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The bridge to possible

Packet Journey Inside ASR 9000

Unicast, multicast, L3, L2, MPLS

Mike Mikhail, Delivery Architect
@MikeMikhail

BRKARC-2000

Acknowledgement

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


SYNC 0
SYNC 1
IEEE 1588
GPS
ALARM OUT

Agenda

- **System architecture**
  Control and forwarding paths and components
- **Control and exception traffic**
  Internal forwarding, and security
- **Transit frame forwarding**
  L3/L2 unicast/multicast in hardware
- **MPLS operation**
  Forwarding & service labels in hardware
- **Troubleshooting**
  Counters, discards, and packet/frame capture

Introduction

- About me
  - Mike Mikhail, Architect, mamikhai@cisco.com
  - Available for “Meet the Engineer” 1:1 & team discussions
  - Interests: ML/AI, Telemetry, SP technologies
- ASR 9000 today
  - Most powerful SP/WAN edge router
  - Hardware forwarding, high density: B’s pps, T’s bps /slot
  - Distributed processing & distributed forwarding
  - Continued dev, busy roadmap, a wealth of new features

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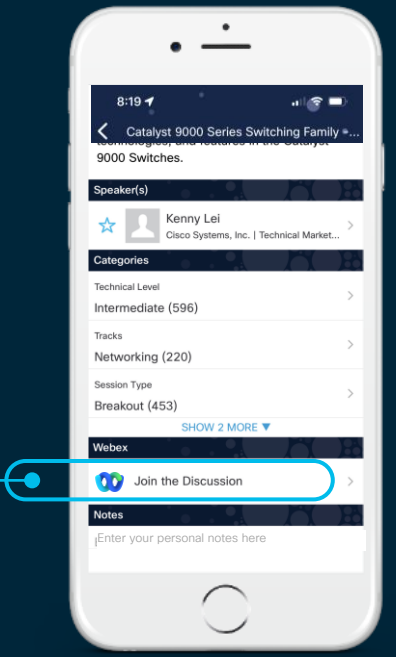

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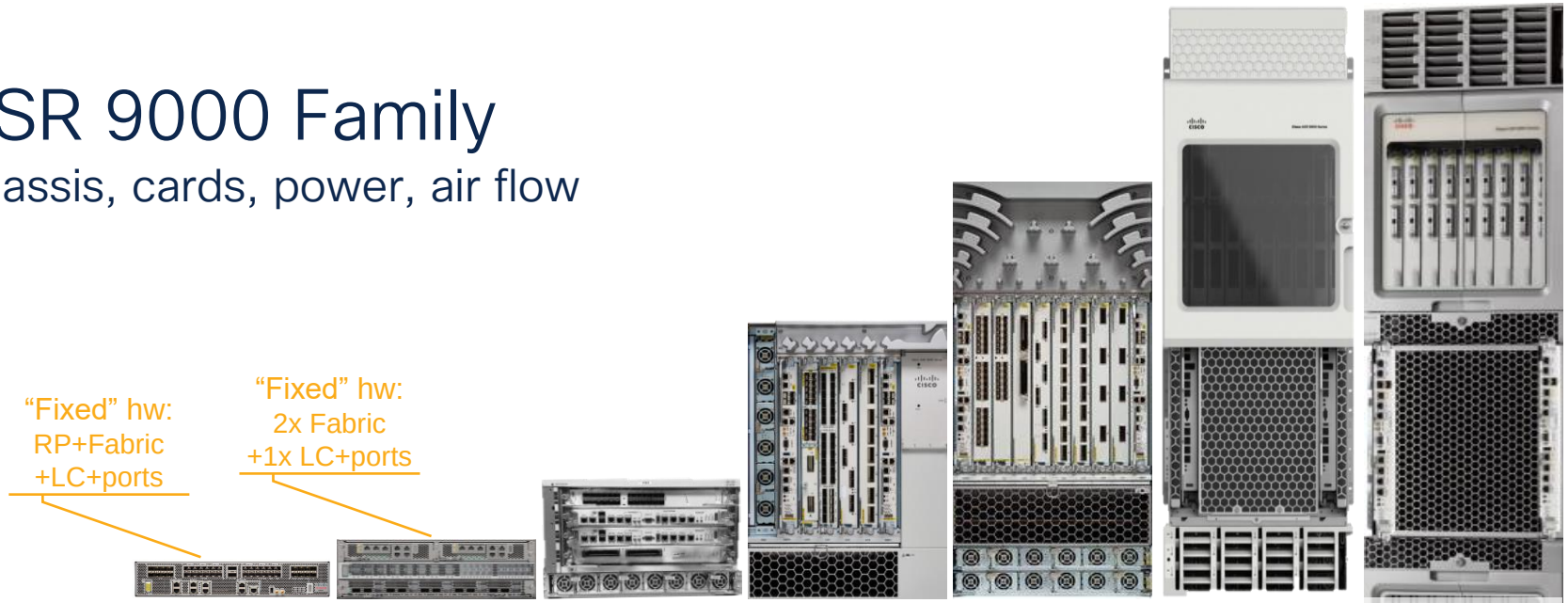
1 System Architecture

ASR 9000 Family

Chassis, cards, power, air flow



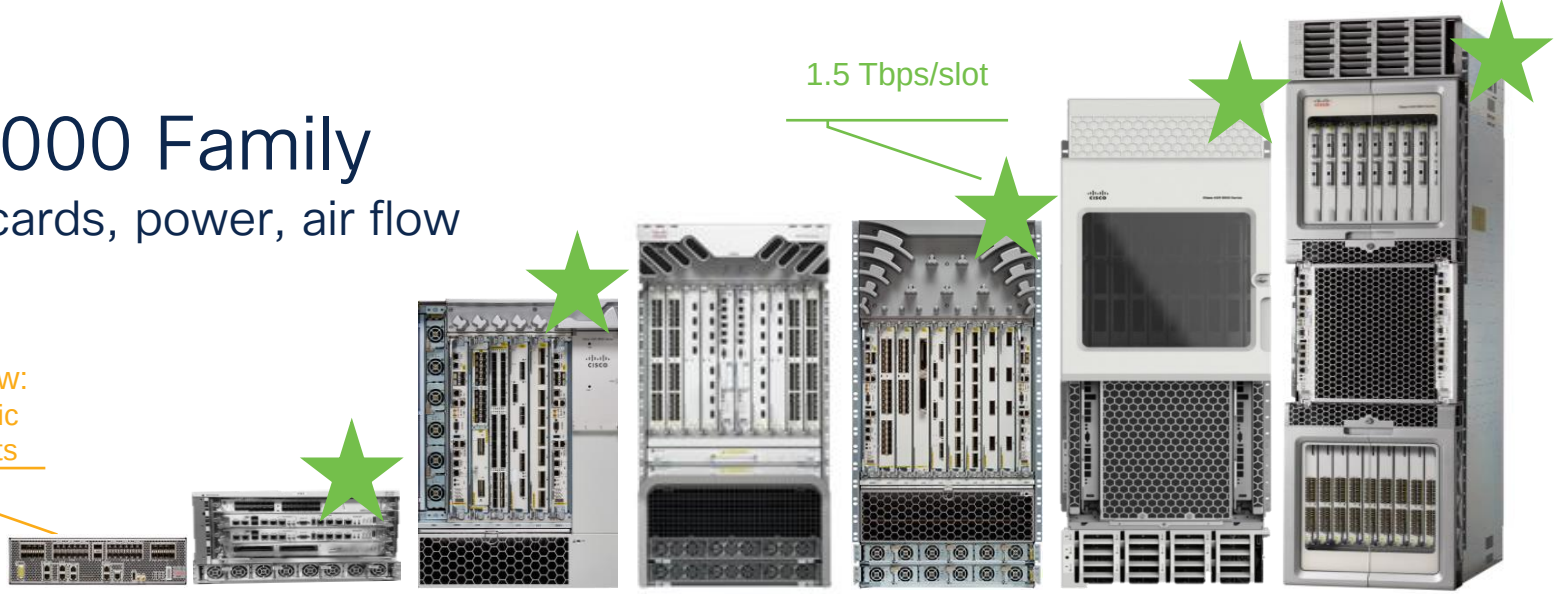
	ASR 9901	ASR 9903	ASR 9904	ASR 9906	ASR 9910	ASR 9912	ASR 9922
RP	1 Built-in	1+1 RP	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RP	1+1 RP
Fabric	1 Built-in	2x Built-in	2x RSP	6+1	6+1	6+1	6+1
Line cards or ports	2x100G +24x1/10G +16x1G	16x100G + 20x10G +exp. 2T or 800G	2	4	8	10	20
Rack units	2	3	6	14	21	30	44
Power modules	2x AC or 2x DC	4x AC or 4x 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	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

