x0]
path-idx 0 NHID 0x0 [0xa0e8f598 0x0]
next hop 10.100.135.5
local adjacency
  local label 16178      labels imposed {17178}
.
```

IPv4 in

```
RP/0/0/CPU0:P103#show mpls forwarding labels 16178 hardware ingress location 0/0/CPU0
Fri Dec 15 11:45:53.382 EST
Local Outgoing Prefix          Outgoing Next Hop Bytes
Label Label or ID           Interface       Switched
----- ----- -----
16178  17178    No ID        Gi0/0/0/0.135 10.100.135.5  N/A
.
```

MPLS in

TE: RSVP

```
RP/0/0/CPU0:P104#show rsvp neighbors
Mon Jun 10 08:38:07.069 EDT
Global Neighbor: 10.100.102.1
Interface Neighbor Interface
-----
10.100.124.2      GigabitEthernet0/0/0/0.124
Global Neighbor: 10.100.103.1
Interface Neighbor Interface
-----
10.100.134.3      GigabitEthernet0/0/0/0.134
Global Neighbor: 10.100.105.1
Interface Neighbor Interface
-----
10.100.145.5      GigabitEthernet0/0/0/0.145
Global Neighbor: 10.100.106.1
Interface Neighbor Interface
-----
10.100.146.6      GigabitEthernet0/0/0/0.146
Global Neighbor: 10.101.124.1
Interface Neighbor Interface
-----
10.100.42.24      GigabitEthernet0/0/0/0.1424
```

TE: RSVP

```
RP/0/0/CPU0:P104#show rsvp interface
```

```
Mon Jun 10 08:38:12.129 EDT
```

```
*: RDM: Default I/F B/W % : 75% [default] (max resv/bc0), 0% [default] (bc1)
```

Interface	MaxBW (bps)	MaxFlow (bps)	Allocated (bps)	MaxSub (bps)
Gi0/0/0.124	38G	38G	3G (7%)	0
Gi0/0/0.134	38G	38G	2G (5%)	0
tt10452	0	0	0 (0%)	0
Gi0/0/0.145	38G	38G	0 (0%)	0
Gi0/0/0.146	38G	38G	5G (13%)	0
tt10454	0	0	0 (0%)	0
Gi0/0/0.1424	9500M	9500M	0 (0%)	0
tt10456	0	0	0 (0%)	0
tt10457	0	0	0 (0%)	0
tt10459	0	0	0 (0%)	0
tt10460	0	0	0 (0%)	0



FRR backup
tunnels at
headend

TE: Links

```
RP/0/0/CPU0:P104#show mpls traffic-eng link-management summary
```

```
Mon Jun 10 11:47:53.059 EDT
```

System Information::

```
Links Count      : 5 (Maximum Links Supported 500)
Flooding System  : enabled
IGP Areas Count  : 1
```

IGP Areas

IGP Area[1]:: IS-IS ISIS level 2

```
Flooding Protocol   : IS-IS
Flooding Status     : flooded
Periodic Flooding   : enabled (every 180 seconds)
Flooded Links       : 5
IGP System ID       : 0101.0010.4001
MPLS TE Router ID  : 10.100.104.1
IGP Neighbors       : 5
```

TE: Topology View [At Headend]

```
RP/0/0/CPU0:PE135#show mpls traffic-eng topology summary
Mon Jun 10 11:50:35.198 EDT
My_System_id: 0101.0113.5001.00 (IS-IS ISIS level-2)
My_BC_Model_Type: RDM

Signalling error holdown: 10 sec Global Link Generation 5292918

IS-IS ISIS level 2
  Local System Id:          0101.0113.5001
  TE router ID configured: 10.101.135.1
                in use:    10.101.135.1

  IGP Id: 0101.0010.8001.00, MPLS TE Id: 10.100.108.1 Router Node
        4 links

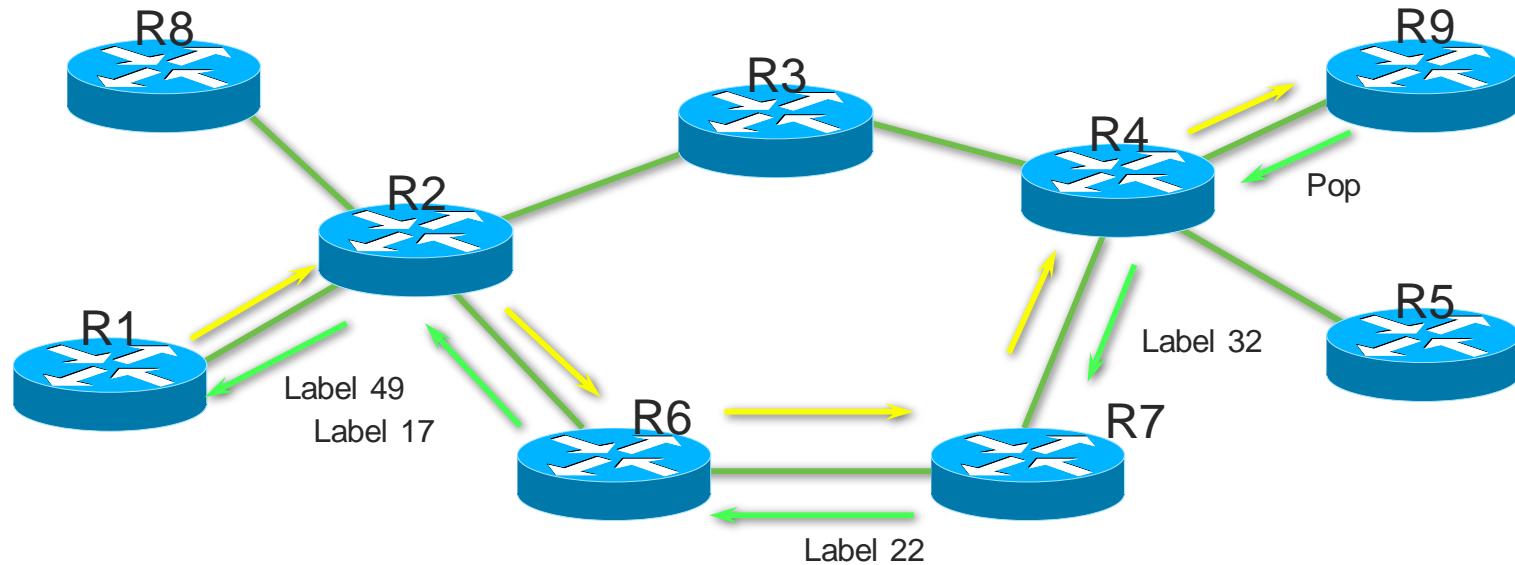
  IGP Id: 0101.0111.2001.00, MPLS TE Id: 10.101.112.1 Router Node (Overloaded)
        2 links

  IGP Id: 0101.0010.8001.05, Network Node
        2 links

  Total: 43 nodes (16 router, 27 network), 108 links

Grand Total: 43 nodes (16 router, 27 network) 108 links
```

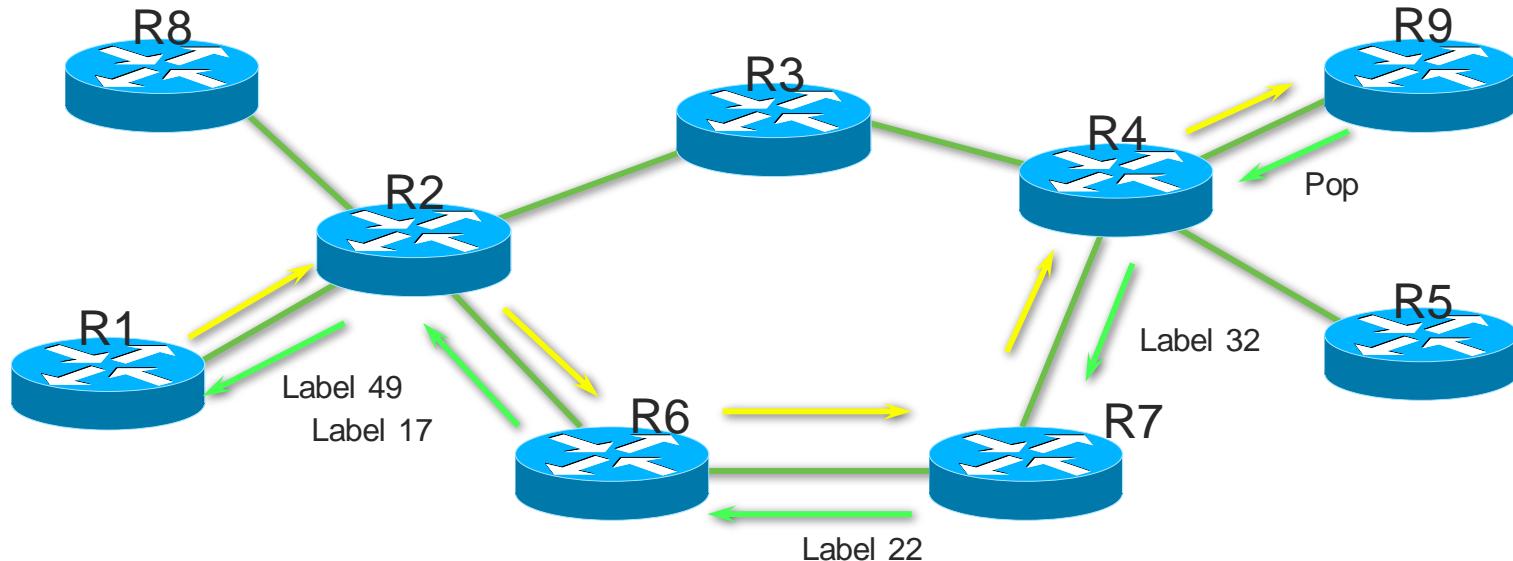
TE: The Label Exchange



Setup: Path (ERO = R1->R2->R6->R7->R4->R9)

Reply: Resv communicates labels & reserves bandwidth on each link

TE: The Path [The Unidirectional Tunnel]



- CSPF calculation & signaling initiated by headend based on its MPLS TE topology view.
- Creates a P2P [or P2MP, MP2MP] unidirectional tunnel.
- Signaling and periodic refreshing of state done using RSVP.

TE: Control Plane View

```
RP/0/0/CPU0:P104#show mpls traffic-eng tunnels tabular
```

```
Mon Jun 10 14:48:32.737 EDT
```

Tunnel Name	LSP ID	Destination Address	Source Address	Tun State	FRR State	LSP Role	Path Prot
*tunnel-te10452	7	10.100.108.1	10.100.104.1	up	Inact	Head	Inact
*tunnel-te10454	2	10.101.124.1	10.100.104.1	up	Inact	Head	Inact
*tunnel-te10460	2	10.101.125.1	10.100.104.1	up	Inact	Head	Inact
P101_t181	25	10.100.108.1	10.100.101.1	up	Inact	Mid	
P108_t811	25	10.100.101.1	10.100.108.1	up	Inact	Mid	
autob_P101_t10150	24	10.101.135.1	10.100.101.1	up	Inact	Mid	
autob_P101_t10152	25	10.101.137.1	10.100.101.1	up	Inact	Mid	
autob_P108_t10868	13	10.100.104.1	10.100.108.1	up	Inact	Tail	
autom_PE112_t1121	16	10.101.188.1	10.101.112.1	up	Ready	Mid	
autom_PE124_t1241	16	10.101.188.1	10.101.124.1	up	Ready	Mid	
autob_PE124_t1245	27	10.100.103.1	10.101.124.1	up	Inact	Mid	
autom_rasr9000-2w	11	10.101.135.1	10.101.188.1	up	Ready	Mid	
autom_rasr9000-2w	11	10.101.137.1	10.101.188.1	up	Ready	Mid	

* = automatically created backup tunnel
+ = automatically created mesh tunnel

TE: Control Plane View

```
RP/0/0/CPU0:P104#show mpls traffic-eng tunnels brief  
Mon Jun 10 15:03:38.965 EDT
```

TUNNEL NAME	DESTINATION	STATUS	STATE
*tunnel-te10452	10.100.108.1	up	up
*tunnel-te10454	10.101.124.1	up	up
*tunnel-te10456	10.100.101.1	up	up
*tunnel-te10457	10.101.135.1	up	up
*tunnel-te10459	10.101.137.1	up	up
*tunnel-te10460	10.101.125.1	up	up
P101_t181	10.100.108.1	up	up
P108_t811	10.100.101.1	up	up
autob_P101_t10150_	10.101.135.1	up	up
autob_P101_t10152_	10.101.137.1	up	up
.			
autom_rasr9000-2w-	10.101.112.1	up	up
autom_rasr9000-2w-	10.101.124.1	up	up
autom_rasr9000-2w-	10.101.125.1	up	up
autom_rasr9000-2w-	10.101.135.1	up	up
autom_rasr9000-2w-	10.101.137.1	up	up

* = automatically created backup tunnel

Displayed 6 (of 6) heads, 33 (of 33) midpoints, 6 (of 6) tails

Displayed 6 up, 0 down, 0 recovering, 0 recovered heads

TE: Control Plane View: Tunnel Headend

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show mpls traffic-eng tunnels 11106 detail
Tue Jun 11 00:04:29.172 EDT
```

Name: tunnel-te11106 Destination: 10.101.112.1 (auto-tunnel mesh)

Status:

Admin: up Oper: up Path: valid Signalling: connected

path option 10, type dynamic (Basis for Setup, path weight 22230)

G-PID: 0x0800 (derived from egress interface properties)

Bandwidth Requested: 1000000 kbps CT0

Creation Time: Fri May 31 16:37:30 2013 (1w3d ago)

Config Parameters:

Bandwidth: 1000000 kbps (CT0) Priority: 3 3 Affinity: 0x0/0xffff

Metric Type: TE (default)

Current LSP Info:

Instance: 2, Signaling Area: IS-IS ISIS level-2

Uptime: 1w3d (since Fri May 31 16:37:30 EDT 2013)

Outgoing Interface: GigabitEthernet0/1/0/1, Outgoing Label: 101048

Router-IDs: local 10.101.111.1
downstream 10.100.101.1

Soft Preemption: None

TE: Control Plane View: Tunnel Midpoint

```
RP/0/0/CPU0:P104#show mpls traffic-eng tunnels 10152
Mon Jun 10 15:01:13.715 EDT

LSP Tunnel 10.100.101.1 10152 [25] is signalled, connection is up
Tunnel Name: autob_P101_t10152_Gi0_0_0_0.113_10.100.103.1 Tunnel Role: Mid
InLabel: GigabitEthernet0/0/0/0.124, 104054
OutLabel: GigabitEthernet0/0/0/0.145, 105016
Signalling Info:
  Src 10.100.101.1 Dst 10.101.137.1, Tun ID 10152, Tun Inst 25, Ext ID 10.100.101.1
  Router-IDs: upstream 10.100.102.1
               local 10.100.104.1
               downstream 10.100.105.1
Bandwidth: 0 kbps (CT0) Priority: 6 6 DSTE-class: no match
Soft Preemption: None
Path Info:
  Incoming Address: 10.100.124.4
  Incoming:
  Explicit Route:
    Strict, 10.100.124.4
    Strict, 10.100.145.4
    Strict, 10.100.145.5
    Strict, 10.100.157.5
```

TE: Forwarding: Headend Forwarding Methods

- Auto-route announce [IGP]
- Forwarding adjacency [IGP]
- Policy-based (& class-based) routing
- Static routes
- Pseudo-wire tunnel selection

TE: Forwarding: Headend

```
RP/0/0/CPU0:PE135#show mpls forwarding tunnels
```

```
Tue Jun 11 07:44:26.151 EDT
```

Tunnel Name	Outgoing Label	Outgoing Interface	Next Hop	Bytes Switched
tt13501	103049	Gi0/0/0/0.1335	10.100.35.3	0
tt13502	103051	Gi0/0/0/0.1335	10.100.35.3	0
tt13503	103048	Gi0/0/0/0.1335	10.100.35.3	105560
tt13504	103047	Gi0/0/0/0.1335	10.100.35.3	2600
tt13505	103037	Gi0/0/0/0.1335	10.100.35.3	0
.				

```
RP/0/0/CPU0:PE135#show mpls forwarding tunnels 13503 detail
```

```
Tue Jun 11 07:45:18.917 EDT
```

Tunnel Name	Outgoing Label	Outgoing Interface	Next Hop	Bytes Switched
tt13503	103048	Gi0/0/0/0.1335	10.100.35.3	105560

```
Updated May 31 07:34:51.047
```

```
Version: 401, Priority: 2
```

```
MAC/Encaps: 18/22, MTU: 4456
```

```
Label Stack (Top -> Bottom): { 103048 }
```

```
Local Label: 135001
```

```
Packets Switched: 1015
```

TE: Hardware Forwarding: Headend

```
RP/0/RSPO/CPU0:rasr9000-2w-b#show cef ipv4 10.101.137.1/32 hardware ingress location 0/1/CPU0
Tue Jun 11 02:36:41.139 EDT
10.101.137.1/32, version 183, internal 0x4000001 (ptr 0x885cd0d8) [1], 0x0 (0x87741040), 0x0 (0x0)
Updated Jun 11 02:19:01.772
Prefix Len 32, traffic index 0, precedence routine (0), priority 1
via 10.101.137.1, tunnel-te18804, 3 dependencies, weight 0, class 0 [flags 0x0]
path-idx 0 [0x8a77f2d8 0x0]
next hop 10.101.137.1
local adjacency
LEAF - HAL pd context :
sub-type : IPV4, ecd_marked:0, has_collapsed_1di:0, collapse_bwalk_required:0, ecdv2_marked:0
Leaf H/W Result:
Physical Result: 0x11a00200 (LE)

Raw Data0: 0x11850000 b9020000 00000000 00000000
Raw Data1: 0x00000000 00000000 00200000 0000a2ff
leaf_resolve_control_byte0
    reserved: 0                                match: 1                                valid: 1
    ifib_lookup: 0
    txadj_internal: 0
    rec_fs: 0
.
```

TE: Hardware Forwarding: Headend – Cont.

```
TE-NH H/W Result for 1st NP:0 (index: 0x5 (BE)):
```

```
Raw Data0: 0x5100002d e6311a5e b170115f 0000008a
Raw Data1: 0x02000000 16000000 00000000 00000000
cb0
    spare: 0          default_action: 1
    backup_indication: 0      match: 1
    rsvd: 0          valid: 1
cb1
    spare_cb: 0          tp_path_ss: 0
te_nh_incomplete: 0
    tunnel_over_tunnel: 0      spare: 0
cb2
    spare: 0          te_nh_incomplete: 0
    spare_cb: 0
TE_local_label:
    label: 188003
    exp: 0          eos: 1
TE_tunnel_label:
    label: 108011
    exp: 0          eos: 1
    te_nh_stats_ptr: 0x70115f
merge_point_label:
.
```

TE: Hardware Forwarding: Headend – Cont.

```
RX H/W Result for 1st NP:0 (index: 0x16 (BE)):
```

```
Raw Data0: 0x91000000 00000088 06000200 00000000
adj_resolve_control_byte0
    match: 1                      valid: 1
    iptunl_adj: 0
    remote_rack: 0

adj_resolve_control_byte1
    adj_down: 0                  mgscp_en: 0
    rx_lag_hash_en: 0
    rx_lag_adj: 0

adj_resolve_control_byte2
    rx_lag_adj: 0                rx_adj_null0: 0
    rp_destined: 0               rx_punt: 0
    rx_drop: 0

sfp/vqi      : 0x88
if_handle     : 0x6000200
```

Egress interface

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers pm location 0/1/CPU0 | begin 6000200
Tue Jun 11 05:19:29.503 EDT
Ifname(2): GigabitEthernet0_1_0_1, ifh: 0x6000200 :
```

TE: Forwarding: Midpoint

```
RP/0/0/CPU0:P104#show mpls forwarding
```

```
Tue Jun 11 07:04:03.137 EDT
```

Local Label	outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
104003	Exp-Null-v4	10254	Gi0/0/0/0.1424	10.100.42.24	0
104004	Exp-Null-v4	10357	Gi0/0/0/0.1424	10.100.42.24	0
104005	Exp-Null-v4	12450	Gi0/0/0/0.134	10.100.134.3	0
104010	106032	10352	Gi0/0/0/0.146	10.100.146.6	0
.					
104028	Exp-Null-v4	10750	Gi0/0/0/0.134	10.100.134.3	0
104042	106003	181	Gi0/0/0/0.146	10.100.146.6	10747212
104044	106004	12410	Gi0/0/0/0.146	10.100.146.6	0
104046	Exp-Null-v4	10260	Gi0/0/0/0.145	10.100.145.5	0
104047	105058	10257	Gi0/0/0/0.145	10.100.145.5	0
104048	105007	10259	Gi0/0/0/0.145	10.100.145.5	0
104049	106017	11210	Gi0/0/0/0.146	10.100.146.6	0
104050	Exp-Null-v4	10153	Gi0/0/0/0.145	10.100.145.5	684820
104052	105059	10150	Gi0/0/0/0.145	10.100.145.5	1108
104054	105016	10152	Gi0/0/0/0.145	10.100.145.5	1392
104059	Exp-Null-v4	10196	Gi0/0/0/0.1424	10.100.42.24	0
104061	102021	18801	Gi0/0/0/0.124	10.100.124.2	0
104062	102044	811	Gi0/0/0/0.124	10.100.124.2	1057172746
.					

Tunnel ID

TE: Hardware Forwarding: Midpoint

```
RP/0/0/CPU0:P104#show mpls forwarding labels 104062 hardware ingress location 0/0/CPU0
```

```
Tue Jun 11 11:31:38.647 EDT
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
104062	102044	811	Gi0/0/0/0.124	10.100.124.2	N/A
.					

Labels in Labels: LDP in TE

```
RP/0/RSP0/CPU0:rasr9000-2w-a#traceroute 10.101.178.1 source 10.101.111.1
Tue Jun 11 20:49:15.907 EDT
```

Type escape sequence to abort.
Tracing the route to 10.101.178.1

TE label

```
1 10.100.11.1 [MPLS: Label 101055 Exp 0] 4 msec 3 msec 2 msec
2 10.100.11.1 [MPLS: Label 101055 Exp 0] 2 msec 3 msec 2 msec
3 10.100.113.3 [MPLS: Label 103097 Exp 0] 1 msec 2 msec 2 msec
4 10.100.135.5 [MPLS: Label 105060 Exp 0] 2 msec 2 msec 2 msec
5 10.100.157.7 [MPLS: Label 107068 Exp 0] 2 msec 2 msec 2 msec
6 10.100.78.78 2 msec * 1 msec
```

TE tunnel

```
RP/0/RSP0/CPU0:rasr9000-2w-a#traceroute 10.101.178.1 source 10.101.111.1
Tue Jun 11 20:56:32.972 EDT
```

Type escape sequence to abort.
Tracing the route to 10.101.178.1

LDP explicit null

```
1 10.100.11.1 [MPLS: Labels 101055/0 Exp 0] 3 msec 3 msec 2 msec
2 10.100.113.3 [MPLS: Labels 103097/0 Exp 0] 1 msec 2 msec 1 msec
3 10.100.135.5 [MPLS: Labels 105060/0 Exp 0] 1 msec 2 msec 2 msec
4 10.100.157.7 [MPLS: Labels 107068/0 Exp 0] 2 msec 2 msec 2 msec
5 10.100.78.78 2 msec * 3 msec
```

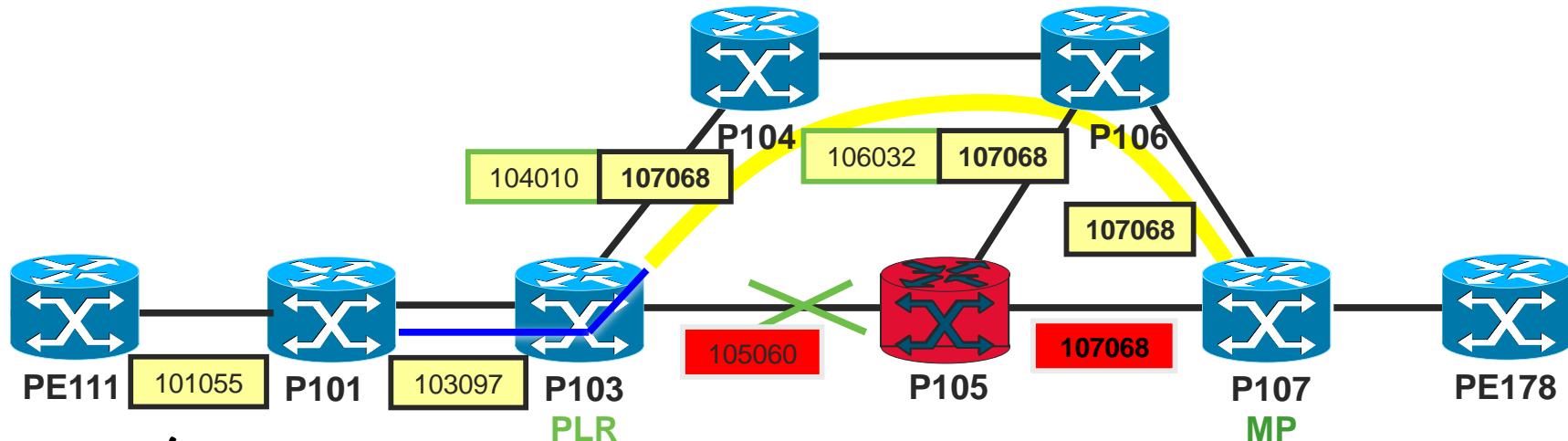
LDP in TE tunnel

Labels in Labels: LDP in TE with NNHOP FRR

```
RP/0/RSP0/CPU0:rasr9000-2w-a#traceroute 10.101.178.1 source 10.101.111.1
```

```
1 10.100.11.1 [MPLS: Labels 101055/0 Exp 0] 3 msec 3 msec 3 msec
2 10.100.113.3 [MPLS: Labels 103097/0 Exp 0] 3 msec 3 msec 2 msec
3 10.100.134.4 [MPLS: Labels 104010/107068/0 Exp 0] 3 msec 3 msec 3 msec
4 10.100.146.6 [MPLS: Labels 106032/107068/0 Exp 0] 4 msec 4 msec 2 msec
5 10.100.167.7 [MPLS: Labels 0/107068/0 Exp 0] 3 msec 3 msec 3 msec
6 10.100.78.78 3 msec * 2 msec
```

LDP in TE tunnel and
FRR active
= 3 labels



Labels in Labels: TE NNHOP PLR

```
RP/0/0/CPU0:P103#show mpls forwarding labels 103097 hardware ingress detail
```

Tue Jun 11 12:51:07.075 EDT

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
-------------	----------------	--------------	--------------------	----------	----------------

103097 105052

11111

Gi0/0/0.135

10.100.135.5

N/A

FRR Ready

Updated Jun 11 12:17:41.262

Path Flags: 0x400 [BKUP-IDX:1 (0xacde6f2c)]

Version: 1598, Priority: 2

MAC/Encaps: 18/22, MTU: 4456

Label Stack (Top -> Bottom): { 105052 }

Packets Switched: 0

```
RP/0/0/CPU0:P103#show mpls forwarding labels 103097 hardware ingress detail
```

Tue Jun 11 12:51:31.414 EDT

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
-------------	----------------	--------------	--------------------	----------	----------------

103097 107068

11111

tt10352

10.100.135.5

N/A

FRR Active

Updated Jun 11 12:51:26.135

Version: 1675, Priority: 2

MAC/Encaps: 18/26, MTU: 4456

Label Stack (Top -> Bottom): { 104010 107068 }

Labels in Labels: LDP in TE at Headend

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show cef ipv4 10.101.178.1/32 hardware egress location 0/1/CPU0
Tue Jun 11 21:41:12.866 EDT
10.101.178.1/32, version 285, internal 0x4004001 (ptr 0x8854bcf8) [1], 0x0 (0x876e74a0), 0x450
(0x89cb6110)
```

Updated Jun 11 21:12:35.330

Prefix Len 32, traffic index 0, precedence routine (0), priority 1
via 10.101.178.1, **tunnel-te11111**, 3 dependencies, weight 0, class 0 [flags 0x0]

path-idx 0 [0x8a7a27d8 0x0]

next hop 10.101.178.1

local adjacency

local label 111011 labels imposed {0}

LDP label

TE-NH H/W Result for 1st NP:0 (index: 0x34 (BE)):

Raw Data0: 0x5100001b lac118ab f138145f 0000008a

Raw Data1: 0x02000000 16000000 00000000 00000000

TE label [topmost]

TE_tunnel_label:

label: **101055**

exp: 0

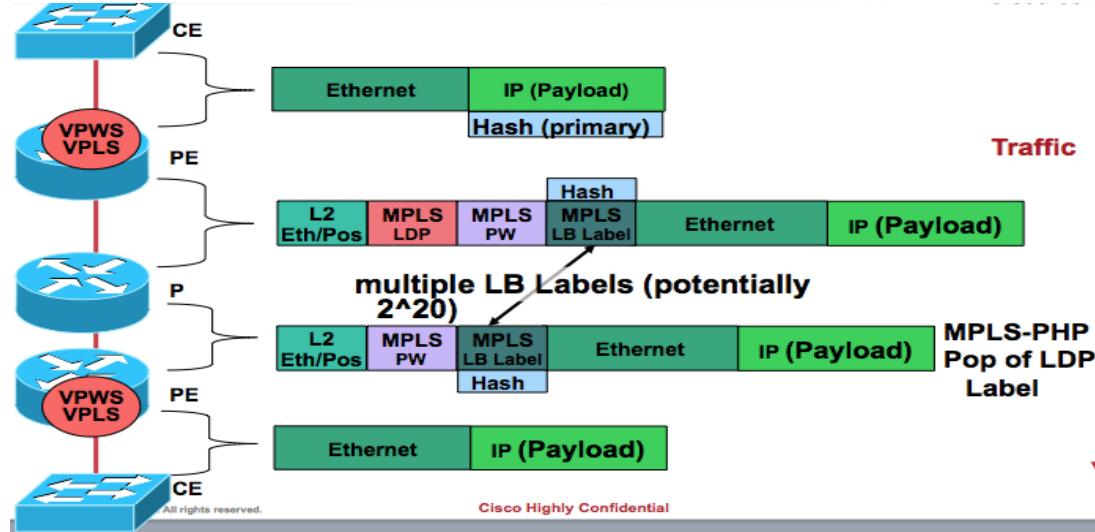
eos: 1

te_nh_stats_ptr: 0x38145f

merge_point_label:

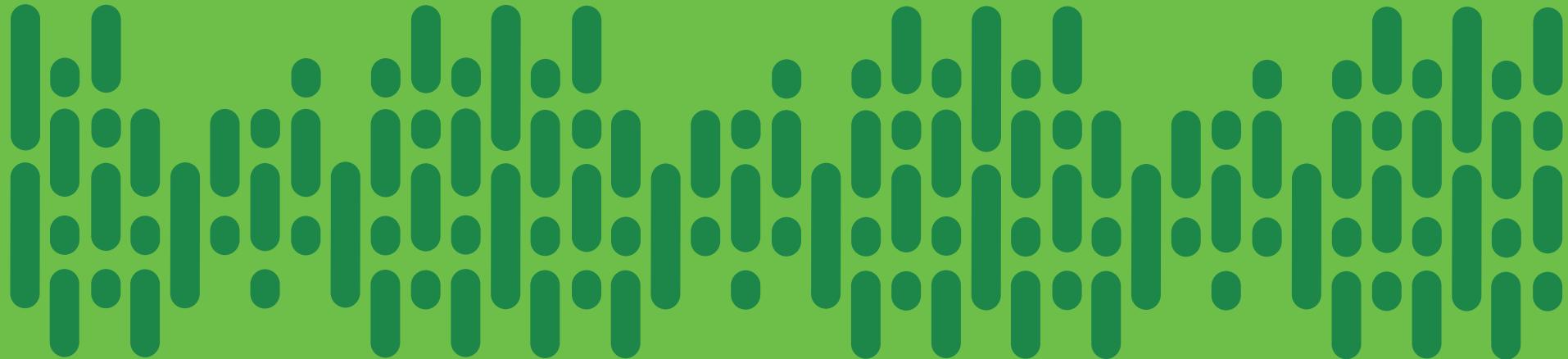
label: 0

Labels in Labels: More Forwarding Labels



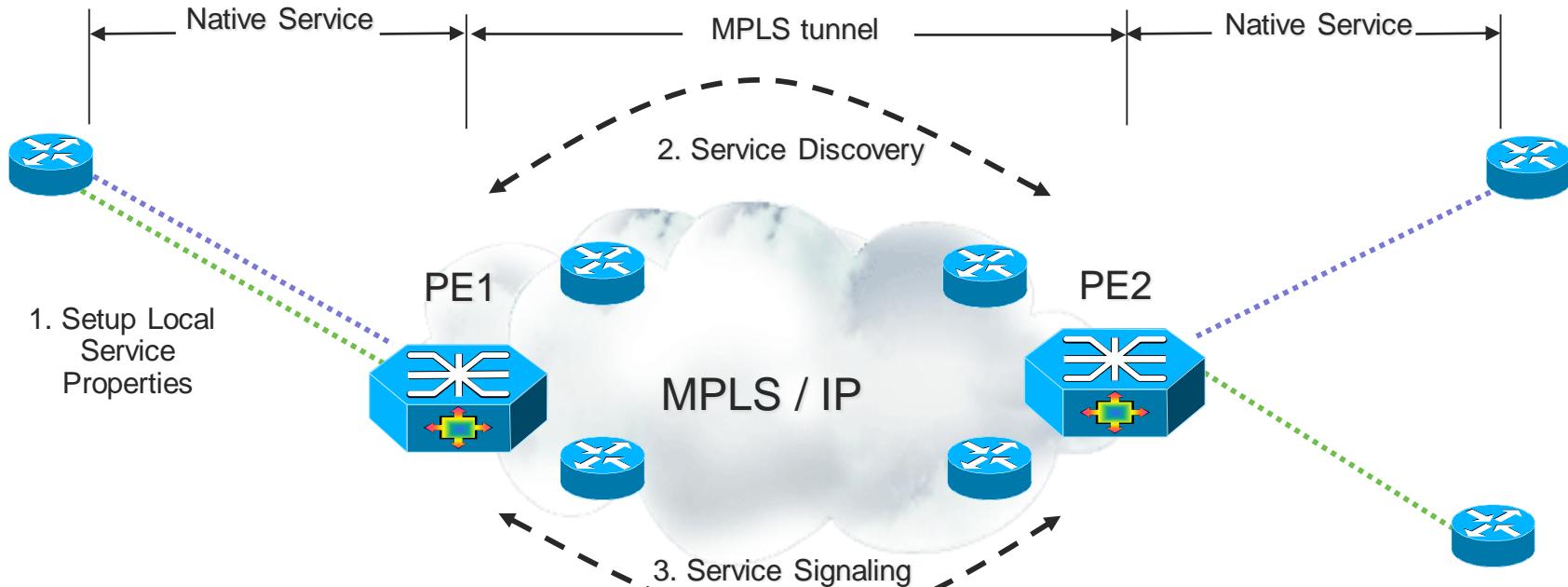
- Flow Label

- Flow Aware Transport Pseudo-Wire [FAT PW] for VPWS and VPLS
- http://www.cisco.com/en/US/partner/docs/routers/asr9000/software/asr9k_r4.3/lxvpn/configuration/guide/lesc_43p2mps.html#wp1339194
- Used for forwarding hashing, but it is at bottom of stack.



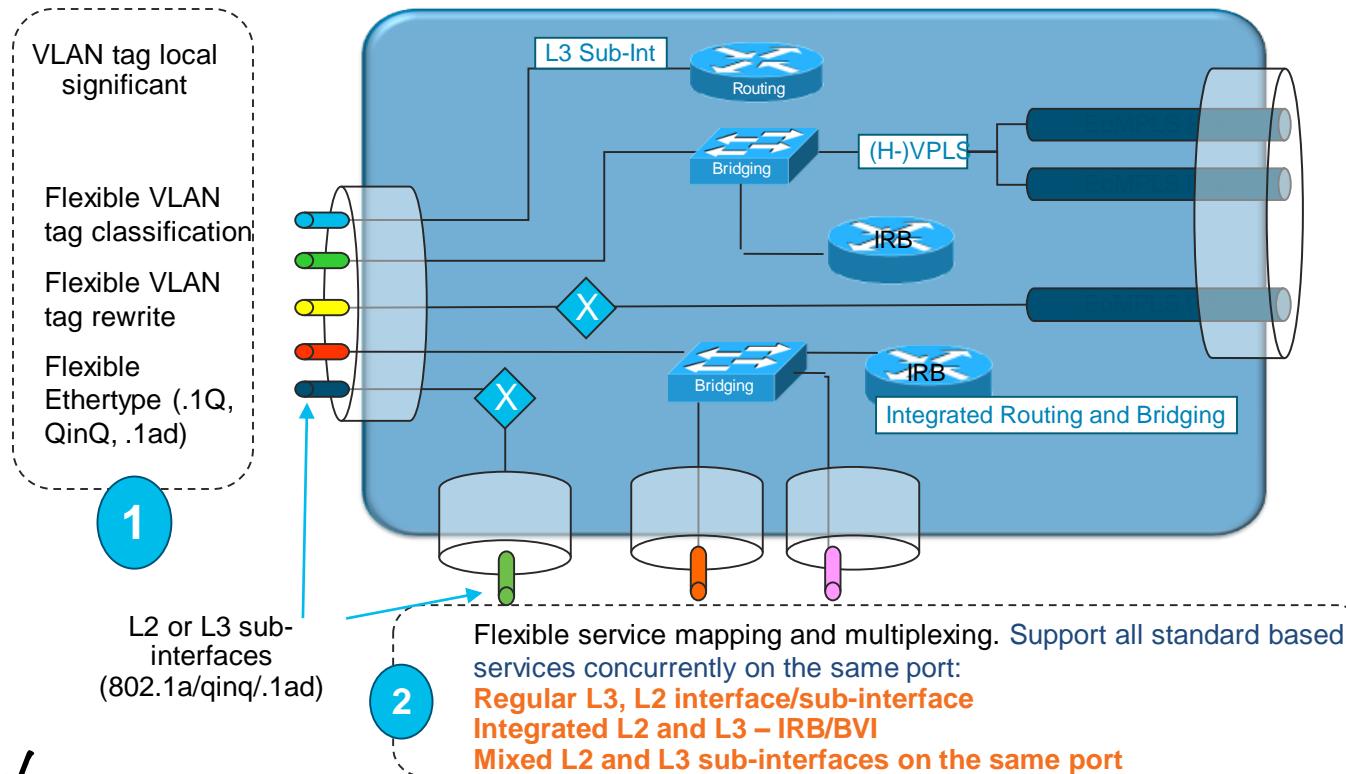
Service Labels

The Service Exchange



- Discovery: Manual or BGP
- Signaling: LDP or BGP

Service Attachment Points



LDP Signaling: PW Example

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show 12vpn xconnect detail
```

```
PW: neighbor 10.101.188.1, PW ID 1, state is up ( established )
PW class ONE, XC ID 0xc0000001
Encapsulation MPLS, protocol LDP
Source address 10.101.111.1
PW type Ethernet, control word enabled, interworking none
PW backup disable delay 0 sec
Sequencing not set
Load Balance Hashing: pw-label
Flow Label flags configured (Tx=1,Rx=1), negotiated (Tx=1,Rx=1)
```