1.5 Tbps/slot

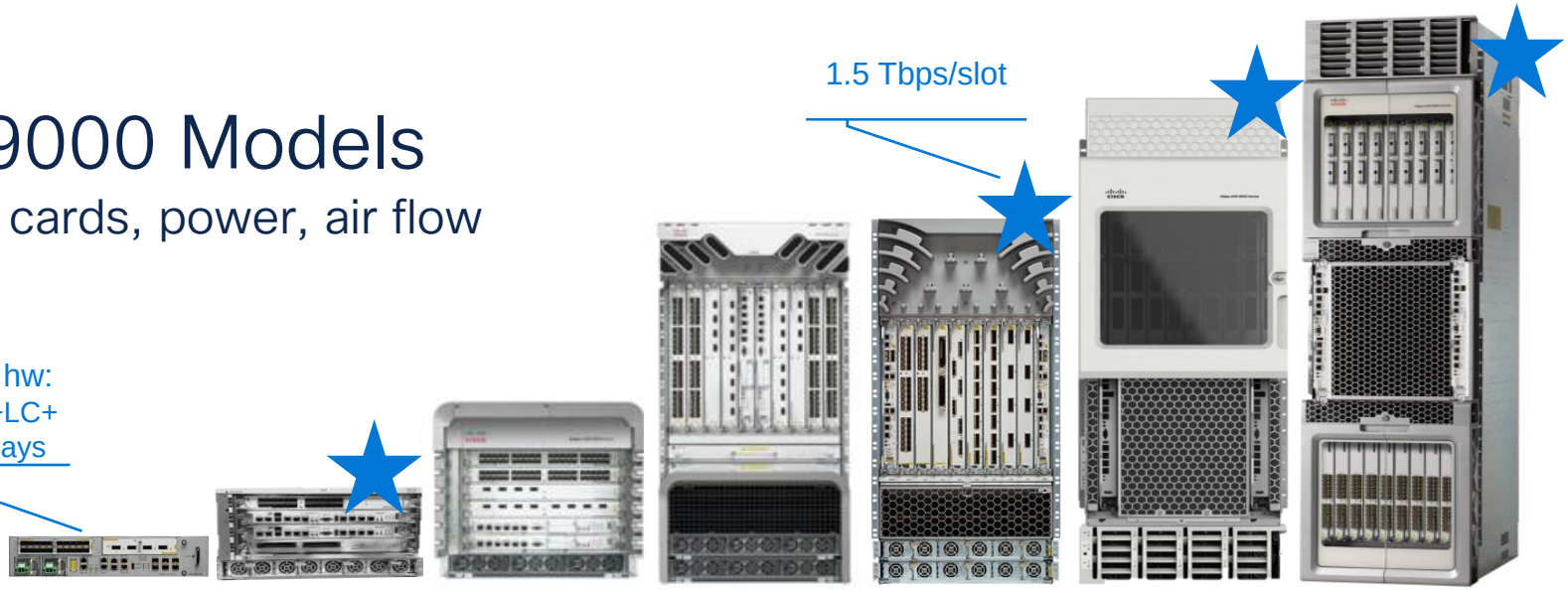
"Fixed" hw:
RP+Fabric
+LC+ports



	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



	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

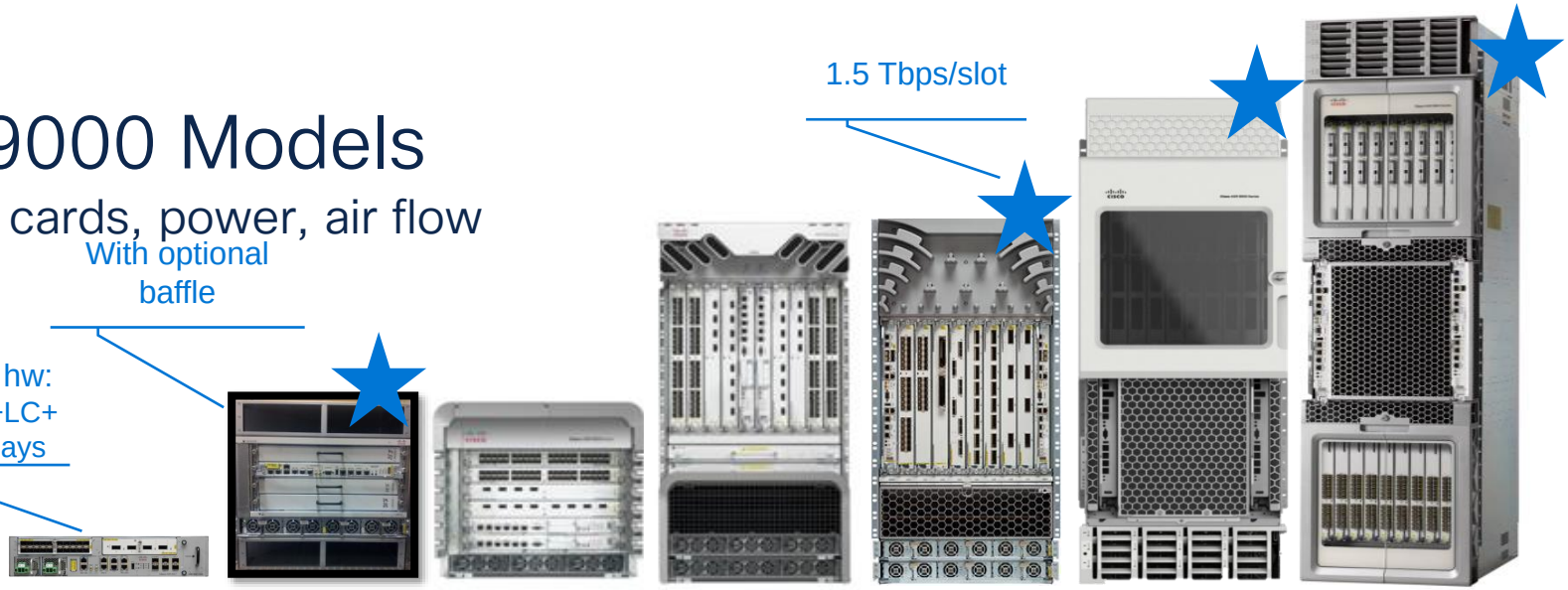
ASR 9000 Models

Chassis, cards, power, air flow

1.5 Tbps/slot

With optional baffle

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

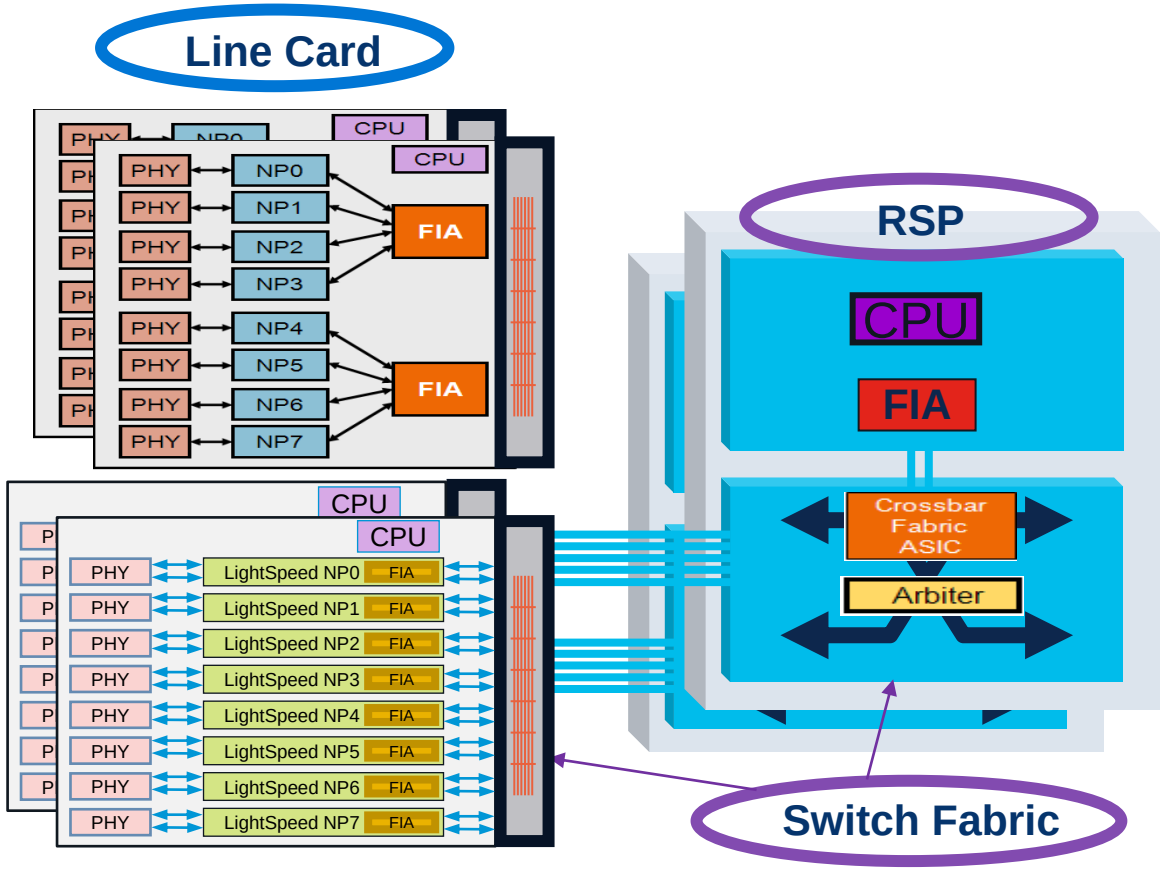


	ASR 9001	ASR 9904	ASR 9006	ASR 9010	ASR 9910	ASR 9912	ASR 9922
RP	Built-in	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RSP	1+1 RP	1+1 RP
Fabric	Built-in	2x RSP	2x RSP	2x RSP	6+1	6+1	6+1
Line cards & ports	4x SFP+ 2x MPA	2	4	8	8	10	20
Rack units	2	10U 2-post 23"	10	21	21	30	44
Power modules	2x AC or 2x DC	4x AC or 4x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