PW Status TLV in use	Local	Advertised	Remote	Received
MPLS	Local			
Label	111014		188014	
Group ID	0x6000180		0x6000180	
Interface	GigabitEthernet0/1/0/3.1		GigabitEthernet0/1/0/3.1	
MTU	1504		1504	
Control word	enabled		enabled	
PW type	Ethernet		Ethernet	
VCCV CV type	0x2 (LSP ping verification)		0x2 (LSP ping verification)	

Forwarding: AC to PW

```
RP/0/RSPO/CPU0:rasr9000-2w-a#show l2vpn forwarding interface g0/1/0/3.1 hardware ingress detail
location 0/1/CPU0
Mon Jun 17 23:18:54.890 EDT
Local interface: GigabitEthernet0/1/0/3.1, Xconnect id: 0xc40001, status: up
Segment 1
  AC, GigabitEthernet0/1/0/3.1, status: Bound
  Statistics:
    packets: received 2809, sent 2810
    bytes: received 330634, sent 386882
    packets dropped: PLU 0, tail 0
    bytes dropped: PLU 0, tail 0
Segment 2
  MPLS, Destination address: 10.101.188.1, pw-id: 1, status: Bound
  Pseudowire label: 188014      Control word enabled
  Load-Balance-Type: pw-label
  Flow Label flag: Tx=1
  Statistics:
    packets: received 2810, sent 2809
    bytes: received 386882, sent 330634
    packets dropped: PLU 0, tail 0, out of order 0
    bytes dropped: PLU 0, tail 0, out of order 0
Platform AC context:
Ingress AC: AToM, State: Bound
```

Forwarding: AC to PW – Cont.

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show 12vpn forwarding interface g0/1/0/3.1 hardware ingress detail  
Location 0/1/CPU0
```

Platform AC context:

Ingress AC: AToM, State: Bound

Flags: Remote is PW

Platform PW context:

Ingress PW: AToM, State: Bound

XID: 0xc0008000, bridge: 0, MAC limit: 0, 12vpn ldi index: 0x0002, vc label: **188014**,
nr_ldi_hash: 0x68, r_ldi_hash: 0xb3, lag_hash: 0xf4, SHG: None

Flags: Control word, Flow Label imposition

NP0

Xconnect ID: 0xc0008000, **NP: 0**

Type: Pseudowire (with control word)

Flags: Learn enable, Type 5, Local replication, **Flow Label imposition**

VC label hash, nR-LDI Hash: 0x68, R-LDI Hash: 0xb6, LAG Hash: 0xf4,

VC output label: 0x2de6e (**188014**), LDI: 0x0002, stats ptr: 0x00000000

Split Horizon Group: None

Forwarding: PW to AC

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show mpls forwarding labels 111014 hardware ingress detail location  
0/1/CPU0  
Mon Jun 17 23:58:30.490 EDT  
Local Outgoing Prefix Outgoing Next Hop Bytes  
Label Label or ID Interface Switched  
-----  
111014 Pop PW(10.101.188.1:1) Gi0/1/0/3.1 point2point N/A  
Updated Jun 15 01:29:06.149  
Path Flags: 0x8 [ ]  
PW Flow Label: Enabled  
MAC/Encaps: 0/0, MTU: 0  
Label Stack (Top -> Bottom): { }  
Packets Switched: 0  
  
LEAF - HAL pd context :  
sub-type : MPLS_VPWS, ecd_marked:0, has_collapsed_ldi:0, collapse_bwalk_required:0, ecdv2_mar  
Leaf H/W Result:  
  
Raw Data0: 0x51009400 01004004 00000000 00000000  
Raw Data1: 0x00000000 00000000 00002013 5f000000  
cb0  
    vpn_special: 0          vc_label_vpws: 1  
    vc_label_vpls: 0         match: 1  
.
```

BGP Signaling: L3 IPv4 VPN

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show bgp vpnv4 unicast labels
```

```
Tue Jun 18 01:25:27.965 EDT
BGP router identifier 10.101.111.1, local AS number 65001
BGP generic scan interval 60 secs
BGP table state: Active
Table ID: 0x0 RD version: 348768
BGP main routing table version 40
BGP scan interval 60 secs
```

```
Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale
```

```
origin codes: i - IGP, e - EGP, ? - incomplete
```

Network	Next Hop	Rcvd Label	Local Label
Route Distinguisher: 65001:1 (default for vrf CUST-A)			
*> 172.20.200.0/24	0.0.0.0	nolabel	111015
*>i172.20.201.0/24	10.101.188.1	188015	nolabel
* i	10.101.188.1	188015	nolabel
*> 172.20.210.0/24	172.20.200.2	nolabel	111016
*>i172.20.211.0/24	10.101.188.1	188016	nolabel
* i	10.101.188.1	188016	nolabel

Advertised

Processed 4 prefixes, 6 paths

Received

Forwarding: IPv4 to VPNv4

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show cef vrf CUST-A ipv4 172.20.211.0/24 hardware ingress location  
0/1/CPU0  
Tue Jun 18 01:45:27.771 EDT  
172.20.211.0/24, version 50, internal 0x14004001 (ptr 0x87935564) [1], 0x0 (0x0), 0x410 (0x89c84170)  
Updated Jun 18 01:25:21.070  
Prefix Len 24, traffic index 0, precedence routine (0), priority 3  
via 10.101.188.1, 5 dependencies, recursive [flags 0x6010]  
path-idx 0 [0x89d4cb84 0x0]  
next hop VRF - 'default', table - 0xe0000000  
next hop 10.101.188.1 via 111007/0/21  
next hop 10.100.101.1/32 tt1111      labels imposed {101000 188016}  
LEAF - HAL pd context :  
sub-type : IPV4, ecd_marked:0, has_collapsed_ldi:0, collapse_bwalk_required:0, ecdv2_marked:0  
Leaf H/W Result:  
Physical Result: 0x11ba0200 (LE)  
  
Raw Data0: 0x51924000 2de70100 00000000 00000000  
Raw Data1: 0x0b000000 00000000 00180000 0000a2ff  
leaf_resolve_control_byte0  
    reserved: 0                         match: 1                         valid: 1  
    ifib_lookup: 0
```

LDP label

VPNv4 label

Forwarding: VPNv4 to IPv4

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show mpls forwarding labels 111016 detail hardware ingress location 0/1/CPU0
Tue Jun 18 02:08:02.870 EDT
Local Outgoing Prefix Outgoing Next Hop Bytes
Label Label or ID Interface Switched
-----
111016 Unlabelled 172.20.210.0/24[V] Gi/0/1/0/3.200 172.20.200.2 N/A
    Updated Jun 17 21:23:42.087
    Version: 47, Priority: 3
    MAC/Encaps: 18/18, MTU: 1500
    Label stack (Top -> Bottom): { Unlabelled }
    Packets Switched: 0

LEAF - HAL pd context :
  sub-type : MPLS_VPN, ecd_marked:0, has_collapsed_ldi:0, collapse_bwalk_required:0, ecdv2_mark
Leaf H/W Result:

Raw Data0: 0x11020900 00000000 00000000 00000000
Raw Data1: 0x99000000 00000000 10000000 0000a2ff
cb0
  vpn_special: 0          vc_label_vpws: 0
  vc_label_vp1s: 0          match: 1
  rsrvd: 0          valid: 1
```

Forwarding: VPNv4 Aggregate to IPv4

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show mpls forwarding labels 111015 detail hardware ingress location  
0/1/CPU0  
Tue Jun 18 02:06:14.191 EDT  
Local Outgoing Prefix Outgoing Next Hop Bytes  
Label Label or ID Interface Switched  
-----  
111015 Aggregate CUST-A: Per-VRF Aggr[v] \  
CUST-A N/A  
Updated Jun 17 20:03:19.525  
Path Flags: 0x10 [ ]  
MAC/Encaps: 0/0, MTU: 0  
Label Stack (Top -> Bottom): { }  
Packets Switched: 0  
  
LEAF - HAL pd context :  
sub-type : MPLS_DEAG, ecd_marked:0, has_collapsed_ldi:0, collapse_bwalk_required:0, ecdv2_mar  
Leaf H/W Result:  
  
Raw Data0: 0x910008ff 00000000 00000000 00000000  
Raw Data1: 0x00000000 00000000 10000015 5f000000  
cb0  
    vpn_special: 1          vc_label_vpws: 0  
    vc_label_vpls: 0         match: 1  
.
```

Forwarding: Load Sharing To Core Bundle

```
RP/0/RSPO/CPU0:rasr9000-2w-b#show cef vrf TRAFFIC ipv4 10.10.6.6 hardware ingress location 0/0/CPU0
Tue Dec 10 10:14:29.843 EST
10.10.6.0/24, version 41, internal 0x14004001 (ptr 0x8dd2b964) [1], 0x0 (0x0), 0x410 (0x90d929b0)
Updated Dec 5 08:06:31.568
Prefix Len 24, traffic index 0, precedence routine (0), priority 3
  via 10.101.111.1, 7 dependencies, recursive [flags 0x6010]
    path-idx 0 [0x90e5ab08 0x0]
    next hop VRF - 'default', table - 0xe0000000
    next hop 10.101.111.1 via 188002/0/21
      next hop 0.0.0.0/32 tt180      labels imposed {ImplNull 111018}
LEAF - HAL pd context :
  sub-type : IPV4, ecd_marked:0, has_collapsed_ldi:0, collapse_bwalk_required:0, ecdv2_marked:0
Leaf H/W Result:

  Physical Result: 0x117a0300 (LE)
  Other fields:
    leaf_ptr: 0xc4bc05(LE)          bgp_next_hop: 0xa656f01
    urpf_ptr: 0
NextHopPrefix:label:eos=188002:0

Please use show cef or show mpls forwarding command again
with nexthop prefix specified for nexthop hardware details
```

Forwarding: Load Sharing To Core Bundle

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show cef ipv4 10.101.111.1 hardware ingress detail location 0/0/CPU0 |  
include if_handle  
Tue Dec 10 11:02:58.582 EST  
    if_handle      : 0x2d320  
  
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers pm location 0/0/CPU0 | include 2d320  
Tue Dec 10 11:03:07.283 EST  
Ifname(2): Bundle-Ether1, ifh: 0x2d320 :  
parent_bundle_ifh 0x2d320  
  
RP/0/RSP0/CPU0:rasr9000-2w-b#show bundle Bundle-Ether 1  
Tue Dec 10 11:03:14.257 EST  
Bundle-Ether1  
  Status: Up  
  Local Links <active/standby/configured>: 5 / 0 / 5  
  Local bandwidth <effective/available>: 50000000 (50000000) kbps  
  MAC address (source): 10f3.110b.161b (chassis pool)  
  Port      Device     State       Port ID      B/W, kbps  
  -----  -----  
  Te0/0/0/5  Local     Active  0x8000, 0x0001  10000000  Link is Active  
  Te0/1/1/0  Local     Active  0x8000, 0x0003  10000000  Link is Active  
  Te0/1/1/1  Local     Active  0x8000, 0x0004  10000000  Link is Active  
  Te0/1/1/2  Local     Active  0x8000, 0x0002  10000000  Link is Active  
  Te0/1/1/3  Local     Active  0x8000, 0x0005  10000000  Link is Active
```

Forwarding: Load Sharing To Core Bundle

```
RP/0/RSP0/CPU0:rasr9000-2w-b#bundle-hash Bundle-Ether 1 location 0/0/CPU0
Tue Dec 10 11:17:15.224 EST
Calculate Bundle-Hash for L2 or L3 or sub-int based: 2/3/4 [3]:
Enter traffic type (1:IPv4-inbound, 2:MPLS-inbound, 3:IPv6-inbound): [1]:
Single SA/DA pair or range: S/R [S]:
Enter source IPv4 address [255.255.255.255]: 10.10.3.3
Enter destination IPv4 address [255.255.255.255]: 10.10.6.6
Compute destination address set for all members? [y/n]: n
Enter L4 protocol ID. (Enter 0 to skip L4 data) [0]:
Invalid protocol. L4 data skipped.
Link hashed [hash_val:3] to is TenGigE0/1/1/3 ICL () LON 4 ifh 0x6000680
Another? [y]: n
RP/0/RSP0/CPU0:rasr9000-2w-b#
```

Forwarding: Load Sharing To Multiple CE's

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show cef vrf TRAFFIC ipv4 10.10.3.3 hardware ingress location 0/1/CPU0
Tue Dec 10 12:13:20 2014 EST
10.10.3.0/24, version 33, internal 0x40000001 (ptr 0x877d8564) [1], 0x0 (0x0), 0x0 (0x0)
Updated Dec 5 08:06:32.256
Prefix Len 24, traffic index 0, precedence routine (0), priority 3
  via 192.2.1.2, 3 dependencies, recursive [flags 0x0]
    path-idx 0 [0x877d8964 0x0]
    next hop 192.2.1.2 via 192.2.1.2/32
  via 192.3.1.2, 3 dependencies, recursive [flags 0x0]
    path-idx 1 [0x877d8f64 0x0]
    next hop 192.3.1.2 via 192.3.1.2/32
  via 192.4.1.2, 3 dependencies, recursive [flags 0x0]
    path-idx 2 [0x877d87e4 0x0]
    next hop 192.4.1.2 via 192.4.1.2/32

NextHopPrefix:192.2.1.2/32
Please use show cef or show mpls forwarding command again
with nexthop prefix specified for nexthop hardware details
NextHopPrefix:192.3.1.2/32
Please use show cef or show mpls forwarding command again
with nexthop prefix specified for nexthop hardware details
NextHopPrefix:192.4.1.2/32
Please use show cef or show mpls forwarding command again
with nexthop prefix specified for nexthop hardware details
```

Forwarding: Load Sharing To Multiple CE's

```
RP/0/RSPO/CPU0:rasr9000-2w-b#show cef vrf TRAFFIC ipv4 exact-route 10.10.6.6 10.10.3.3 hardware
ingress location 0/0/CPU0
Tue Dec 10 12:17:36.699 EST
10.10.3.0/24, version 33, internal 0x4000001 (ptr 0x8dd31064) [1], 0x0 (0x0), 0x0 (0x0)
Updated Dec 5 08:06:31.504
local adjacency 192.2.1.2
Prefix Len 24, traffic index 0, precedence routine (0), priority 3
via TenGigE0/0/0/0
via 192.2.1.2, 3 dependencies, recursive [flags 0x0]
path-idx 0 [0x8dd29564 0x0]
next hop 192.2.1.2 via 192.2.1.2/32

RP/0/RSPO/CPU0:rasr9000-2w-b#show cef adjacency tenGigE 0/0/0/0 192.2.1.2 hardware egress detail
location 0/0/CPU0
Tue Dec 10 12:23:14.902 EST
Display protocol is ipv4
Interface Address Type Refcount
Te0/0/0/0 Prefix: 192.2.1.2/32 local 5
Adjacency: PT:0x8a7742e8 192.2.1.2/32
Interface: Te0/0/0/0
MAC: 02.c0.00.00.f3.10.02.01.90.61.05.11.00.00
Interface Type: 0x1e, Base Flags: 0x1 (0x91c7ad58)
Nhinfo PT: 0x91c7ad58, Idb PT: 0x8d18a318, If Handle: 0x40000c0
Dependent adj type: remote (0x90fd7c70)
```

BGP Signaling: VPLS Bridge

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show bgp 12vpn vpls
Tue Jun 18 18:59:28.339 EDT
BGP router identifier 10.101.111.1, local AS number 65001
BGP generic scan interval 60 secs
BGP table state: Active
Table ID: 0x0 RD version: 412008
BGP main routing table version 35
BGP scan interval 60 secs

Status codes: s suppressed, d damped, h history, * valid, > best
              i - internal, r RIB-failure, S stale
Origin codes: i - IGP, e - EGP, ? - incomplete
Network          Next Hop        Rcvd Label      Local Label
Route Distinguisher: 65001:100 (default for vrf BRIDGES:BR-A)
*> 111:110/32      0.0.0.0      nolabel       111030
*> 111:130/32      0.0.0.0      nolabel       111090
*> 111:180/32      0.0.0.0      nolabel       111060
.
*>i188:110/32     10.101.188.1  188060        nolabel
*i                  10.101.188.1  188060        nolabel
*>i188:130/32     10.101.188.1  188090        nolabel
*i                  10.101.188.1  188090        nolabel
.
Processed 13 prefixes, 23 paths
```

Advertised

Received

Forwarding: VPLS Bridge: EFP to VFI

```
RP/0/RSPO/CPU0:rasr9000-2w-a#show l2vpn forwarding bridge-domain BRIDGES:BR-A hardware ingress detail  
location 0/1/CPU0
```

```
Tue Jun 18 21:18:34.152 EDT
```

```
Bridge-domain name: BRIDGES:BR-A, id: 0, state: up
MAC learning: enabled
MAC port down flush: enabled
Flooding:
    Broadcast & Multicast: enabled
    Unknown unicast: enabled
    MAC aging time: 300 s, Type: inactivity
    MAC limit: 4000, Action: none, Notification: syslog
    MAC limit reached: no
    MAC Secure: disabled, Logging: disabled
    DHCPv4 snooping: profile not known on this node
    Dynamic ARP Inspection: disabled, Logging: disabled
    IP Source Guard: disabled, Logging: disabled
    IGMP snooping: disabled, flooding: enabled
Bridge MTU: 1500 bytes
Number of bridge ports: 5
Number of MAC addresses: 2
Multi-spanning tree instance: 0
Platform bridge context:
```

Lots of information:
All EFP's, all PW's,
all labels!

Forwarding: VPLS Bridge: EFP to VFI

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show 12vpn forwarding bridge-domain BRIDGES:BR-A mac-address  
hardware ingress detail location 0/1/CPU0
```

Tue Jun 18 21:10:27.472 EDT

To Resynchronize MAC table from the Network Processors, use the command...
12vpn resynchronize forwarding mac-address-table location <r/s/i>

Mac Address	Type	Learned from/Filtered on	LC learned	Resync	Age	Mapped to
0022.9088.2ac0	dynamic	Gi0/1/0/3.300	0/1/CPU0	0d 0h 0m 5s		N/A
0022.55e6.ae20	dynamic	(10.101.188.1, 300)	0/1/CPU0	0d 0h 0m 4s		N/A
.						

Dest MAC

PW

Forwarding: VPLS Bridge: EFP to VFI

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show l2vpn forwarding neighbor 10.101.188.1 300 hardware egress detail  
location 0/1/CPU0
```

Tue Jun 18 21:21:47.126 EDT

Xconnect id: 0xc0000007, Status: up

Segment 1

MPLS, Destination address: 10.101.188.1, pw-id: 300, status: Bound

Pseudowire label: 188061 Control word disabled

Statistics:

packets: received 376162, sent 376005

bytes: received 51910302, sent 44368536

packets dropped: PLU 0, tail 0, out of order 0

bytes dropped: PLU 0, tail 0, out of order 0

PW label

Segment 2

Bridge id: 0, Split horizon group id: 1

Storm control: disabled

MAC learning: enabled

MAC port down flush: enabled

Flooding:

Broadcast & Multicast: enabled

Unknown unicast: enabled

MAC aging time: 300 s, Type: inactivity

MAC limit: 4000, Action: none, Notification: syslog

MAC limit reached: no

Forwarding: VPLS Bridge: VFI to EFP

RP/0/RSP0/CPU0:rasr9000-2w-b#show mpls forwarding					
Local Label		Outgoing Label or ID	Outgoing Interface	Next Hop	Bytes Switched
188000	Pop	10.101.112.1/32	tt18800	10.101.112.1	0
188001	Pop	10.101.124.1/32	tt18801	10.101.124.1	0
188002	Pop	10.101.125.1/32	tt18802	10.101.125.1	300
188003	Pop	10.101.135.1/32	tt18803	10.101.135.1	0
188004	Pop	10.101.137.1/32	tt18804	10.101.137.1	300
188005	Pop	10.101.178.1/32	tt18805	10.101.178.1	0
188013	108009	10.101.111.1/32	tt8881	10.100.108.1	219343578
188014	Pop	PW(10.101.111.1:1)	Gi0/1/0/3.1	point2point	319362
188015	Aggregate	CUST-A: Per-VRF Aggr[v]	\		
		CUST-A			49800
188016	Unlabelled	172.20.211.0/24[V]	Gi0/1/0/3.200	172.20.201.2	0
188061	Pop	PW(10.101.111.1:300)	\		
		BD=0	point2point		100172000
188075	Pop	PW(10.101.125.1:300)	\	point2point	0
		BD=0	point2point		
188097	Pop	PW(10.101.137.1:300)	\	point2point	0
		BD=0	point2point		

Pop label

Forwarding: VPLS Bridge: VFI to EFP

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show 12vpn forwarding bridge-domain BRIDGES:BR-A mac-address  
hardware egress location 0/1/CPU0
```

Tue Jun 18 06:44:04.464 EDT

To Resynchronize MAC table from the Network Processors, use the command...
12vpn resynchronize forwarding mac-address-table location <r/s/i>

Mac Address	Type	Learned from/Filtered on	LC learned	Resync	Age	Mapped to
0022.55e6.ae20	dynamic	Gi0/1/0/3.300	0/1/CPU0	0d 0h 0m 4s		N/A
0022.9088.2ac0	dynamic	(10.101.111.1, 300)	0/1/CPU0	0d 0h 0m 5s		N/A
.						

Dest MAC

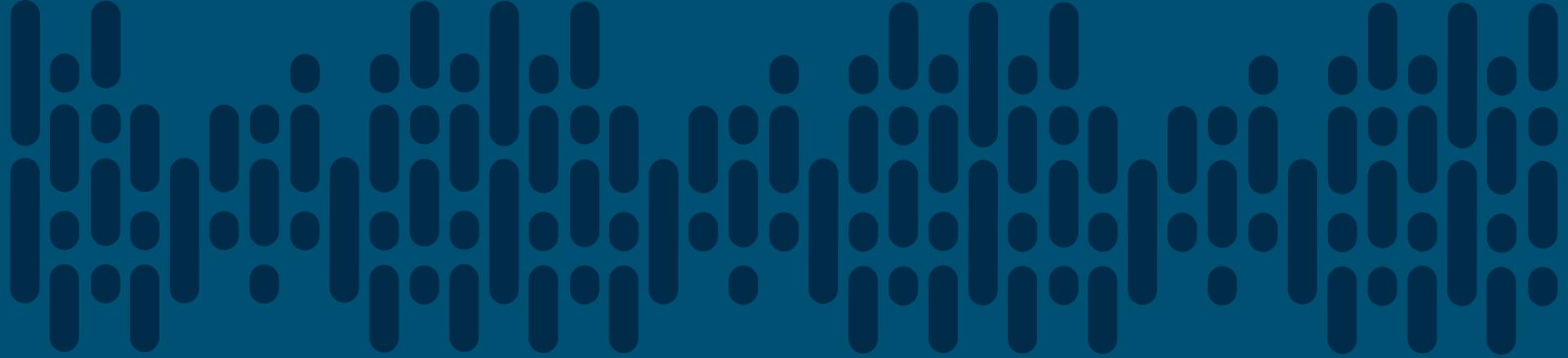
Agenda

- ✓ **System Architecture:** System anatomy and health
- ✓ **Operating System & Configuration:** IOS-XR & configuration models
- ✓ **Control, Management, & Security:** Processing of control & exceptions
- ✓ **Transit Packet/Frame Journey:** Life of L3/L2 unicast/multicast
- ✓ **MPLS Operation:** Processing, forwarding and L3/L2 service operation
- **Troubleshooting:** Diagnostics, counters, drops, and packet capture

6 Troubleshooting



You make customer experience **possible**

The background of the slide features a repeating pattern of the Cisco logo, which consists of a series of dark blue vertical bars of varying heights.

System Diagnostics

Background Diagnostics

RSP default diagnostics

```
RP/0/RSP0/CPU0:rasr9000-2w-a#admin show diagnostic content location 0/RSP0/CPU0  
Wed Dec 11 19:44:32.957 EST
```

RP 0/RSP0/CPU0:

Diagnostics test suite attributes:

M/C/* - Minimal bootup level test / Complete bootup level test / NA
B/O/* - Basic ondemand test / not Ondemand test / NA
P/V/* - Per port test / Per device test / NA
D/N/* - Disruptive test / Non-disruptive test / NA
S/* - Only applicable to standby unit / NA
X/* - Not a health monitoring test / NA
F/* - Fixed monitoring interval test / NA
E/* - Always enabled monitoring test / NA
A/I - Monitoring is active / Monitoring is inactive

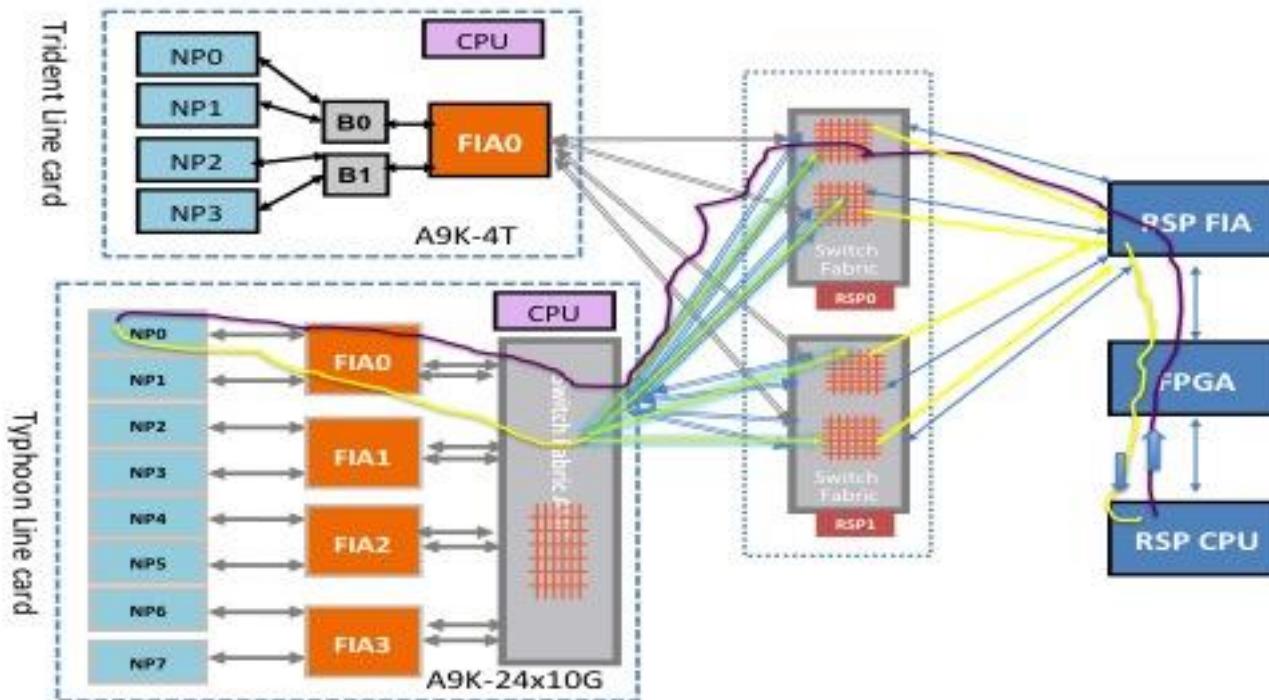
Every minute or
every 5 seconds

ID	Test Name	Attributes	Test Interval (day hh:mm:ss.ms)	Thre- shold
1)	CPUCtrlScratchRegister ----->	***N*****A	000 00:01:00.000	1
2)	ClkCtrlScratchRegister ----->	***N*****A	000 00:01:00.000	1
3)	ZenJfScratchRegister ----->	***N*****A	000 00:01:00.000	1
4)	FabSwitchIdRegister ----->	*B*N*****A	000 00:01:00.000	1
5)	SrspStandbyEobcHeartbeat ----->	*B*NS***A	000 00:00:05.000	3
6)	SrspActiveEobcHeartbeat ----->	*B*NS***A	000 00:00:05.000	3
7)	FabricLoopback ----->	MB*N*****A	000 00:01:00.000	3
8)	PuntFabricDataPath ----->	*B*N*****A	000 00:01:00.000	3

Error threshold
(consecutive)

Background Diagnostics

Test example: PuntFabricDataPath



- Looping the path between RP CPU and each NP

Background Diagnostics

LC default diagnostics

```
RP/0/RSP0/CPU0:rasr9000-2w-a#admin show diagnostic content location 0/0/CPU0  
Wed Dec 11 20:32:08.842 EST
```

A9K-24x10GE-SE 0/0/CPU0:

Diagnostics test suite attributes:

M/* - Minimal bootup level test / Complete bootup level test / NA
B/* - Basic ondemand test / not Ondemand test / NA
P/* - Per port test / Per device test / NA
D/* - Disruptive test / Non-disruptive test / NA
S/* - Only applicable to standby unit / NA
X/* - Not a health monitoring test / NA
F/* - Fixed monitoring interval test / NA
E/* - Always enabled monitoring test / NA
A/I - Monitoring is active / Monitoring is inactive

ID	Test Name	Attributes	Test Interval (day hh:mm:ss.ms)	Thre- hold
1)	CPUCtrlScratchRegister ----->	*B*N****A	000 00:01:00.000	1
2)	PHYCtrlScratchRegister ----->	*B*N****A	000 00:01:00.000	1
3)	PortCtrlScratchRegister ----->	*B*N****A	000 00:01:00.000	1
4)	FIAScratchRegister ----->	*B*N****A	000 00:01:00.000	1
5)	LcEobcHeartbeat ----->	*B*N****A	000 00:00:05.000	3
6)	NPULoopback ----->	*B*N****A	000 00:01:00.000	3

Background Diagnostics

Reading the results

```
RP/0/RSP0/CPU0:rusr9000-2w-a#admin show diagnostic result location  
0/RSP1/CPU0 detail
```

Wed Dec 11 20:35:26.998 EST

Current bootup diagnostic level for RP 0/RSP1/CPU0: minimal

RP 0/RSP1/CPU0:

Overall diagnostic result: PASS

Diagnostic level at card bootup: minimal

Test results: (. = Pass, F = Fail, U = Untested)

1) CPUCtrlScratchRegister -----> .

```
Error code -----> 0 (DIAG_SUCCESS)  
Total run count -----> 31553  
Last test execution time ----> Wed Dec 11 20:35:08 2013  
First test failure time -----> n/a  
Last test failure time -----> n/a  
Last test pass time -----> Wed Dec 11 20:35:08 2013  
Total failure count -----> 0  
Consecutive failure count ---> 0
```

2) clkCtrlScratchRegister -----> .

```
Error code -----> 0 (DIAG_SUCCESS)  
Total run count -----> 31553  
Last test execution time ----> Wed Dec 11 20:35:08 2013  
First test failure time -----> n/a  
Last test failure time -----> n/a  
Last test pass time -----> Wed Dec 11 20:35:08 2013  
Total failure count -----> 0  
Consecutive failure count ---> 0
```

6) SrspActiveEobcHeartbeat -----> .

```
Error code -----> 0 (DIAG_SUCCESS)  
Total run count -----> 378621  
Last test execution time ----> Wed Dec 11 20:35:25 2013  
First test failure time -----> n/a  
Last test failure time -----> n/a  
Last test pass time -----> Wed Dec 11 20:35:25 2013  
Total failure count -----> 0  
Consecutive failure count ---> 0
```

7) FabricLoopback -----> .

```
Error code -----> 0 (DIAG_SUCCESS)  
Total run count -----> 31552  
Last test execution time ----> Wed Dec 11 20:35:08 2013  
First test failure time -----> n/a  
Last test failure time -----> n/a  
Last test pass time -----> Wed Dec 11 20:35:08 2013  
Total failure count -----> 0  
Consecutive failure count ---> 0
```