9910, 9906, 9904

- Distributed control plane
  - L2 protocols, ARP, BFD, CFM, Netflow run on LC CPU
- Distributed data plane
  - Forwarding distributed to NP's
- All active sw fabric
  - Each RSP houses a fabric instance

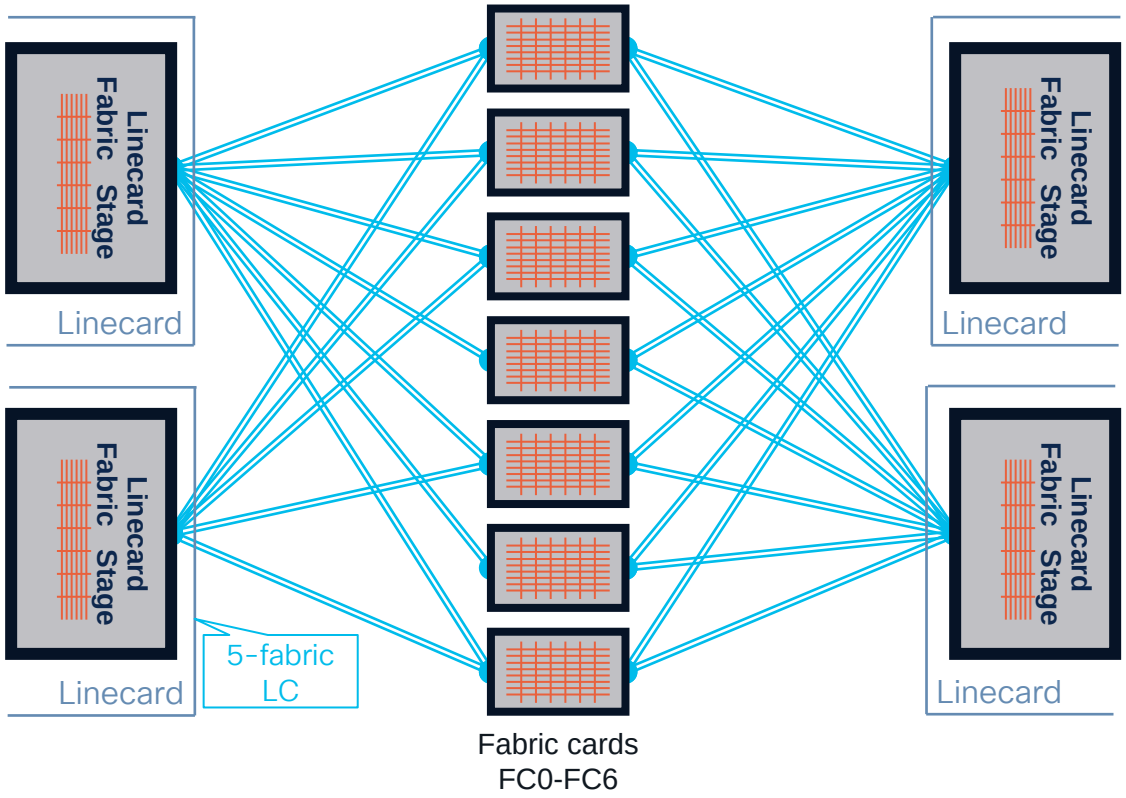


The Switch Fabric

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 link:

  Up to 14 bidir per LC
  - SFC1: 110G [Typhoon gen]
  - SFC2: 230G [Tomahawk gen]
  - SFC3: 300G [Lightspeed gen]
- Fabric load sharing
  - Unicast: per super-frame
  - Multicast: per flow

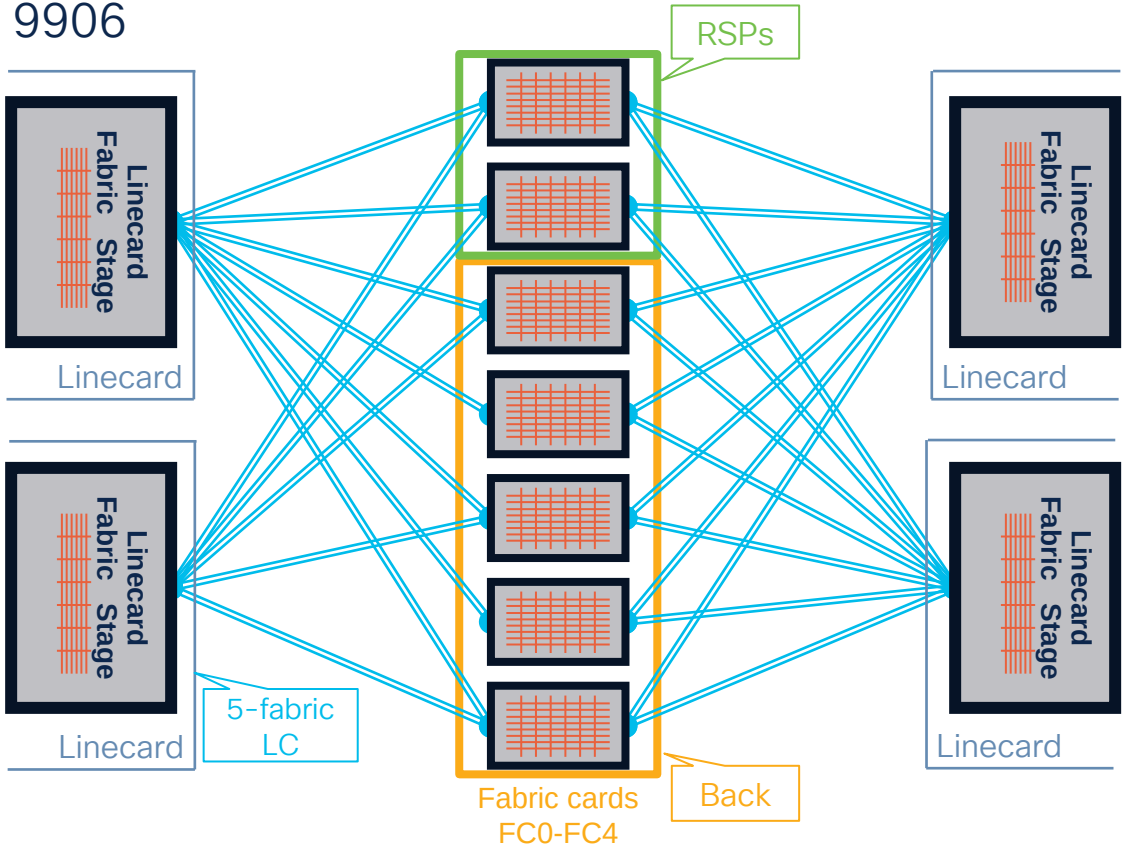


The Switch Fabric

Mid-plane chassis: 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 link:

  Up to 14 bidir per LC
  - SFC1: 110G [Typhoon gen]
  - SFC2: 230G [Tomahawk gen]
  - SFC3: 300G [Lightspeed gen]
- Fabric load sharing
  - Unicast: per super-frame
  - Multicast: per flow



The 7 Fabrics

9906 Example [mid-plane chassis]

```
RP/0/RSP0/CPU0:asr9906-2y-P192#admin show platform
Tue Apr 28 15:44:05.307 UTC
Node                Type                          State            Config State
--------------------------------------------------------------------------------
0/RSP0/CPU0         A99-RSP-SE(Active)            IOS XR RUN       PWR,NSHUT,MON
0/RSP1/CPU0         A99-RSP-SE(Standby)           IOS XR RUN       PWR,NSHUT,MON
0/FT0/SP            ASR-9906-FAN                  READY
0/FT1/SP            ASR-9906-FAN                  READY
0/0/CPU0            A9K-8X100GE-CM                IOS XR RUN       PWR,NSHUT,MON
0/PS0/M0/SP         PWR-6KW-AC-V3                 READY            PWR,NSHUT,MON
0/PS0/M1/SP         PWR-6KW-AC-V3                 READY            PWR,NSHUT,MON
0/FC0/SP            A99-SFC-T                     OK               PWR,NSHUT,MON
0/FC1/SP            A99-SFC-T                     OK               PWR,NSHUT,MON
0/FC2/SP            A99-SFC-T                     OK               PWR,NSHUT,MON
0/FC3/SP            A99-SFC-T                     OK               PWR,NSHUT,MON
0/FC4/SP            A99-SFC-T                     OK               PWR,NSHUT,MON
RP/0/RSP0/CPU0:asr9906-2y-P192#
```