8) PuntFabricDataPath -----> .

```
Error code -----> 0 (DIAG_SUCCESS)  
Total run count -----> 31552  
Last test execution time ----> Wed Dec 11 20:35:08 2013  
First test failure time -----> n/a  
Last test failure time -----> n/a  
Last test pass time -----> Wed Dec 11 20:35:08 2013  
Total failure count -----> 0  
Consecutive failure count ---> 0
```

Background Diagnostics

Errors and clears

- Set: threshold exceeded
 - Path to LC 2 NP 0 failed in this example
- Clear: test previously failing, now passed
 - Indication of “transient” fault. Keep watching
- “show pfm location all” shows platform errors reported

```
RP/0/RSP0/CPU0:Feb 5 05:05:44.051 :  
pfm_node_rp[354]:%PLATFORM-DIAGS-3-PUNT_FABRIC_DATA_PATH_FAILED :  
Set|online_diag_rsp[237686]|System Punt/Fabric/data Path  
Test(0x2000004)|failure threshold is 3, (slot, NP)failed:  
(0/2/CPU0, 0)
```

```
RP/0/RSP0/CPU0:Feb 5 05:05:46.051 :  
pfm_node_rp[354]:%PLATFORM-DIAGS-3-PUNT_FABRIC_DATA_PATH_FAILED :  
Clear|online_diag_rsp[237686]|System Punt/Fabric/data Path  
Test(0x2000004)|failure threshold is 3, (slot, NP)failed:  
(0/2/CPU0, 0)
```

On Board Failure Logging [OBFL]

Logging errors, temperature, voltage locally on NVRAM

```
RP/0/RSP0/CPU0:rasr9000-2w-b#admin show Logging onboard ?
```

all	All Application
cbc	CBC OBFL Commands
detail	Onboard logging detail information
diagnostic	Online Diagnostic Application
environment	Environment Application
error	Syslog Application
location	Locations to filter on
raw	Onboard logging raw information
summary	Onboard logging summary information
temperature	Temperature Application
trace	Debug traces for OBFL(cisco-support)
uptime	Uptime Application
verbose	Display internal debugging information
voltage	Voltage Application
	Output Modifiers

<cr>

```
RP/0/RSP0/CPU0:rasr9000-2w-b#admin show Logging onboard error location 0/1/CPU0 | utility tail count 15
```

Tue Jan 21 23:32:30.047 EST

```
11/15/2013 19:27:50 sev:1 0/1/CPU0 pfm_node_1c[290]: %PLATFORM-CROSSBAR-1-SERDES_ERROR_LNK0 :  
Set|fab_xbar[172110]|Crossbar Switch(0x1017010)|Slot_0_XBAR_1  
12/19/2013 17:28:35 sev:1 0/1/CPU0 pfm_node_1c[291]: %PLATFORM-CROSSBAR-1-SERDES_ERROR_LNK0 :  
Set|fab_xbar[172110]|Crossbar Switch(0x1017010)|Slot_0_XBAR_1
```

EOBC Switch

Switch links and interfaces

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show controllers  
backplane ethernet detail location 0/RSP0/CPU0  
Wed Dec 11 21:53:1.24 EST  
GigabitEthernet0_RSP0_CPU0 is up  
Active RSP is RSP 0  
Hardware is Gigabit Ethernet, H/W address is  
564b.4700.0001  
Internet address is 127.0.1.0  
MTU 1514 bytes  
Encapsulation ASR9KIES (ASR9K Internal Ethernet  
Server)  
Mode : Full Duplex, Rate : 1Gb/s  
317863661 packets input, 4291854728 bytes, 0 total  
input drops  
0 packets discarded (0 bytes) in garbage  
collection  
300 packets discarded (83692 bytes) in recv  
processing  
0 incomplete frames discarded  
0 packets discarded due to bad headers  
0 packets waiting for clients  
1 packets waiting on Rx  
Received 379557 broadcast packets, 17762716  
multicast packets 0 dropped flood packets  
Input errors: 0 CRC, 0 overrun, 0 alignment, 0  
length, 0 collision  
301873561 packets output, 2396666126 bytes, 0  
total output drops  
Output 0 broadcast packets, 37045337 multicast  
.
```

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show controllers backplane  
ethernet detail location 0/0/CPU0  
Wed Dec 11 21:53:00.797 EST  
GigabitEthernet0_0_CPU0 is up  
Active RSP is RSP 0  
Hardware is Gigabit Ethernet, H/W address is  
564b.4700.0821  
Internet address is 127.0.1.2  
MTU 1514 bytes  
Encapsulation ASR9KIES (ASR9K Internal Ethernet Server)  
Mode : Full Duplex, Rate : 1Gb/s  
107127056 packets input, 707649689 bytes, 0 total  
input drops  
12 packets discarded (792 bytes) in garbage  
collection  
29433394 packets discarded (936722920 bytes) in recv  
processing  
0 incomplete frames discarded  
0 packets discarded due to bad headers  
0 packets waiting for clients  
1 packets waiting on Rx  
Received 379530 broadcast packets, 53601523 multicast  
packets 0 dropped flood packets  
Input errors: 0 CRC, 0 overrun, 0 alignment, 0  
length, 0 collision  
67306802 packets output, 22632683 bytes, 0 total  
output drops  
Output 1 broadcast packets, 1179989 multicast  
.
```

LC & NP Resources

L3 forwarding resources

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show cef resource hardware ingress detail location 0/0/CPU0
Wed Dec 11 22:27:57.319 EST
CEF resource availability summary state: GREEN
CEF will work normally
  ipv4 shared memory resource:
    CurrMode GREEN, CurrAvail 1609412608 bytes, MaxAvail 1683308544 bytes
  ipv6 shared memory resource:
    CurrMode GREEN, CurrAvail 1609412608 bytes, MaxAvail 1683308544 bytes
  mpls shared memory resource:
    CurrMode GREEN, CurrAvail 1609412608 bytes, MaxAvail 1683308544 bytes
  common shared memory resource:
    CurrMode GREEN, CurrAvail 1609412608 bytes, MaxAvail 1683308544 bytes
  DATA_TYPE_TABLE_SET hardware resource: GREEN
  DATA_TYPE_TABLE hardware resource: GREEN
  DATA_TYPE_IDB hardware resource: GREEN
  DATA_TYPE_IDB_EXT hardware resource: GREEN
  DATA_TYPE_LEAF hardware resource: GREEN
  DATA_TYPE_LOADINFO hardware resource: GREEN
  DATA_TYPE_PATH_LIST hardware resource: GREEN
  DATA_TYPE_NHINFO hardware resource: GREEN
  DATA_TYPE_LABEL_INFO hardware resource: GREEN
  DATA_TYPE_FRR_NHINFO hardware resource: GREEN
  DATA_TYPE_ECD hardware resource: GREEN
```

LC & NP Resources

L2 service resources

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show l2vpn forwarding resource hardware ingress detail location  
0/0/CPU0
```

```
Wed Dec 11 22:26:07.070 EST
```

```
L2VPN forwarding resource availability summary state: GREEN
```

```
shared memory resource:
```

```
    CurrMode GREEN, CurrAvail 1609412608 bytes, MaxAvail 1650212864 bytes
```

```
AC hardware resource: GREEN
```

```
MPLS hardware resource: GREEN
```

```
PBB PORT hardware resource: GREEN
```

```
NHOP hardware resource: GREEN
```

```
L2TP hardware resource: GREEN
```

```
L2TP_SESSION hardware resource: GREEN
```

```
VFI hardware resource: GREEN
```

```
BRIDGE hardware resource: GREEN
```

```
BRIDGE SHG hardware resource: GREEN
```

```
BRIDGE PORT hardware resource: GREEN
```

```
BRIDGE MAC hardware resource: GREEN
```

```
MSTI MAIN PORT hardware resource: GREEN
```

```
BRIDGE MAIN PORT hardware resource: GREEN
```

```
MCAST TABLE hardware resource: GREEN
```

```
MCAST LEAF hardware resource: GREEN
```

```
MCAST XID hardware resource: GREEN
```

```
PBB BMAC SA hardware resource: GREEN
```

LC & NP Resources

L2 service resources - continued

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show l2vpn forwarding resource hardware ingress detail location 0/0/CPU0
```

Platform resource:

Hardware Resource Summary - NPO

	Set T/F	Modify T/F	Clear T/F	Get T/F	Get Info T/F	Delete T/F	All T/Max
XID	24/0	117/0	8/0	0/0	0/0	0/0	16/262144
BRIDGE	1/0	15/0	0/0	0/0	0/0	0/0	1/65536
STATIC MAC	1/0	0/0	0/0	0/0	0/0	0/0	1/2097152
BRIDGE PORT	0/0	0/0	0/0	0/0	0/0	0/0	0/393216
UIDB	39/0	0/0	3/0	0/0	0/0	0/0	-/-
VPLS PW STATS	7/0	-/-	4/0	-/-	0/0	-/-	-/-
ISID	0/0	0/0	0/0	0/0	0/0	0/0	0/65536
L2TP	0/0	0/0	0/0	0/0	0/0	0/0	0/131072
DHCP	0/0	0/0	0/0	0/0	0/0	0/0	0/131072
TOTAL MAC	-/-	-/-	-/-	-/-	-/-	-/-	1/2097152
Total	72/0	132/0	15/0	0/0	0/0	0/0	

Hardware Performance Summary

XID	< 1 ms	< 1 ms	< 1 ms	< 1 ms	< 1 ms	< 1 ms
BRIDGE	000.001 s	< 1 ms				
STATIC MAC	< 1 ms	< 1 ms	< 1 ms	< 1 ms	< 1 ms	< 1 ms

TCP Resources

TCP connections states

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show tcp brief
```

```
Fri Dec 13 22:29:33.189 EST
```

PCB	VRF-ID	Recv-Q	Send-Q	Local Address	Foreign Address	State
0x10174ad8	0x60000000	0	0	:::179	:::0	LISTEN
0x10174f8	0x60000001	0	0	:::179	:::0	LISTEN
0x10174798	0x60000002	0	0	:::179	:::0	LISTEN
0x10174938	0x60000003	0	0	:::179	:::0	LISTEN
0x101cce2c	0x6000000b	0	0	:::179	:::0	LISTEN
0x1016fefc	0x00000000	0	0	:::179	:::0	LISTEN
0x101ac7ac	0x60000000	0	0	10.101.111.1:179	10.100.101.1:20100	ESTAB
0x1017bbf4	0x60000000	0	0	10.101.111.1: 646	10.101.188.1:30687	ESTAB
0x10182b38	0x60000000	0	0	10.101.111.1: 179	10.100.103.1:59214	ESTAB
0x1002e004	0x6000000d	0	0	10.100.111.1:17514	10.100.111.100: 13680	ESTAB
0x10161e18	0x60000000	0	0	0.0.0.0:23	0.0.0.0:0	LISTEN
0x101cc968	0x00000000	0	0	0.0.0.0:23	0.0.0.0:0	LISTEN
0x101594b4	0x60000000	0	0	0.0.0.0:646	0.0.0.0:0	LISTEN
0x1016f7f0	0x60000000	0	0	0.0.0.0:179	0.0.0.0:0	LISTEN
0x10165d74	0x60000001	0	0	0.0.0.0:179	0.0.0.0:0	LISTEN
0x1016f4b0	0x60000002	0	0	0.0.0.0:179	0.0.0.0:0	LISTEN
0x1016f650	0x60000003	0	0	0.0.0.0:179	0.0.0.0:0	LISTEN
0x101ade54	0x6000000b	0	0	0.0.0.0:179	0.0.0.0:0	LISTEN
0x1016276c	0x00000000	0	0	0.0.0.0:179	0.0.0.0:0	LISTEN
0x1015e304	0x00000000	0	0	0.0.0.0:0	0.0.0.0:0	CLOSED

TCP Resources

TCP connections parameters

```
RP/0/RSP0/CPU0:rasr9000-2w-a#show tcp detail pcb 0x10182b38
Wed Dec 11 22:47:18.708 EST
```

```
=====
Connection state is ESTAB, I/O status: 0, socket status: 0
Established at Thu Dec 5 04:13:28 2013
```

```
PCB 0x10182b38, SO 0x10182968, TCPCB 0x101cc2b4, vrfid
0x60000000,
Pak Prio: Medium, TOS: 192, TTL: 255, Hash index: 717
Local host: 10.101.111.1, Local port: 179 (Local App PID:
287053)
Foreign host: 10.100.103.1, Foreign port: 59214
```

```
Current send queue size in bytes: 0 (max 24576)
Current receive queue size in bytes: 0 (max 32768) mis-
ordered: 0 bytes
Current receive queue size in packets: 0 (max 0)
```

Timer	Starts	Wakeups	Next(msec)
Retrans	9789	0	0
SendWnd	0	0	0
TimeWait	0	0	0
AckHold	9817	9605	0
KeepAlive	1	0	0
PmtuAger	0	0	0
GiveUp	0	0	0
Throttle	0	0	0

```
iss: 2038437204 snduna: 2038628753 sndnxt: 2038628753
sndmax: 2038628753 sndwnd: 31856 sndcwnd: 3648
irs: 2495655735 rcvnxt: 2495854116 rcvwnd: 31894
rcvadv: 2495886010
```

```
SRTT: 217 ms, RTTO: 300 ms, RTV: 11 ms, KRTT: 0 ms
minRTT: 1 ms, maxRTT: 289 ms
```

```
ACK hold time: 200 ms, Keepalive time: 0 sec, SYN waittime: 30
sec
Giveup time: 0 ms, Retransmission retries: 0, Retransmit
forever: FALSE
Connect retries remaining: 0, connect retry interval: 0 secs
```

```
State flags: none
Feature flags: MD5, Win Scale, Nagle
Request flags: Win Scale
```

```
Datagrams (in bytes): MSS 1216, peer MSS 1216, min MSS 1240,
max MSS 1240
```

```
Window scales: rcv 0, snd 0, request rcv 0, request snd 0
Timestamp option: recent 0, recent age 0, last ACK sent 0
Sack blocks {start, end}: none
Sack holes {start, end, dups, rxmit}: none
Socket options: SO_REUSEADDR, SO_REUSEPORT, SO_NBIO
Socket states: SS_ISCONNECTED, SS_PRIV
Socket receive buffer states: SB_DEL_WAKEUP
Socket send buffer states: SB_DEL_WAKEUP
Socket receive buffer: Low/High watermark 1/32768
Socket send buffer : Low/High watermark 2048/24576, Notify
threshold 0
```

```
PDU information:
#PDU's in buffer: 0
FIB Lookup Cache: IFH: 0x134e0 PD ctx: size: 8 data: 0x0
0xb1494a74
Num Labels: 0 Label Stack:
```

A decorative header element consisting of a repeating pattern of orange vertical bars and dots, resembling the Cisco logo.

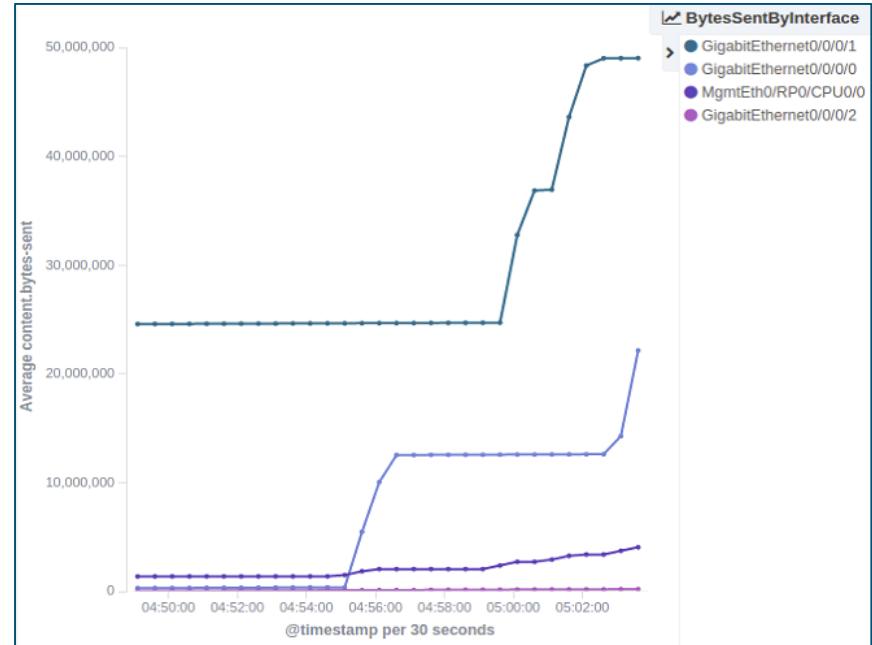
Troubleshooting: Forwarding Path

Telemetry

Streaming YANG model telemetry (push subscription model)

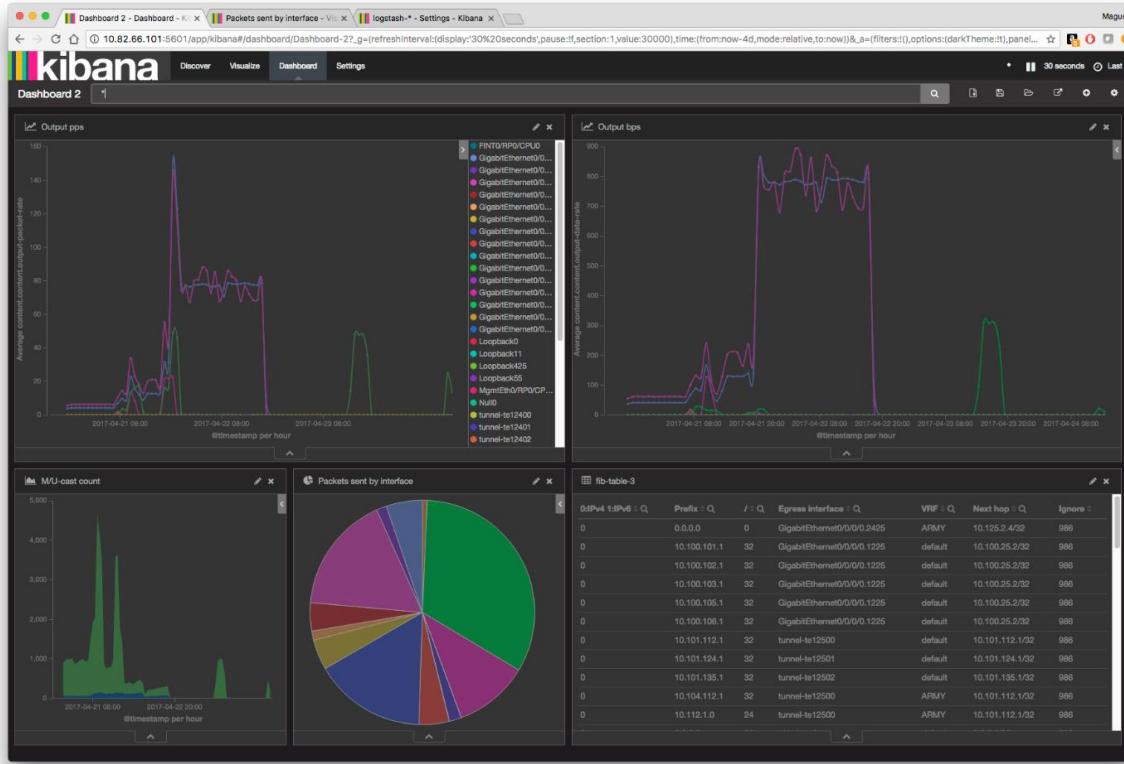
```
RP/0/RP0/CPU0:PE125#show running-config telemetry
model-driven
Tue Feb 14 13:06:18.261 UTC
telemetry model-driven
destination-group COLL1
address family ipv4 192.168.30.101 port 2103
encoding self-describing-gpb
protocol tcp
!
!
sensor-group YD1
sensor-path Cisco-IOS-XR-infra-statsd-oper:infra-
statistics/interfaces/interface/latest/generic-counters
!
subscription SUB1
sensor-group-id YD1 sample-interval 60000
destination-id COLL1
!
```

YANG sub-tree



Telemetry

Build your own dashboard



Monitor Interface

See interface stats in almost real time

```
RP/0/RSP0/CPU0:rasr9000-2w-b#monitor interface tenGigE 0/1/1/1
```

```
rasr9000-2w-b          Monitor Time: 00:00:22          SysUptime: 501:59:18
```

```
TenGigE0/1/1/1 is up, line protocol is up  
Encapsulation ARPA
```

```
Traffic Stats:(2 second rates)
```

		Delta
Input Packets:	2495245669613	14890408
Input pps:	7441113	
Input Bytes:	164703177204108	982758522
Input Kbps (rate):	3928857	(39%)
Output Packets:	3017277633655	13261227
Output pps:	6626897	
Output Bytes:	205177835436607	901762428
Output Kbps (rate):	3605031	(36%)

```
Errors Stats:
```

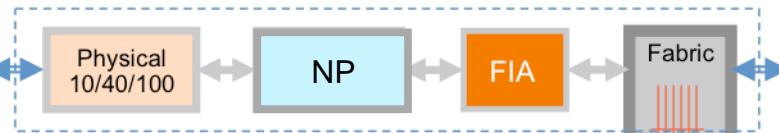
Input Total:	1	0
Input CRC:	0	0
Input Frame:	0	0
Input Overrun:	0	0
Output Total:	0	0
Output Underrun:	0	0

```
Quit='q', Freeze='f', Thaw='t', Clear='c', Interface='i',  
Next='n', Prev='p'
```

```
Brief='b', Detail='d', Protocol(IPv4/IPv6)='r'
```

The Physical

Checking on port physical: SFP/XFP, levels



```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers TenGigE 0/0/0/0 phy
Mon Dec  9 13:53:37.848 EST
```

```
SFP EEPROM port: 0
  Xcvr Type: SFP
  Xcvr Code: SFP-10G-SR
  Encoding: 64B66B
  Bit Rate: 10300 Mbps
  Link Reach 50u fiber: 80 meter
  Link Reach 62.5u fiber: 20 meter
  Vendor Name: CISCO-FINISAR
  Vendor OUI: 00.90.65
  Vendor Part Number: FTLX8571D3BCL-C2 (rev.: A    )
  Laser wavelength: 850 nm (fraction: 0.00 nm)
  Optional SFP Signal: Rate Sel, LOS
  Vendor Serial Number: FNS164018G7
  Date Code (yy/mm/dd): 12/10/06 lot code:
```

Thresholds:	Alarm High	Warning High	Warning Low	Alarm Low
Temperature:	+75.000 C	+70.000 C	+0.000 C	-5.000 C
Voltage:	3.630 Volt	3.465 volt	3.135 volt	2.970 volt
Bias:	11.800 mAmps	10.800 mAmps	5.000 mAmps	4.000 mAmps
Transmit Power:	1.479 mw (1.70 dBm)	0.741 mw (-1.30 dBm)	0.186 mw (-7.30 dBm)	0.074 mw (-11.30 dBm)
Receive Power:	1.585 mw (2.00 dBm)	0.794 mw (-1.00 dBm)	0.102 mw (-9.90 dBm)	0.041 mw (-13.90 dBm)
Temperature:	26.684			
Voltage:	3.301 volt			
Tx Bias:	7.612 mAmps			
Tx Power:	0.613 mw (-2.13 dBm)			
Rx Power:	0.567 mw (-2.46 dBm)			
Oper. Status/Control:				

The Physical

Reading the controller counters: In, out, invalid, unicast, mcast, frame sizes

```
RP/0/RSP0/CPU0:rusr9k-1y#show controllers TenGigE0/4/0/20
```

stats

Sun Feb 24 14:44:18.899 UTC

Statistics for interface TenGigE0/4/0/20 (cached values):

Ingress:

Input total bytes = 3081227904920
Input good bytes = 3081227904920

Input total packets = 23220024479
Input 802.1Q frames = 0
Input pause frames = 0
Input pkts 64 bytes = 7143534733
Input pkts 65-127 bytes = 2888766549
Input pkts 128-255 bytes = 13124923916
Input pkts 256-511 bytes = 62799261
Input pkts 512-1023 bytes = 0
Input pkts 1024-1518 bytes = 0
Input pkts 1519-Max bytes = 0

Input good pkts = 23220024479
Input unicast pkts = 23220023458
Input multicast pkts = 62
Input broadcast pkts = 959

Input drop overrun = 0

Egress:

Output total bytes = 1345771624
Output good bytes = 1345771624

Output total packets = 21895707
Output 802.1Q frames = 0
Output pause frames = 0
Output pkts 64 bytes = 21665536
Output pkts 65-127 bytes = 21179
Output pkts 128-255 bytes = 168767
Output pkts 256-511 bytes = 40225
Output pkts 512-1023 bytes = 0
Output pkts 1024-1518 bytes = 0
Output pkts 1519-Max bytes = 0

Output good pkts = 21895707
Output unicast pkts = 21870499
Output multicast pkts = 25195
Output broadcast pkts = 13

Output drop underrun = 0
Output drop abort = 0
Output drop other = 0

Output error other = 0

Interface Programming in Hardware

Example L3 VLAN sub-interface

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show ethernet hardware  
interface TenGigE 0/0/0/2.200 location 0/0/CPU0
```

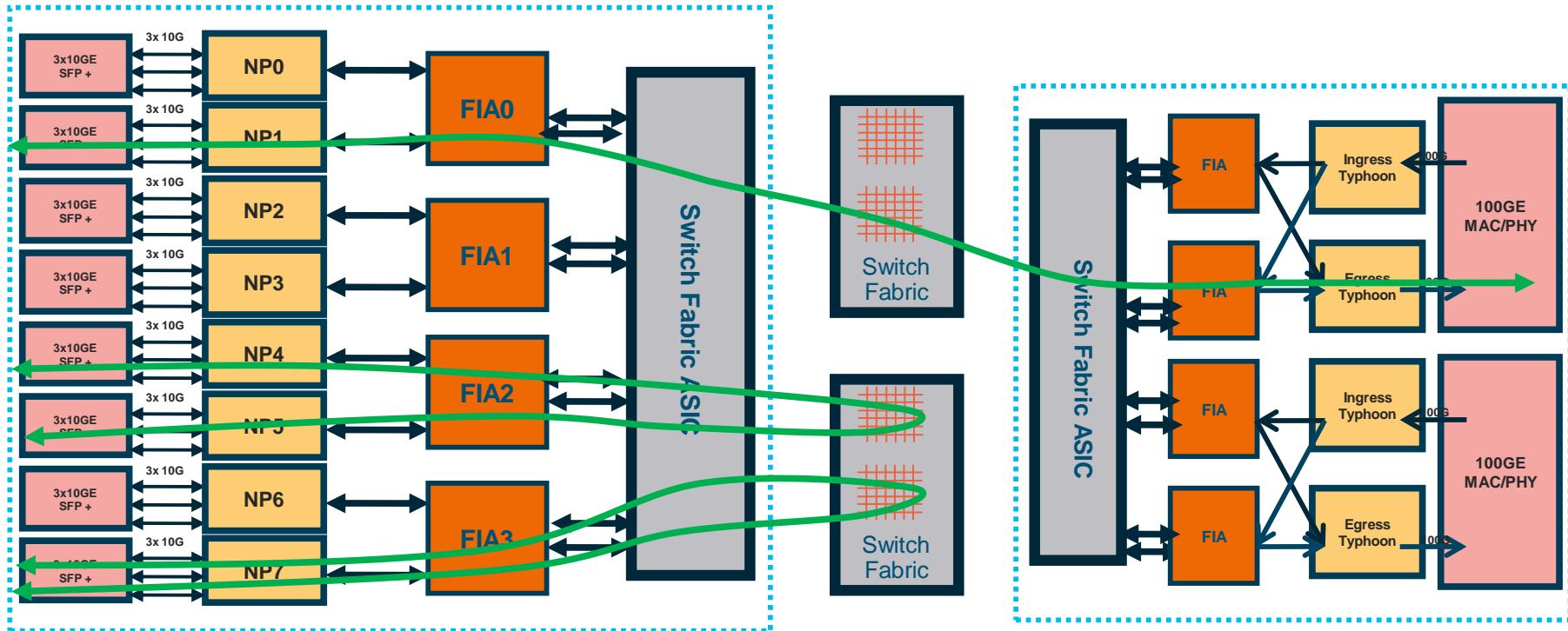
Tue Jan 21 21:45:18.351 EST

```
Physical port : 2  
Interface name : TenGigE0/0/0/2.200  
Ifhandle : 0x040012C0  
Parent Ifhandle : 0x04000140  
Status : Init|Mem|Alloc|TShm|Pgm  
TCAM entries : 1  
TCAM entry type : Single tag exact  
Channel ID : 0  
PI policy validity : 0x0  
NP port : 4  
NP map (previous) : 0x0 (0x0)  
idb pointer : 0x5002b570  
Admin mode : 1 (Up)  
Interface state : 1 (Up)  
Interface type : 3 (L3 Sub-if over Physical)  
tunn_ovrd_mode : QnQ Child /w no parent  
tunneling ethertype set  
Ingress UIDB index : 29  
Egress UIDB index : 29  
TCAM key status: 0x404 index: 0  
TCAM 0 address: 0x23880  
TCAM 1 address: 0x0  
TCAM 2 address: 0x0
```

```
.  
..... TCAM entry 0 (uncompressed logical)  
.....  
Port Number : mask=0xFFFF value=0x0004(4)  
validity Bits:  
    validity1: mask=1 value=1  
    validity2: mask=1 value=0  
    validity3: mask=0 value=0  
    isid_valid: mask=0 value=0  
Tag 1 :  
    ethertype: mask=0xFFFF value=0x8100  
    VLAN id : mask=0x0FFF value=0x00C8(200)  
Tag 2 :  
    ethertype: mask=0x0000 value=0x0000  
    VLAN id : mask=0x0000 value=0x0000(0)  
Source MAC :  
    mask : 0000.0000.0000  
    value : 0000.0000.0000  
..... TCAM entry 0 (2nd gen physical)  
.....  
TCAM mask:  
  FC FF 00 00 FF FF FF FF FF FF 00 F0  
  FF 00 00 BB BB BB  
TCAM value:  
  01 00 00 81 00 00 00 00 00 00 00 C8 00  
  00 04 00 00 00 00 00
```

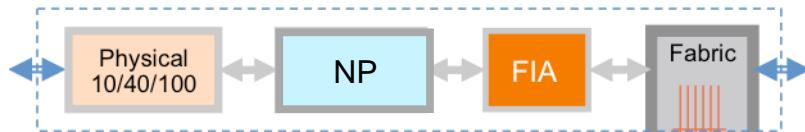
Unicast Transit Frame Path

Physical > NP > FIA > Fabric > FIA > NP > Physical



The Internal Path

Mapping the port to NP and FIA



! Example: Path from GigabitEthernet0/0/1/0 192.3.1.2 TO TenGigE0/4/0/20.6 192.6.1.2

RP/0/RSP0/CPU0:rasr9k-1y#show controllers NP ports all location 0/0/CPU0

Fri Feb 22 15:57:32.307 UTC
Node: 0/0/CPU0:

NP	Bridge	Fia	Ports
0	--	0	TenGigE0/0/0/0, TenGigE0/0/0/1, TenGigE0/0/0/2, TenGigE0/0/0/3
1	--	1	GigabitEthernet0/0/1/0 - GigabitEthernet0/0/1/19

RP/0/RSP0/CPU0:rasr9k-1y#show controllers NP ports all location 0/4/CPU0

Fri Feb 22 15:55:22.370 UTC
Node: 0/4/CPU0:

NP	Bridge	Fia	Ports
0	--	0	TenGigE0/4/0/0, TenGigE0/4/0/1, TenGigE0/4/0/2
1	--	0	TenGigE0/4/0/3, TenGigE0/4/0/4, TenGigE0/4/0/5
2	--	1	TenGigE0/4/0/6, TenGigE0/4/0/7, TenGigE0/4/0/8
3	--	1	TenGigE0/4/0/9, TenGigE0/4/0/10, TenGigE0/4/0/11
4	--	2	TenGigE0/4/0/12, TenGigE0/4/0/13, TenGigE0/4/0/14
5	--	2	TenGigE0/4/0/15, TenGigE0/4/0/16, TenGigE0/4/0/17
6	--	3	TenGigE0/4/0/18, TenGigE0/4/0/19, TenGigE0/4/0/20
7	--	3	TenGigE0/4/0/21, TenGigE0/4/0/22, TenGigE0/4/0/23

Map the port to NP
and FIA

Inside a Network Processor

Reading pipeline counters



```
RP/0/RSP0/CPU0:rusr9000-2w-a#show controllers NP counters np0 location 0/1/CPU0
Wed Nov 27 21:09:07.635 EST
```

Node: 0/1/CPU0:

Show global stats counters for NP0, revision v2

Read 64 non-zero NP counters:

Offset Counter

Offset	Counter	Value	Rate (pps)
16	MDF_TX_LC_CPU	6722114	10
17	MDF_TX_WIRE	1826039	3
21	MDF_TX_FABRIC	1635541	2
29	PARSE_FAB_RECEIVE_CNT	1837406	3
33	PARSE_INTR_RECEIVE_CNT	5083364	7
37	PARSE_INJ_RECEIVE_CNT	1228130	2
499	RSV_ING_L2_SMAC_MISS	60	0
502	RSV_ING_L2_LEARN	60	0
541	RSV_REFRESH_FROM_NOTIFY_CNT	62	0
584	RSV_L2BC_BVI	2	0
604	RESOLVE_REMOTE_RACK_PREP_CNT	5539915	8
708	LRN_PERIODIC_AGING_DELETE_ENTRY	60	0
774	ARP	119	0
848	PUNT_ADJ	2	0
852	PUNT_ACL_DENY	161	0
900	PUNT_STATISTICS	5083356	7
902	PUNT_DIAGS_RSP_ACT	11419	0
904	PUNT_DIAGS_RSP_STBY	11427	0

Description of NP counters:
show controllers np descriptions location <location>

NP Counters and Rates

Example: Ingress NP, no drops



```
RP/0/RSP0/CPU0:rusr9000-2w-b#show controllers NP counters np0 location 0/0/CPU0
Mon Dec  9 15:16:34.889 EST
```

```
Node: 0/0/CPU0:
```

```
Show global stats counters for NP0, revision v2
```

```
Read 59 non-zero NP counters:
```

Offset	Counter	FrameValue	Rate (pps)
16	MDF_TX_LC_CPU	10255120	8
17	MDF_TX_WTRF	6382883323428	1
21	MDF_TX_FABRIC	8903307706961	31250074
29	PARSE_FAB_RECEIVE_CNT	6382883151049	0
33	PARSE_INTR_RECEIVE_CNT	8653828	8
37	PARSE_TN1_RECVTF_CNT	744943	1
41	PARSE_ENET_RECEIVE_CNT	8910925981070	31250074
45	PARSE_TM_LOOP_RECEIVE_CNT	8035316	5
49	PARSE_TOP_LOOP_RECEIVE_CNT	61	0
57	PARSE_ING_DISCARD	2344591	0
195	PRS_HEALTH_MON	8035316	5
204	INTR_FRAME_TYPE_7	8653827	8
214	DBG_PRS_EP_L_PRS_VPLS_PW_IMPOSE	10	0
233	PARSE_RSP_INJ_FAB_CNT	70634	0
235	PARSE_RSP_INJ_DIAGS_CNT	55255	0
236	PARSE_EGR_INJ_PKT_TYP_UNKNOWN	66847	0
237	PARSE_EGR_INJ_PKT_TYP_IPV4	3787	0
246	PARSE_LC_INJ_FAB_CNT	101092	0

To FIA

From Phy

NP Counters and Rates

NP drops, rates and direction