Front

Back

Arbiter Status

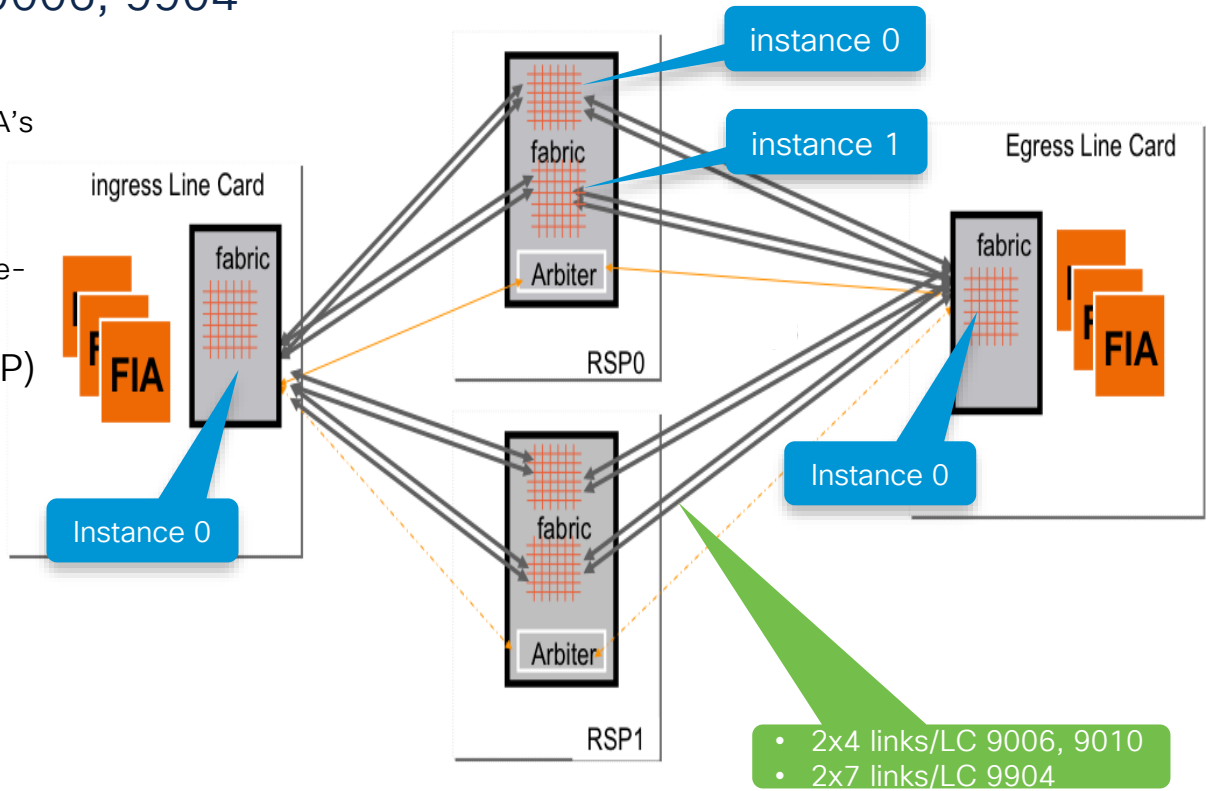
9910 Example [RSP Arbiters]

```
RP/0/RSP0/CPU0:R98#show controllers fabric arbiter link-status location 0/RSP0/CPU0
Tue Apr 28 12:34:24.688 EDT
Port    Remote Slot  Remote Elem    Remote Inst  Status
=======================================================
01      0/0/CPU0           ARB            0        Up
09      0/3/CPU0           ARB            0        Up
10      0/2/CPU0           ARB            0        Up
24      0/RSP0/CPU0        FIA            0        Up
25      0/RSP1/CPU0        FIA            0        Up
RP/0/RSP0/CPU0:R98#show controllers fabric arbiter link-status location 0/RSP1/CPU0
Tue Apr 28 12:34:34.381 EDT
Port    Remote Slot  Remote Elem    Remote Inst  Status
=======================================================
12      0/3/CPU0           ARB            0        Up
13      0/2/CPU0           ARB            0        Up
14      0/0/CPU0           ARB            0        Up
24      0/RSP1/CPU0        FIA            0        Up
25      0/RSP0/CPU0        FIA            0        Up
RP/0/RSP0/CPU0:R98#
```

The Switch Fabric

No FC chassis: 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



Fabric link status

Line card fabric instance

```
RP/0/RSP0/CPU0:R98#show controllers fabric crossbar link-status instance 0 location 0/3/CPU0
Tue May  5 11:57:25.647 EDT
PORT    Remote Slot  Remote Inst    Logical ID  Status
=======================================================
00      0/3/CPU0          01              1       Up
03      0/3/CPU0          00              0       Up
04      0/3/CPU0          00              1       Up
07      0/FC0/SP          01              0       Up
09      0/FC2/SP          01              0       Up
11      0/RSP1/CPU0       01              0       Up
12      0/RSP0/CPU0       01              0       Up
14      0/FC4/SP          01              0       Up
15      0/FC2/SP          00              0       Up
16      0/RSP0/CPU0       00              0       Up
17      0/RSP1/CPU0       00              0       Up
18      0/FC4/SP          00              0       Up
19      0/FC0/SP          00              0       Up
24      0/3/CPU0          01              0       Up

RP/0/RSP0/CPU0:R98#
```

5-fabric, fabric side

Fabric link status

Central fabric instance

```
RP/0/RSP0/CPU0:R98#show controllers fabric crossbar link-status instance 0 spine 2
Tue May  5 12:06:32.111 EDT
PORT     Remote Slot  Remote Inst    Logical ID  Status
======================================================
01       0/2/CPU0          00             1         Up
05       0/3/CPU0          00             1         Up
08       0/3/CPU0          00             0         Up
11       0/2/CPU0          00             0         Up
15       0/0/CPU0          00             0         Up
26       0/0/CPU0          00             1         Up

RP/0/RSP0/CPU0:R98#
```

FC2

2 bidir links to LC0

Fabric Statistics

Unicast/Multicast, Ingress/Egress, Hi/Low priority, errors/drops, per link

```
RP/0/RSP0/CPU0:R98#show controllers fabric crossbar statistics instance 0 location 0/3/CPU0
Tue Apr 28 12:42:13.457 EDT
.

Port statistics for xbar:0 port:3
==============================
Hi priority stats (unicast)
===========================
    Ingress Packet Count Since Last Read       : 14861
    Egress Packet Count Since Last Read        : 28611

Low priority stats (multicast)
==========================
    Ingress Channel Utilization Count          : 1073737248
    Input Buffer Back Pressure Count           : 4611667465472285196
    Xbar Timeout Drop Count                    : 173143068108
    HOL Drop Count                             : 4611669114694547292
    NULL FPOE Drop Count                       : 4611673786360528898
    Diagnostic Packet Count                    : 4611673873333613824
    Input Buffer Correctable ECC Error Count   : 4611674662533857280
    Input Buffer Uncorrectable ECC Error Count : 4611666778232345248
    Header CRC Error Count                     : 9603246718976
.
```

Slot Address

Internal slot address, slot mask, and fabric group ID

Location	Slot		Slot Mask	
	Logical	Physical	Binary	Hex
0/10/CPU0 – 0/19/CPU0	LC10-19	12-21	0000 0000 0100 – 1000 0000 0000	0x0004 – 0x800
0/4/CPU0 – 0/9/CPU0	LC4-9	6-11	0000 0100 0000 - 1000 0000 0000	0x0021 – 0x800
0/3/CPU0	LC3	5	0000 0010 0000	0x0020
0/2/CPU0	LC2	4	0000 0001 0000	0x0010
0/1/CPU0	LC1	3	0000 0000 1000	0x0008
0/0/CPU0	LC0	2	0000 0000 0100	0x0004
0/RSP1/CPU0	RSP1/RP1	1	0000 0000 0010	0x0002
0/RSP0/CPU0	RSP0/RP0	0	0000 0000 0001	0x0001

- Follows the sequence of slots in chassis up to 9912, repeats LC slots for 9922
- 22/12/6/4/3 RP slots: 0000 0011 which is 0x0003, decimal 3
- Exception: 9010 RSP slots: 00 0011 0000 which is 0x0030, decimal 48