```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP counters np0 location 0/0/CPU0
Tue Dec 10 14:18:39.195 EST
```

Node: 0/0/CPU0:

Show global stats counters for NP0, revision v2

Read 59 non-zero NP counters:

Offset Counter

Offset	Counter	Frame	Value	Rate (pps)
16	MDF_TX_LC_CPU		11004363	9
17	MDF_TX_WIRE		8712222364719	29761820
21	MDF_TX_FABRIC		11063035007386	27714366
29	PARSE_FAB_RECEIVE_CNT		8712222113330	29761820
33	PARSE_INTR_RECEIVE_CNT		9401470	9
37	PARSE_INJ_RECEIVE_CNT		832185	1
41	PARSE_ENET_RECEIVE_CNT		11070653296959	27714366
45	PARSE_TM_LOOP_RECEIVE_CNT		8437075	5
359	PARSE_MAC_NOTIFY_RCV		183	0
367	PARSE_FAST_DISCARD_LOW_PRIORITY_DROP_0		106211394050	883832
368	PARSE_FAST_DISCARD_LOW_PRIORITY_DROP_1		106210662138	883856
369	PARSE_FAST_DISCARD_LOW_PRIORITY_DROP_2		106211061617	883943
370	PARSE_FAST_DISCARD_LOW_PRIORITY_DROP_3		106211474043	883922
373	DBG_RSV_EP_L_RSV_ING_L3_IFIB		3707021673	0
830	PUNT_NO_MATCH		4746	0
831	PUNT_NO_MATCH_EXCD		464963896	0
849	PUNT_ADJ_EXCD		273406	0
852	PUNT_ACL_DENY		1479378	0
853	PUNT_ACL_DENY_EXCD		1163570900	0

To egress

To fabric

From fabric

From interface

Typhoon NP catching up

NP Counters and Rates

NP drops



```
RP/0/RSP0/CPU0:ASR9006-2w-a.PE2#show drops np np0 location 0/1/CPU0
Thu Jul 7 16:53:34.665 EDT
```

Node: 0/1/CPU0:

NP 0 Drops:

RSV_DROP_IN_L3_NOT_MYMAC	136912
MODIFY_PUNT_REASON_MISS_DROP	2
PARSE_EGR_INJ_PKT_TYP_UNKNOWN	4042
PARSE_DROP_IN_UIDB_TCAM_MISS	60081
PARSE_DROP_IN_UIDB_DOWN	15
PARSE_DROP_IPV4_MCAST_NOT_ENABLED	331791
UNKNOWN_L2_ON_L3_DISCARD	341153

```
RP/0/RSP0/CPU0:ASR9006-2w-a.PE2#
```

NP Counters and Rates

Per (sub)interface NP drop counters



```
RP/0/RSP0/CPU0:ASR9006-2w-a.PE2#monitor np interface TenGigE 0/0/0/1 count 3 time 10 location 0/0/CPU0  
Thu Jul 7 04:49:13.840 EDT
```

Monitor NP counters of TenGigE0_0_0_1 for 30 sec

**** Thu Jul 7 04:49:24 2016 ****

Monitor 0 non-zero NP0 counter: TenGigE0_0_0_1

Offset Counter

1171 MDF_PUNT_POLICE_DROP

(Count 1 of 3)

FrameValue

Rate (pps)

7924962277743

21

Non-intrusive

Monitor 0 non-zero NP0 counter: TenGigE0_0_0_1

Offset Counter

1171 MDF_PUNT_POLICE_DROP

(Count 2 of 3)

FrameValue

Rate (pps)

7924962277933

19

Total per interface

Monitor 0 non-zero NP0 counter: TenGigE0_0_0_1

Offset Counter

1171 MDF_PUNT_POLICE_DROP

(Count 3 of 3)

FrameValue

Rate (pps)

7924962278163

23

Rate since last read
[10 seconds]

```
RP/0/RSP0/CPU0:ASR9006-2w-a.PE2#
```

NP Counters and Rates

Decoding dropped frames



```
RP/0/RSP0/CPU0:ASR9006-2w-a.PE2#show controllers np capture np0 location 0/0/CPU0
Thu Jul 7 05:38:27.686 EDT
```

NP0 capture buffer has seen 8 packets - displaying 8

```
Sun Jul 03 20:51:59.414 : PARSE_DROP_IN_UIDB_DOWN
  From TenGigE0_0_0_1: 64 byte packet on NP0
0000: ff ff ff ff ff ff 10 f3 11 36 6a 04 08 06 00 01
0010: 08 00 06 04 00 02 10 f3 11 36 6a 04 0a 01 02 01
0020: ff ff ff ff ff ff 0a 01 02 01 00 00 00 00 00 00
0030: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

Sun Jul 03 20:51:59.410 : PARSE_DROP_IN_UIDB_DOWN
  From TenGigE0_0_0_1: 253 byte packet on NP0
0000: 01 00 0c cc cc cc 10 f3 11 36 6a 04 00 eb aa aa
0010: 03 00 00 0c 20 00 02 b4 de 09 00 01 00 1c 41 53
0020: 52 39 30 30 31 2d 53 2d 32 59 2d 41 2e 63 69 73
0030: 63 6f 2e 63 6f 6d 00 03 00 12 54 65 6e 47 69 67
0040: 45 30 2f 30 2f 32 2f 30 00 02 00 11 00 00 00 01
0050: 01 01 cc 00 04 0a 01 02 01 00 04 00 08 00 00 00
0060: 01 00 05 00 5b 43 69 73 63 6f 20 49 4f 53 20 58
0070: 52 20 53 6f 66 74 77 61 72 65 2c 20 56 65 72 73
0080: 69 6f 6e 20 35 2e 33 2e 33 5b 44 65 66 61 75 6c
0090: 74 5d 0a 43 6f 70 79 72 69 67 68 74 20 28 63 29
00a0: 20 32 30 31 36 20 62 79 20 43 69 73 63 6f 20 53
00b0: 79 73 74 65 6d 73 2c 20 49 6e 63 2e 00 06 00 16
00c0: 63 69 73 63 6f 20 41 53 52 39 4b 20 53 65 72 69
00d0: 65 73 00 0a 00 06 00 00 00 0b 00 05 01 00 14 00
00e0: 1c 41 53 52 39 30 30 31 6d 39 f5 78 be fd 07 00
.
```



Filter out drops of no interest:

```
sh controllers np capture np1 filter ...
```

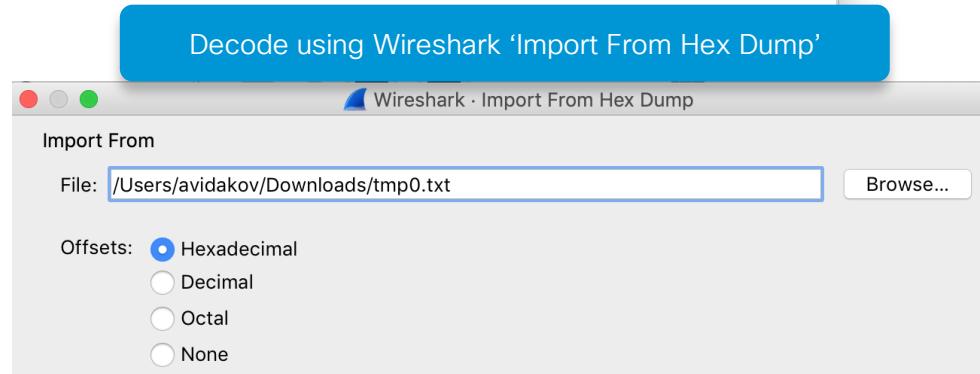
NP Counters and Rates

Decoding dropped frames



- ▶ Frame 1: 160 bytes on wire (1280 bits), 160 bytes captured (1280 bits)
- ▶ IEEE 802.3 Ethernet
- ▶ Logical-Link Control
- ▼ Cisco Discovery Protocol
 - Version: 2
 - TTL: 180 seconds
- ▶ Checksum: 0xde09 [incorrect, should be 0xe54e]
- ▼ Device ID: ASR9001-S-2Y-A.cisco.com
 - Type: Device ID (0x0001)
 - Length: 28
 - Device ID: ASR9001-S-2Y-A.cisco.com
- ▶ Port ID: TenGigE0/0/2/0
- ▼ Addresses
 - Type: Addresses (0x0002)
 - Length: 17
 - Number of addresses: 1
 - ▶ IP address: 10.1.2.1
- ▶ Capabilities
- ▼ Software Version
 - Type: Software version (0x0005)
 - Length: 91
 - Software version: Cisco IOS XR Software, Version 5.3.3[Default]

Decode using Wireshark 'Import From Hex Dump'



NP Counters and Rates

Traffic Manager drops



```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP tm counters np1 location 0/0/CPU0
Tue Dec 10 14:40:47.210 EST
```

Node: 0/0/CPU0:

==== TM Counters (NP 1 TM 0) ====

TM Counters:
xmt paks: 897837659243, xmt bytes: 62718673698431
drop paks: 29447137293, drop_bytes: 2002405351616

```
RP/0/RSP0/CPU0:rasr9000-2w-b#
```

```
RP/0/RSP0/CPU0:rasr9000-2w-b#
```

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP tm counters np1 location 0/0/CPU0
```

Tue Dec 10 14:40:49.816 EST

Node: 0/0/CPU0:

==== TM Counters (NP 1 TM 0) ====

TM Counters:
xmt paks: 897909308598, xmt bytes: 62723686013270
drop paks: 29466027670, drop_bytes: 2003689898884

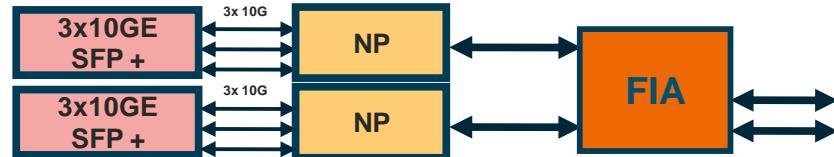
FIA Counters

FIA counts, drops and direction

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers fabric  
fia instance 0 stats location 0/0/CPU0
```

Tue Dec 10 14:49:58.704 EST

```
***** FIA-0 *****  
Category: count-0  
From Unicast Xbar[0] 733461306331  
From Unicast Xbar[1] 733460650405  
From Unicast Xbar[2] 0  
From Unicast Xbar[3] 0  
From MultiCast Xbar[0] 233068  
From MultiCast Xbar[1] 0  
From MultiCast Xbar[2] 0  
From MultiCast Xbar[3] 0  
    To Unicast Xbar[0] 933450146675  
    To Unicast Xbar[1] 932066610046  
    To Unicast Xbar[2] 0  
    To Unicast Xbar[3] 0  
    To MultiCast Xbar[0] 451799  
    To MultiCast Xbar[1] 0  
    To MultiCast Xbar[2] 0  
    To MultiCast Xbar[3] 0  
    To Line Interface[0] 8759312354291  
    To Line Interface[1] 457138023968  
From Line Interface[0] 11117127781061  
From Line Interface[1] 489302108080  
Ingress drop: 97191712670  
Egress drop: 0  
Total drop: 97191712670
```



```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers fabric fia  
instance 0 drops ingress location 0/0/CPU0
```

Tue Dec 10 15:33:37.655 EST

```
***** FIA-0 *****  
Category: in_drop-0  
From Spau1 Drop-0 0  
    acpt tbl-0 0  
    ctl len-0 0  
    short pkt-0 0  
    max pkt len-0 0  
    min pkt len-0 0  
From Spau1 Drop-1 0  
    acpt tbl-1 0  
    ctl len-1 0  
    short pkt-1 0  
    max pkt len-1 0  
    min pkt len-1 0  
    Tail drp 125787328841  
    Vqi drp 0  
Header parsing drp 0  
    pw to ni drp 0  
    ni from pw drp 0  
        sp0 crc err 0  
        sp0 bad align 0  
        sp0 bad code 0  
sp0 align fail 3  
    sp0 prot err 0  
        sp1 crc err 0  
        sp1 bad align 0
```

Back pressure
from egress NP

Line Card Drops

All drops for all reasons on a line card

```
RP/0/RSP0/CPU0:ASR9006-2w-a.PE2#show drops all  
location 0/1/CPU0
```

```
Thu Jul  7 17:04:12.291 EDT
```

```
=====  
Checking for drops on 0/1/CPU0  
=====
```

```
show arp traffic:  
[arp:ARP] IP Packet drop count for node 0/1/CPU0: 1
```

```
show cef drops:  
[cef:0/1/CPU0] Discard drops      packets : 15
```

```
show controllers fabric fia drops ingress:
```

```
[fabric:FIA-0] sp0 crc err: 9  
[fabric:FIA-0] sp0 align fail: 3  
[fabric:FIA-0] sp1 align fail: 3  
[fabric:FIA-1] sp0 align fail: 3  
[fabric:FIA-1] sp1 crc err: 14  
[fabric:FIA-1] sp1 bad code: 14  
[fabric:FIA-1] sp1 align fail: 3  
[fabric:FIA-1] sp1 prot err: 1
```

```
show netio drops:  
[netio:Interface: GigabitEthernet0/1/0/10]  
/pkg/lib/libip4_fib_switch.dll: 4043  
[netio:Interface: GigabitEthernet0/1/0/10]  
packet_null_action: 305
```

```
show controller np counters:  
[np:NPO] RSV_DROP_IN_L3_NOT_MYMAC: 137015  
[np:NPO] MODIFY_PUNT_REASON_MISS_DROP: 2  
[np:NPO] PARSE_DROP_IN_UIDB_TCAM_MISS: 60198  
[np:NPO] PARSE_DROP_IN_UIDB_DOWN: 15  
[np:NPO] PARSE_DROP_IPV4_MCAST_NOT_ENABLED: 332431  
[np:NPO] UNKNOWN_L2_ON_L3_DISCARD: 341810  
[np:NP1] MODIFY_PUNT_REASON_MISS_DROP: 3
```

```
show spp node-counters:  
[spp:port4/classify] Dropped due to unknown SID: 164862  
[spp:port4/classify] Invalid: logged n dropped: 1
```

Line Card Drops

Modifying the "show drops all" template

Example: include drops from "show controllers np fast-drop" command in the output of the "show drops all" command

Step 1: Copy the /pkg/etc/packet_drops.list file to /disk0a:/usr/

```
run  
cd /pkg/etc  
cp packet_drops.list /disk0a:/usr/  
exit
```

Step 2: Edit the file offline or on the router using the 'vim' editor in the shell.

```
run  
vim /disk0a:/usr/packet_drops.list  
exit
```

Step 3: Add this sequence to the end of the '#NP' section of the packet_drops.list file:

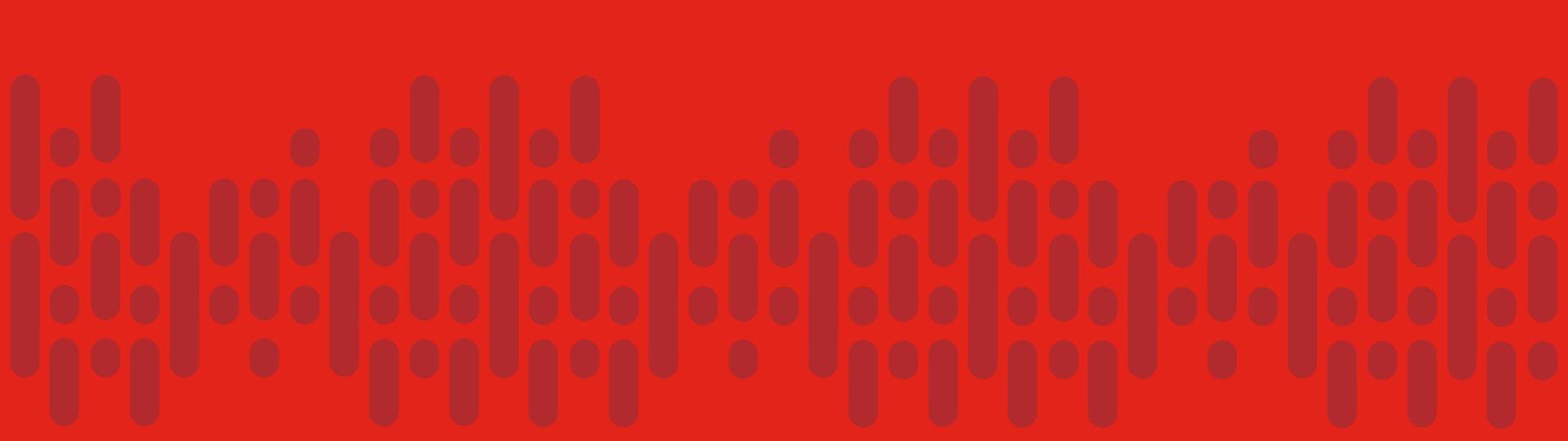
```
[commandstart]  
cmd_name = show controller np fast-drop  
cmd_exec = prm_np_show fast-drop -s $location  
module = np  
group = ^.*Show NP EFD stats counters for (NP\d),  
default_group = ERROR!! - Group not found!!  
drop_regex1 = ^\s*(\S+Priority[0-9]\S)\s+(\d+)  
[commandend]
```

Step 4: Verify the command works as expected by using the 'self-test' option:

```
sh drops all self-test location <location> | b fast-  
drop
```

You should see in the output everything except the lines that are matching the drop_regex1 pattern. Compare this to the output of:

```
sh controllers np fast-drop all location <location>
```



Troubleshooting: Packet Capture

Packet Capture: Problem Packets

Example: incrementing drops



```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP counters np0 Location 0/0/CPU0 | include DROP  
Sat Jan 18 18:46:52.618 EST
```

370	RSV_DROP_XID_NO_MATCH	209680463	0
404	RSV_ING_VPWS_ERR_DROP	3719838164404	11160601
411	RSV_L2_SHG_DROP	27390624	0
1171	MDF_PUNT_POLICE_DROP	7924962278163	23809032
1178	MODIFY_PUNT_REASON_MISS_DROP	1	0
1246	VIRTUAL_IF_GENERIC_INPUT_DROP	1	0

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP counters np0 Location 0/0/CPU0 | include DROP  
Sat Jan 18 18:46:56.297 EST
```

370	RSV_DROP_XID_NO_MATCH	209680463	0
404	RSV_ING_VPWS_ERR_DROP	3719879236984	11161027
411	RSV_L2_SHG_DROP	27390624	0
1171	MDF_PUNT_POLICE_DROP	7925049898728	23809936
1178	MODIFY_PUNT_REASON_MISS_DROP	1	0
1246	VIRTUAL_IF_GENERIC_INPUT_DROP	1	0

incrementing

Rate [PPS] or
increments from
last command run

Packet Capture: Problem Packets

Example: incrementing drops



```
RP/0/RSP0/CPU0:rasr9000-2w-b#monitor np counter RSV_ING_VPWS_ERR_DROP np0 count 3 location  
0/0/CPU0
```

Sat Jan 18 19:02:36.386 EST

Warning: Every packet captured will be dropped! If you use the 'count' option to capture multiple protocol packets, this could disrupt protocol sessions (eg, OSPF session flap). So if capturing protocol packets, capture only 1 at a time.