Fabric

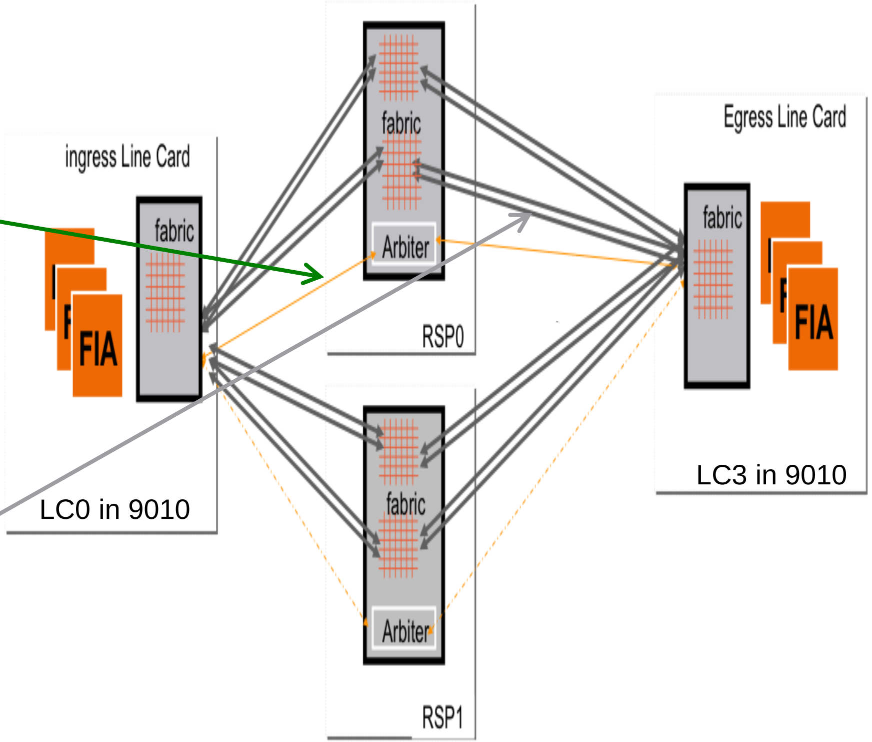
Link status

```
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
```

Internal slot number

```
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

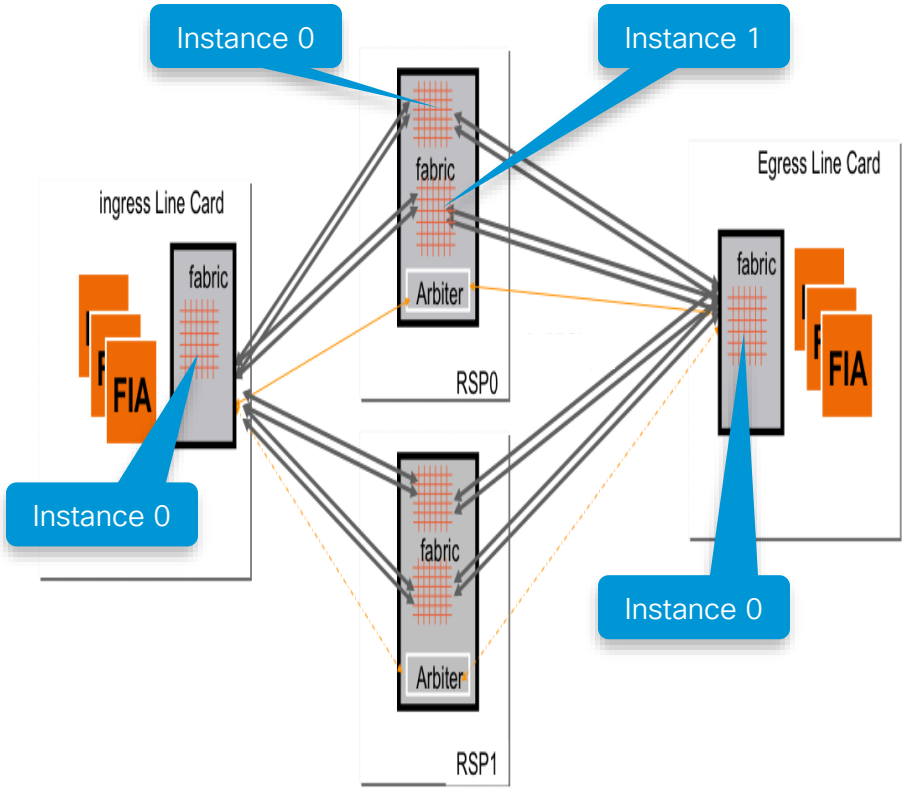
Link statistics

```
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
.

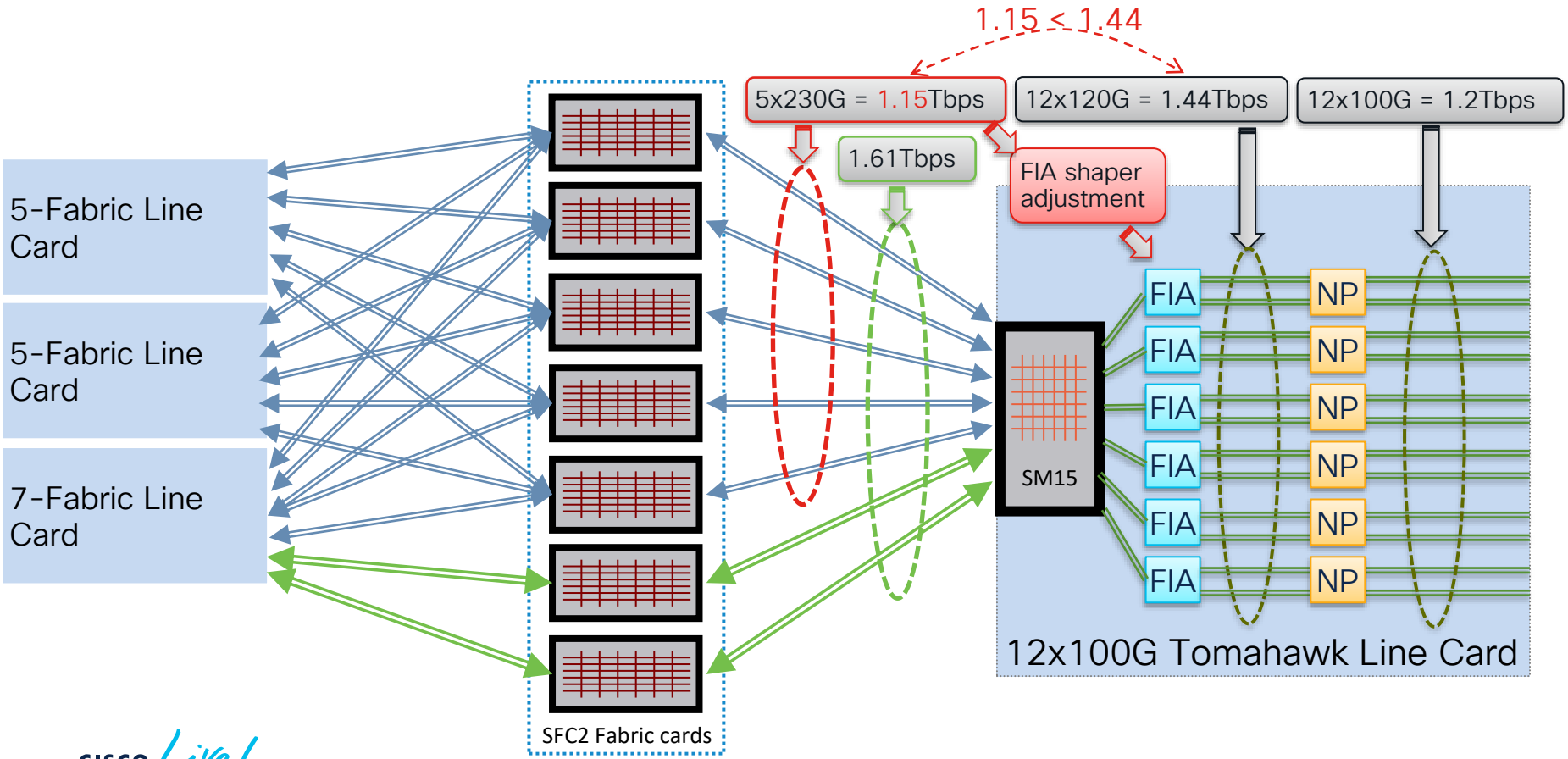
Port statistics for xbar:1 port:16
================================
Hi priority stats (unicast)
============================
    Ingress Packet Count Since Last Read       : 49365
    Egress Packet Count Since Last Read        : 323

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
```

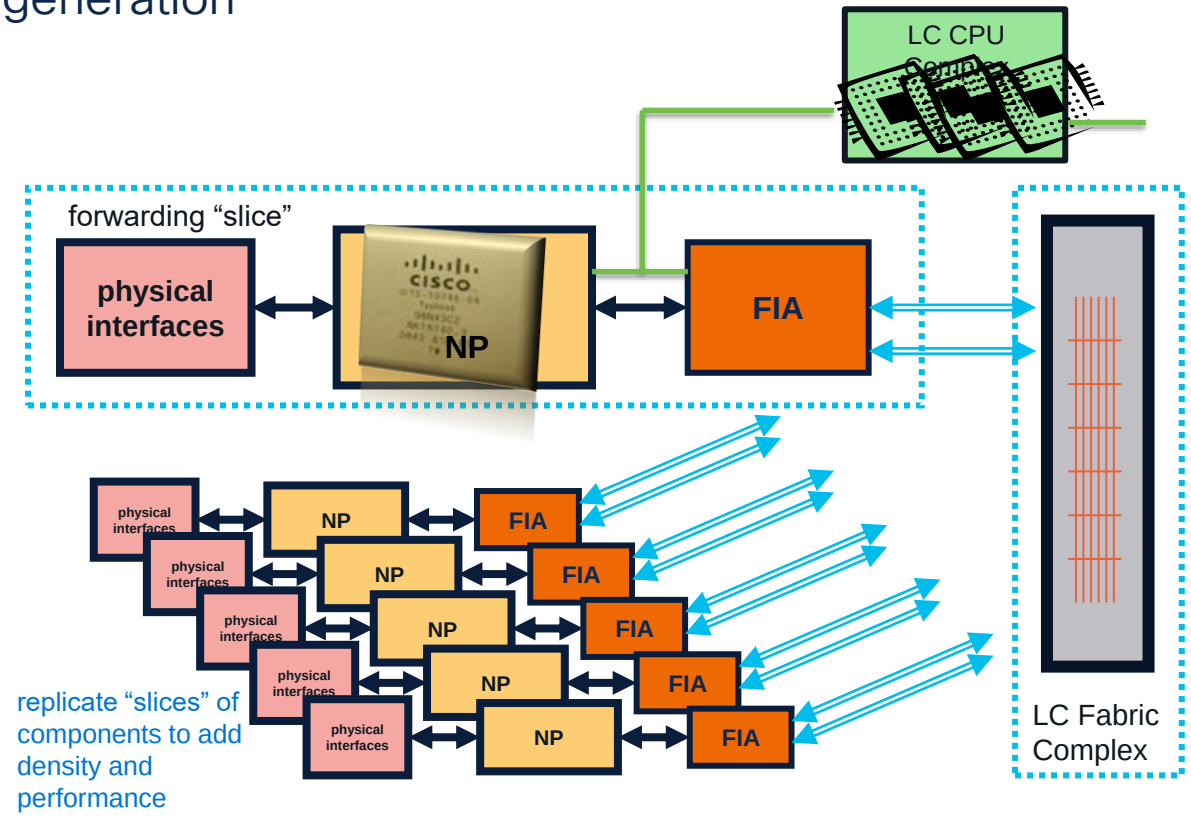
Fabric Interworking: 5-Fab LC to 12x100G LC

- 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

Lightspeed & Tomahawk generation

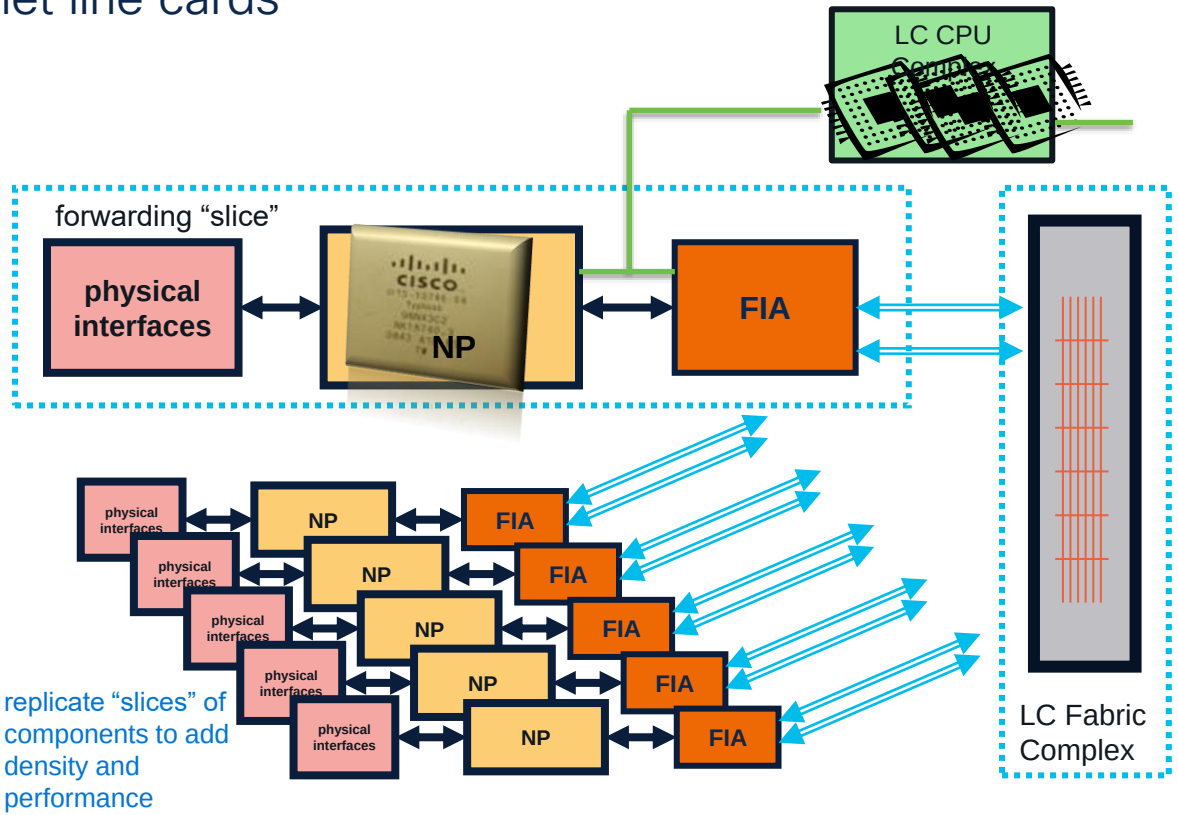
- Physical 400/200/100 GE
  - No frame processing there
- Lightspeed (+) or [Tomahawk] NP
  - FIB, MAC, ACL, QoS, encap/decap, LPTS, all hw features, buffer, i/f stats
  - 420 [240] Gbps 300 [150] Mpps bidirectional
- Fabric Interface ASIC
  - On-chip for Lightspeed
  - 2PQ+1BE into fabric, VOQ
  - System priority queueing
  - Separate unicast and multicast queueing
  - Super-framing and buffering



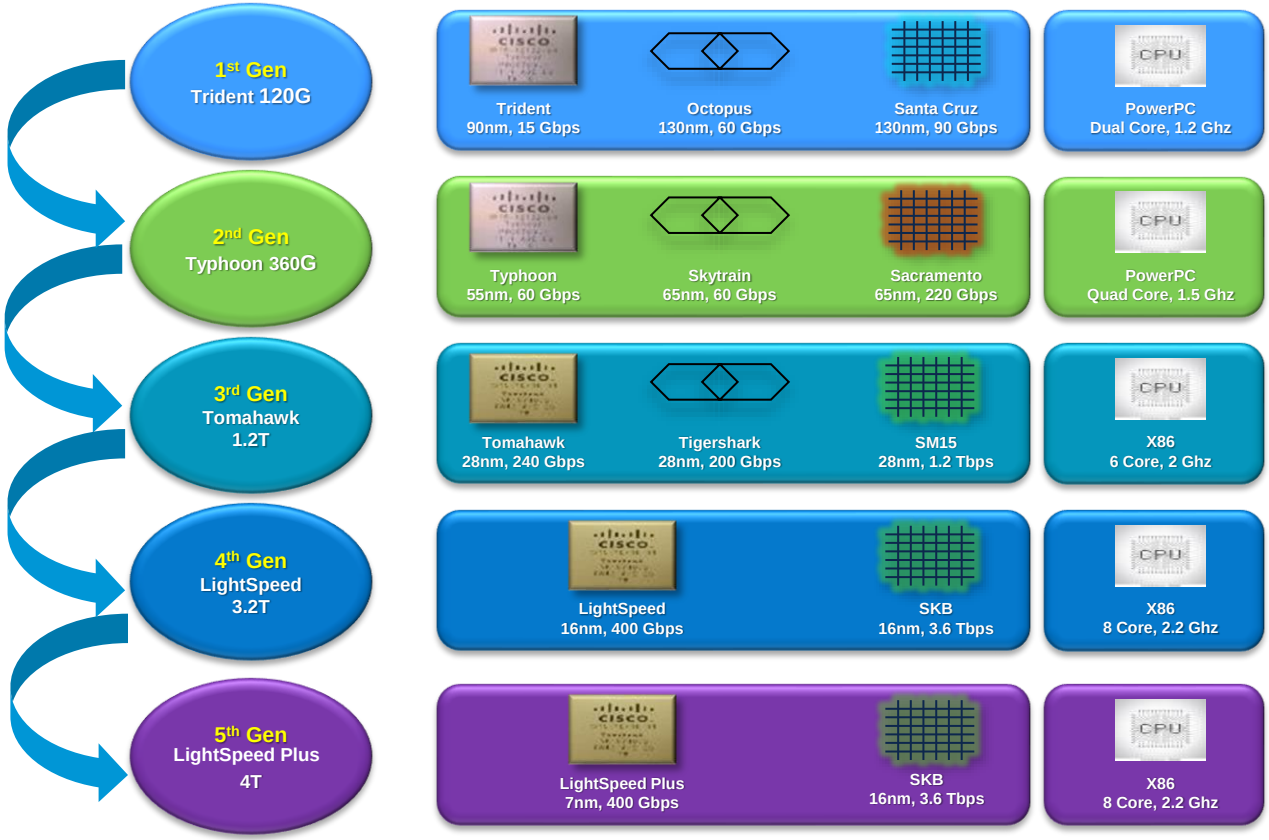