Warning: A mandatory NP reset will be done after monitor to clean up. This will cause ~50ms traffic outage. Links will stay Up.

Proceed y/n [y] >



Packet Capture: Problem Packets

Example: incrementing drops



```
RP/0/RSP0/CPU0:rasr9000-2w-b#monitor np counter RSV_ING_VPWS_ERR_DROP np0 count 3 location  
0/0/CPU0
```

Sat Jan 18 19:02:36.386 EST

Warning: Every packet captured will be dropped! If you use the 'count' option to capture multiple protocol packets, this could disrupt protocol sessions (eg, OSPF session flap). So if capturing protocol packets, capture only 1 at a time.

Warning: A mandatory NP reset will be done after monitor to clean up. This will cause ~50ms traffic outage. Links will stay down.

Proceed y/n [y] >

Monitor RSV_ING_VPWS_ERR_DROP on NPO ... (Ctrl-C to quit)

Sat Jan 18 19:02:44 2014 -- NPO packet

From TenGigE0/0/0/0: 157 byte packet, bytes[0-3] invalid!

```
0000: 00 00 02 01 61 90 00 00 c0 02 01 02 81 00 00 0a  . . . a . . @ .  
0010: 08 00 45 00 00 8b 00 00 00 00 40 3d f8 30 c0 01  . E . . . @=x0@.  
0020: 01 01 c0 01 01 02 00 00 00 00 00 00 00 00 00 00  . @ .  
0030: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  . . . .  
0040: 10 f3 11 05 00 00 00 00 00 00 00 00 00 00 00 00  . . . .  
0050: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  . . . .  
0060: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  . . . .  
0070: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  . . . .  
0080: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  . . . .  
0090: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  . . . .
```

Ignore
[internal]



UP to 300 B
No CRC



Packet Capture: Problem Packets

Example: incrementing drops



```
From TenGigE0/0/0/0: 234 byte packet, bytes[0-3] invalid!
0000: 00 00 02 01 61 90 00 00 c0 02 01 02 81 00 00 0a  ....a...@.....
0010: 08 00 45 00 00 d8 00 00 00 00 40 3d f7 e3 c0 01  ..E..X...@=wc@.
0020: 01 01 c0 01 01 02 00 00 00 00 00 00 00 00 00 00 00  ..@.....
0030: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0040: 10 f3 11 05 00 00 00 00 00 00 00 00 00 00 00 00 00 00  .s.....
0050: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0060: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0070: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0080: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0090: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00a0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00b0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00c0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00d0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00e0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

(count 3 of 3)

Cleanup: Confirm NP reset now (~50ms traffic outage).

Ready? [y] >

RP/0/RSP0/CPU0:rasr9000-2w-b#



Packet Capture: Problem Packets

Decoding



```
00 00 02 01 61 90 00 00 c0 02 01 02 81 00 00 0a  
08 00 45 00 00 8b 00 00 00 00 40 3d f8 30 c0 01  
01 01 c0 01 01 02 00 00 00 00 00 00 00 00 00 00  
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
10 f3 11 05 00 00 00 00 00 00 00 00 00 00 00 00  
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

Decode using Wireshark 'Import From Hex Dump'

```
Ethernet II, Src: WesternD_02:01:02 (00:00:c0:02:01:02), Dst: Xerox_01:61:90 (00:00:02:01:61:90)  
  Destination: Xerox_01:61:90 (00:00:02:01:61:90)  
  Source: WesternD_02:01:02 (00:00:c0:02:01:02)  
  Type: 802.1Q Virtual LAN (0x8100)  
802.1Q Virtual LAN, PRI: 0, CFI: 0, ID: 10  
  000. .... .... = Priority: 0  
  ...0 .... .... = CFI: 0  
  .... 0000 0000 1010 = ID: 10  
  Type: IP (0x0800)  
Internet Protocol, Src: 192.1.1.1 (192.1.1.1), Dst: 192.1.1.2 (192.1.1.2)  
  Version: 4  
  Header length: 20 bytes  
  Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00)  
  Total Length: 139
```

Packet Capture: Transit Packets

Example: IPv4 L3VPN ingress

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show running-config ipv4 access-list CAPTURE
```

```
Sat Jan 18 20:13:35.941 EST
```

```
ipv4 access-list CAPTURE
```

```
10 permit ipv4 192.4.1.0/24 10.10.6.0/24 capture
```

```
20 permit ipv4 any any
```

```
!
```

Count in NP

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show running-config interface TenGigE 0/0/0/2
```

```
Sat Jan 18 20:13:50.654 EST
```

```
interface TenGigE0/0/0/2
```

```
vrf TRAFFIC
```

```
ipv4 address 192.4.1.1 255.255.255.0
```

```
ipv4 access-group CAPTURE ingress
```

```
!
```

Let all else go!

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP counters np0 location 0/0/CPU0 | include  
ACL_CAPTURE_NO_SPAN
```

```
Sat Jan 18 20:14:26.109 EST
```

```
477 ACL_CAPTURE_NO_SPAN
```

6802507

38003

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP counters np0 location 0/0/CPU0 | include  
ACL_CAPTURE_NO_SPAN
```

```
Sat Jan 18 20:14:28.819 EST
```

```
477 ACL_CAPTURE_NO_SPAN
```

6905417

380

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP counters np0 location 0/0/CPU0 | include  
ACL_CAPTURE_NO_SPAN
```

```
Sat Jan 18 20:14:34.597 EST
```

```
477 ACL_CAPTURE_NO_SPAN
```

7124969

37991

NP ACL "capture"
counter
incrementing

Packet Capture: Transit Packets

Example: IPv4 L3VPN ingress

```
RP/0/RSP0/CPU0:rasr9000-2w-b#monitor np counter ACL_CAPTURE_NO_SPAN np0 count 3 location 0/0/CPU0  
Sat Jan 18 20:31:53.311 EST
```

Warning: Every packet captured will be dropped! If you use the 'count' option to capture multiple protocol packets, this could disrupt protocol sessions (eg, OSPF session flap). So if capturing protocol packets, capture only 1 at a time.

Warning: A mandatory NP reset will be done after monitor to clean up. This will cause ~50ms traffic outage. Links will stay Up.

Proceed y/n [y] >



Packet Capture: Transit Packets

Example: IPv4 L3VPN ingress

```
RP/0/RSP0/CPU0:rasr9000-2w-b#monitor np counter ACL_CAPTURE_NO_SPAN np0 count 3 location 0/0/CPU0  
Sat Jan 18 20:31:53.311 EST
```

Warning: Every packet captured will be dropped! If you use the 'count' option to capture multiple protocol packets, this could disrupt protocol sessions (eg, OSPF session flap). So if capturing protocol packets, capture only 1 at a time.

Warning: A mandatory NP reset will be done after monitor to clean up. This will cause ~50ms traffic outage. Links will stay Up.

Proceed y/n [y] >

Monitor ACL_CAPTURE_NO_SPAN on NP0 ... (Ctrl-C to quit)

```
Sat Jan 18 20:32:34 2014 -- NPO packet
```

From TenGigE0/0/0/2: 250 byte packet, bytes[0-5] invalid

```
0000: 00 11 0b 00 61 92 00 00 c0 04 01 02 08 00 45 60 .a...@.....E`  
0010: 00 ec 00 00 00 00 40 3d a8 08 c0 04 01 02 0a 0a .]....@=(. @....  
0020: 06 5d 00 00 00 00 00 00 00 00 00 00 00 00 00 00 ..]  
0030: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....  
0040: 10 f3 11 05 00 00 00 00 00 00 00 00 00 00 00 00 .s.....  
0050: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....  
0060: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....  
0070: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....  
0080: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....  
0090: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
```

Those 3 packets
are dropped!



Packet Capture: Transit Packets

Example: IPv4 L3VPN ingress

```
(count 2 of 3)
Sat Jan 18 20:32:36 2014 -- NP0 packet
From TenGigE0/0/0/2: 220 byte packet, bytes[0-3] invalid!
0000: 00 11 0b 00 61 92 00 00 c0 04 01 02 08 00 45 00 . . . a . . @ . . . E .
0010: 00 ce 00 00 00 00 40 3d a8 bc c0 04 01 02 0a 0a . N . . . @ = (<@ . . .
0020: 06 27 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . ' . . . .
0030: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
0040: 10 f3 11 05 00 00 00 00 00 00 00 00 00 00 00 00 . s . . . .
0050: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
0060: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
0070: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
0080: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
0090: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
00a0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
00b0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
00c0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
00d0: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 . . . .
```

(count 3 of 3)

Cleanup: Confirm NP reset now (~50ms traffic outage).
Ready? [y] >

RP/0/RSP0/CPU0:rasr9000-2w-b#

Those 3 packets
were dropped!



Packet Capture: Transit Packets

Decoding the packet

Decode using Wireshark ‘Import From Hex Dump’

```
... Ethernet II, Src: WesternD_04:01:02 (00:00:c0:04:01:02), Dst: Franklin_00:61:92 (00:11:0b:00:61:92)
4 Internet Protocol, Src: 192.4.1.2 (192.4.1.2), Dst: 10.10.6.93 (10.10.6.93)
  Version: 4
  Header length: 20 bytes
  Differentiated Services Field: 0x60 (DSCP 0x18: Class Selector 3; ECN: 0x00)
  Total Length: 236
  Identification: 0x0000 (0)
  Flags: 0x00
  Fragment offset: 0
  Time to live: 64
  Protocol: SHIM6 header (0x3d)
  Header checksum: 0xa888 [correct]
```

We have covered..

- ✓ **System Architecture:** System anatomy and health
- ✓ **Operating System & Configuration:** IOS-XR & configuration models
- ✓ **Control, Management, & Security:** Processing of control & exceptions
- ✓ **Transit Packet/Frame Journey:** Life of L3/L2 unicast/multicast
- ✓ **MPLS Operation:** Processing, forwarding and L3/L2 service operation
- ✓ **Troubleshooting:** Diagnostics, counters, drops, and packet capture

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Thank you





A horizontal sequence of nine stylized lowercase 'i' characters, each composed of a colored dot at the top and a vertical bar below. The colors alternate and include blue, green, orange, and red.

You make **possible**

Glossary

1R2C	One rate two color
2R3C	Two rate 3 color
802.1Q	An IEEE [Institute of Electrical and Electronics Engineers] standard
AAA	Authentication, Authorization, and Accounting
AAL5	ATM Adaptation Layer 5
AC	Attachment Circuit
ACE	Access Control Entry
ACL	Access Control List
ADJ	Adjacency
ARP	Address Resolution Protocol
ASIC	Application-Specific Integrated Circuit
ATM	Asynchronous Transfer Mode
B	Byte
bc	Burst committed
Bcast	Broadcast
BD	Bridge Domain
be	Burst excess
BFD	Bidirectional Forwarding Detection
BGP	Border Gateway Protocol
BPDU	Bridge Protocol Data Unit
CAM	Content Addressable Memory
CBWFQ	Class-Based Weighted Fair Queuing
CDP	Cisco Discovery Protocol
CEF	Cisco Express Forwarding
cir	Committed information rate

CLNS	Connectionless Network Service
CoS	Class of Service
CoPP	Control Plane Policing
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
CSC	Carrier Supporting Carrier
DBUS	Data bus
dCEF	Distributed Cisco Express Forwarding
DB	Database
DDR	Double Data Rate
DFC	Distributed Forwarding Card
DoS	Denial of Service
DRAM	Dynamic Random Access Memory
DSCP	Differentiated Services Code Point
DTP	Dynamic Trunking Protocol
DWDM	Dense Wavelength Division Multiplexing
EFP	Ethernet Flow Point
EIGRP	enhanced Internal Gateway Routing Protocol
ELAM	Embedded Logic Analyzer Module
EOBC	Ethernet Out of Band Channel
EoMPLS	Ethernet over Multiprotocol Label Switching
eq	Equal
ES+	Ethernet Services Plus
FIB	Forwarding Information Base
FPD	Field Programmable Device

Glossary

FPGA	Field Programmable Gate Array
FW	Firmware
Gbits	Gigabits
Gbps	Gigabit per second
GByte	Gigabyte
GE	Gigabit Ethernet
GHz	Gigahertz
GRE	Generic routing Encapsulation
HA	High Availability
HbH	Hop by Hop
HSRP	Hot Standby Router Protocol
H/W	Hardware
H-QoS	Hierarchical Quality of Service
ICMP	Internet Control Message Protocol
ID	Identity
IDS	Intrusion Detection system
IFIB	Internal FIB [Forwarding Information Base]
IOS	Internet Operating system
IP	Internet Protocol
IPCP	IP [Internet Protocol] Control Protocol [Part of PPP]
IPSec	Internet Protocol Security
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
IPV6CP	IPv6 [Internet Protocol version 6] control Protocol [Part of PPP]
ISIS	Intermediate System - Intermediate System [Internal gateway routing protocol]

L2	Layer 2 [OSI Open Systems Interconnection] OR Level 2
L2PT	Layer 2 Protcol Tunneling
L2VPN	Layer 2 VPN [Virtual Private Network]
L3	Layer 3 [OSI Open Systems Interconnection] or Level 3
L4	Layer 4 [OSI Open Systems Interconnection] or Level 4
LACP	Link Aggregation Control Protocol
LAN	Local Area Network
LC	Line Card
LCDBUS	Line Card Data Bus
LCP	Link Control Protocol [Part of PPP]
LCRBU	Line Card Results Bus
LDP	Label Distribution Protocol
LFI	Link Fragment Interleave
LFIB	Label Forwarding Information Base
LLQ	Low Latency Queue
LPTS	Local Packet Transport Services
MAC	Media Access Control
Mbps	Megabits per second
MByte	Megabyte
Mcast	Multicast
MET	Multicast Expansion Table
MHz	Megahertz
MIB	Management Information Base
MIPS	Multiprocessor without Interlock Pipeline Stages
Mod	Modulo

Glossary

Mpps	Megapackets per second
MPLS	Multiprotocol Label Switching
MPLS-TP	Multiprotocol Label Switching - Transport Profile
MPP	Management Plane Protection
MQC	Modular Quality of service Command line interface
MSDP	Multicast Source Discovery Protocol
MSFC	Multilayer Switch Feature Card
MTU	Maximum Transmission Unit
MUX	Multiplexer
NAT	Network Address Translation
ND	Neighbor Discovery [protocol]
NP	Network Processor
NPU	Network Processor Unit
NSF	Non-Stop forwarding
NTP	Network Time Protocol
NVRAM	Non-Volatile Random Access Memory
OSM	Optical Services Module
OSPF	Open Shortest Path First [protocol]
PA	Port Adapter
PAgP	Port Aggregation Protocol
PDU	Protocol Data Unit
PFC	Policy Feature Card
PIFIB	Pre-IFIB [Internal Forwarding Information Base]
PoP	Point of Presence
POS	Packet Over sonet

PPP	Point to Point Protocol
PPS	Packets Per Second
PSIRT	Product Security Incident Reponse Team [Cisco]
PW	Pseudo-Wire
QoS	Quality of Service
RADIUS	Remote Authentication Dial In Service [protocol]
RARP	Reverse ARP [Address Resolution Protocol]
RBUS	Results bus
RIP	Routing Information Protocol
RJ45	An 8 wire wiring standard
RP	Routing Processor
RPF	Reverse Path Forwarding
RSP	Routing and Switching Processor OR Route Switch Processor [Cisco]
RSVP	Resource reservation protocol
RTBH	Remote Triggered Black Holing
SCP	Secure Copy
SDRAM	Synchronous Dynamic Random Access Memory
SFP	Small Form-factor Pluggable
Sh	Shaper
SIP	Shared Port Adapter Interface Processor [Cisco]
SNMP	Simple Network Management Protocol
SP	Service Provider OR Switching Processor
SPA	Shared Port Adapter
SRAM	Static Random Access Memory
SSH	Secure Shell [protocol]

Glossary

SSO	Stateful Switch Over
SSRAM	Synchronous Static Random Access Memory
SUP	Supervisor [Cisco]
SW	Switching
TAC	Technical Assistance Center [Cisco]
TACACS	Terminal access Control Access-Control System [protocol]
TCAM	Tertiary Content Addressable Memory
TCB	Transmission Control Block
TCL	Tool Command Language
TCP	Transmission Control Protocol
TDM	Time Division Multiplexing
TTL	Time To Live
tx	Transmit
uC	Microcontroller
UDLD	Unidirectional Link Detection
uRPF	Unicast Reverse Path Forwarding
VACL	VLAN [Virtual Local Access Network] Access control List
VLAN	Virtual Local Access Network
VPLS	Virtual Provate LAN [Local Access Network] Service
VPN	Virtual Private Network
VRF	Virtual Routing and Forwarding
VRRP	Virtual Router Redundancy Protocol
VTP	Virtual Trunking Protocol
VTY	Virtual Terminal line
WAN	Wide Area Network

WFQ	Weighted Fair Queuing [Cisco]
WRR	Weighted Round Robin
XML	Extensible Markup Language