Line Card Architecture

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 Linecard Silicon Evolution

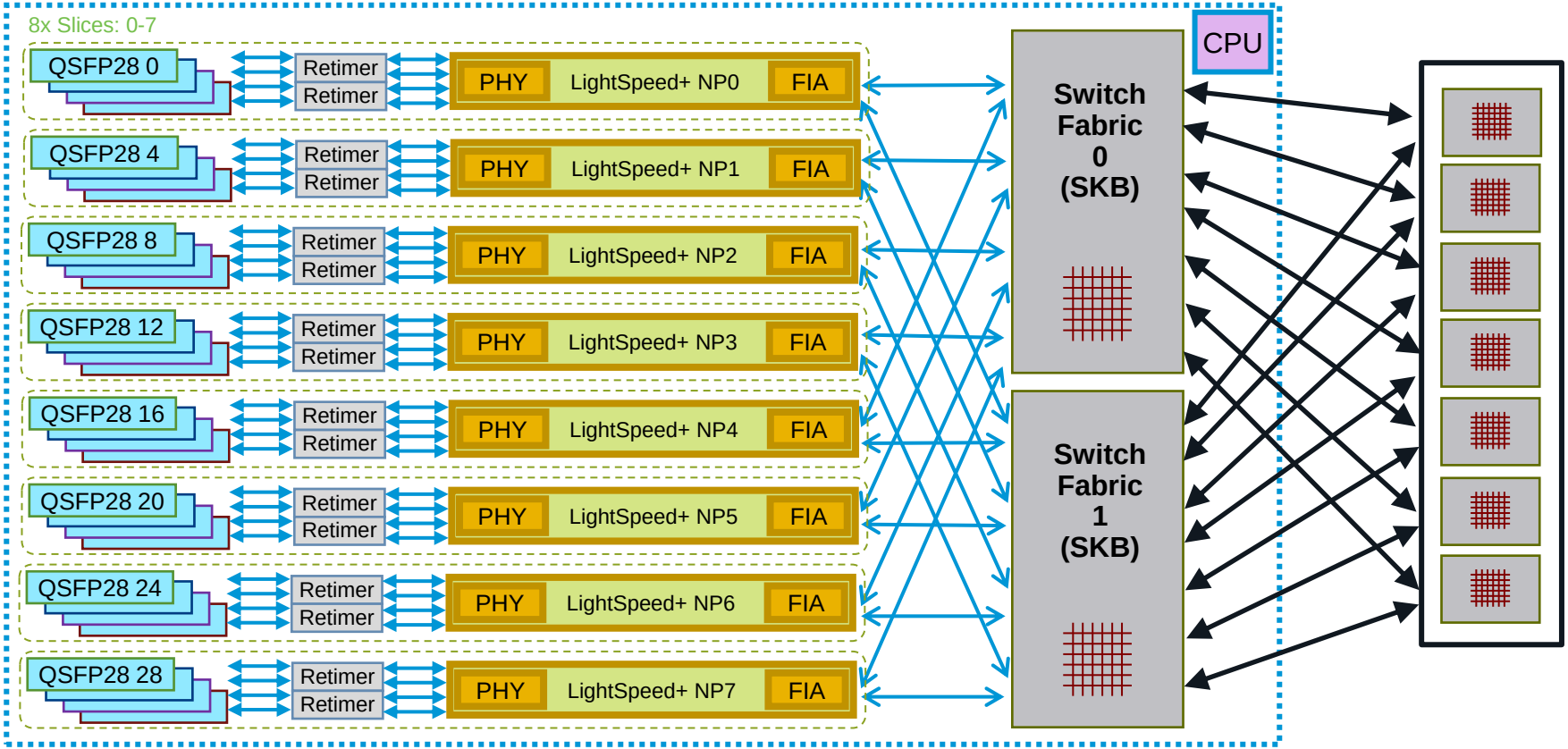


Line Cards: 5th Generation [Lightspeed+ NP]

32x 100GE, 400/100/40/10 GE FLEX Combo Line Cards

Line Card Architecture

32x 100GE



ASR 9903 Architecture

RP0 | RP CPU | SDRAM 24GB | SSD 240GB

RP1 | RP CPU | SDRAM 24GB | SSD 240GB

LC CPU | SDRAM 32GB | SSD 240GB

Tornado ASIC (Arbiter)

Switch Fabric

Switch Fabric

1.6T Fixed Board

Backplane

LS+ NPU

PHY

QSFP28

SFP+

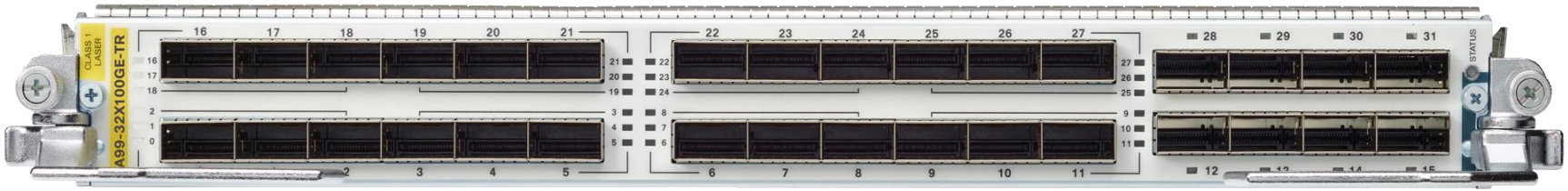
OSFP28

OSFP-DD

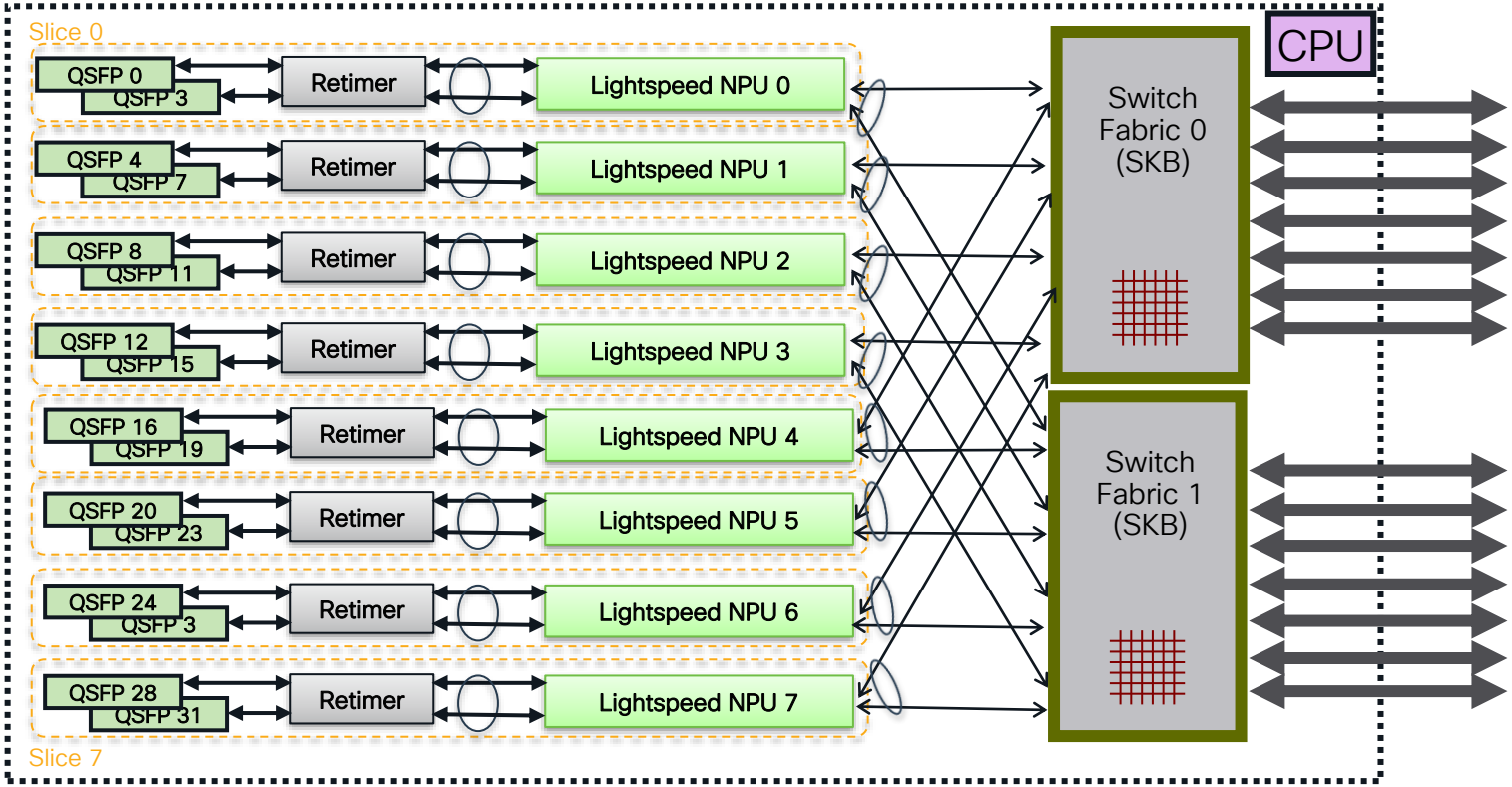
2T Port Expansion Card

Line Cards: 4th Generation [Lightspeed NP]

32x, 16x 100G Line Cards



Line Cards: 4th Generation (Lightspeed)



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

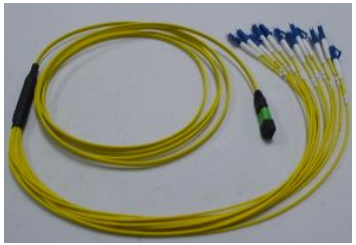
Line Cards: 3rd Generation [Tomahawk NP]

8x & 4x 100G CPAK Line Cards

A9K-8X100G

A9K-4X100G

CPAK



MPO24 TO 10X DUPLEX LC SM

MPO24 TO 10X DUPLEX LC MM

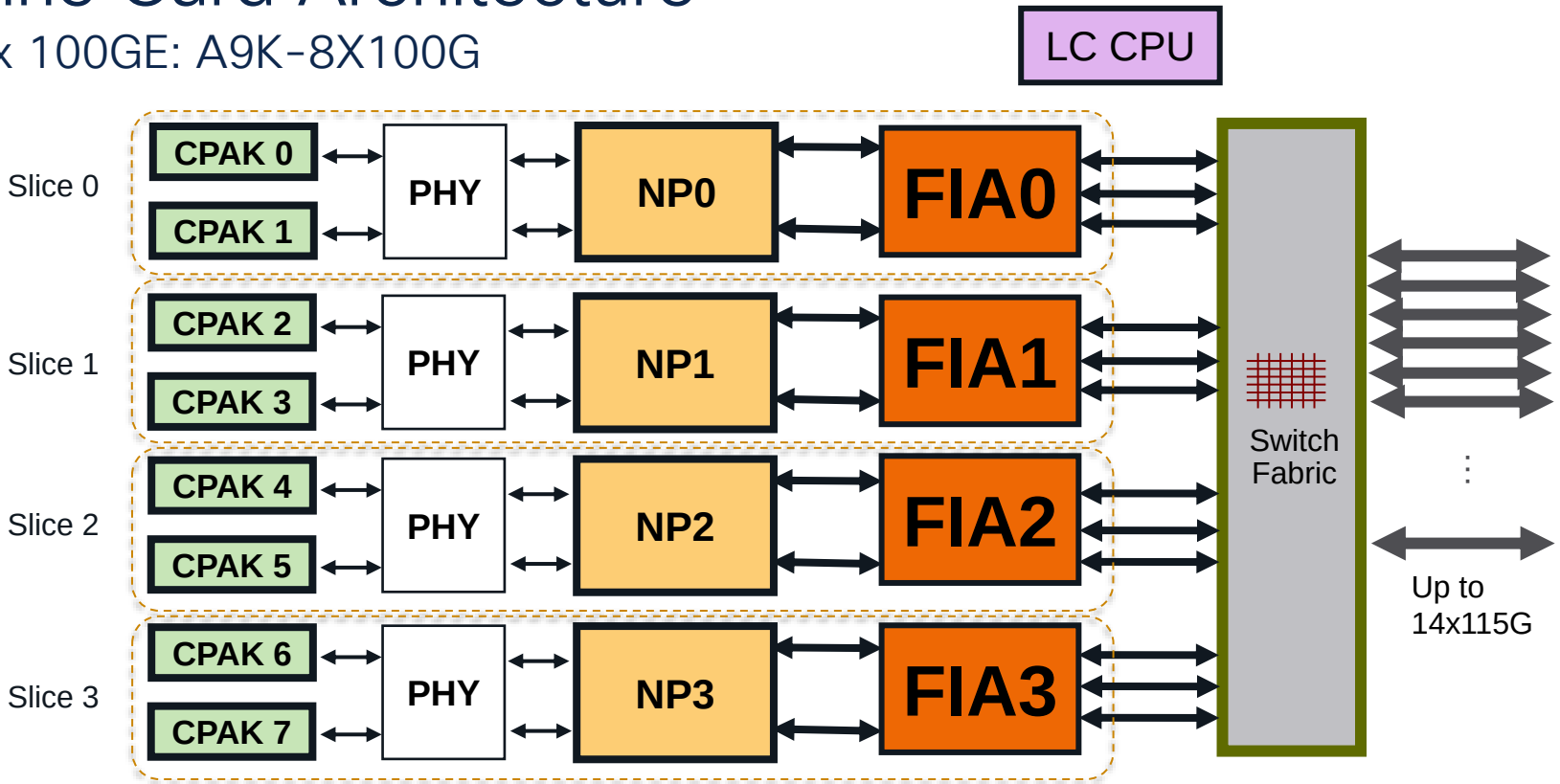
Tomahawk Line Card

Notes on 8x 100G line card

- SE and TR versions
  - SE System Edge: More processor memories, scalable hierarchical 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

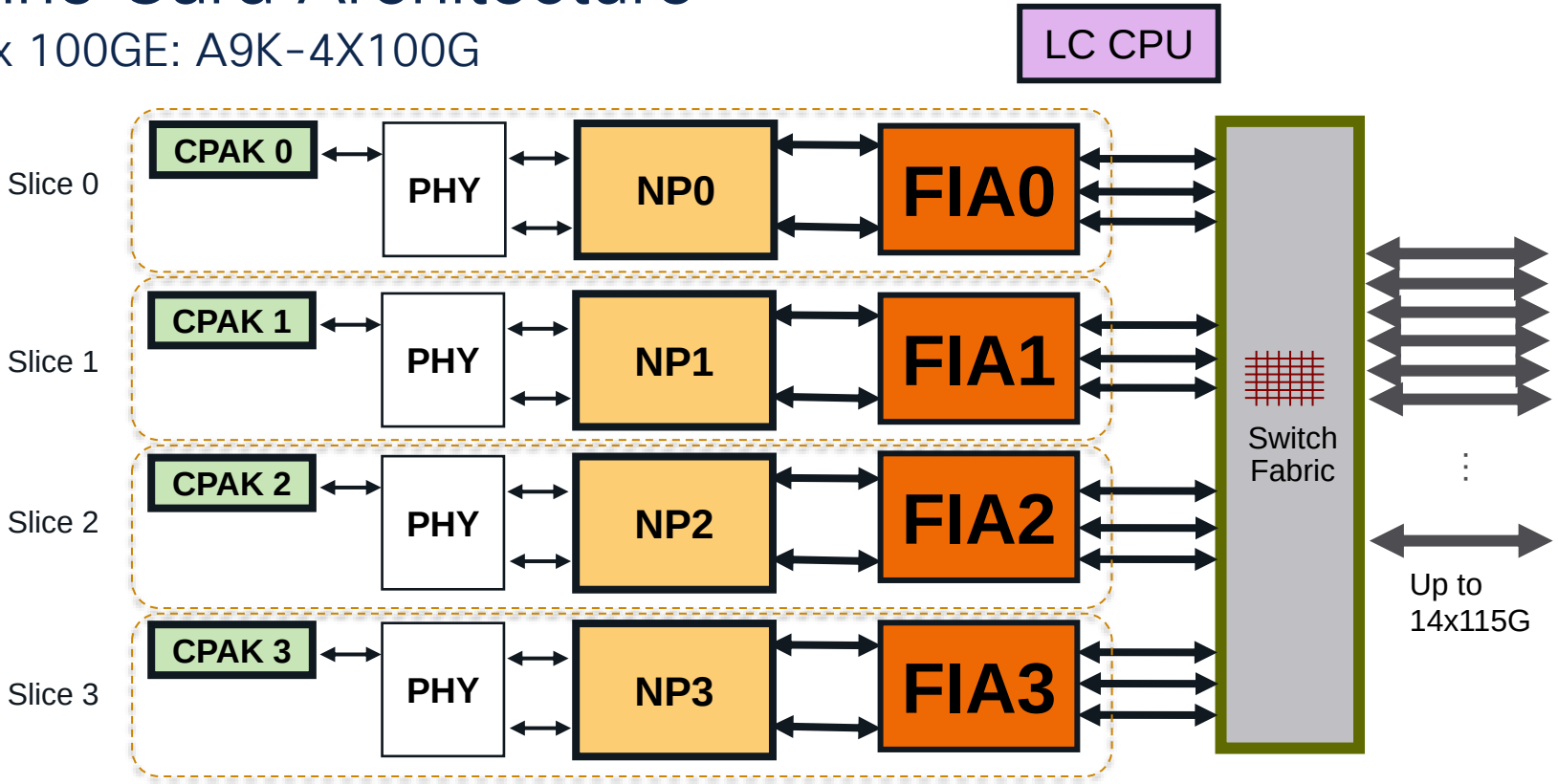
Line Card Architecture

8x 100GE: A9K-8X100G



Line Card Architecture

4x 100GE: 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

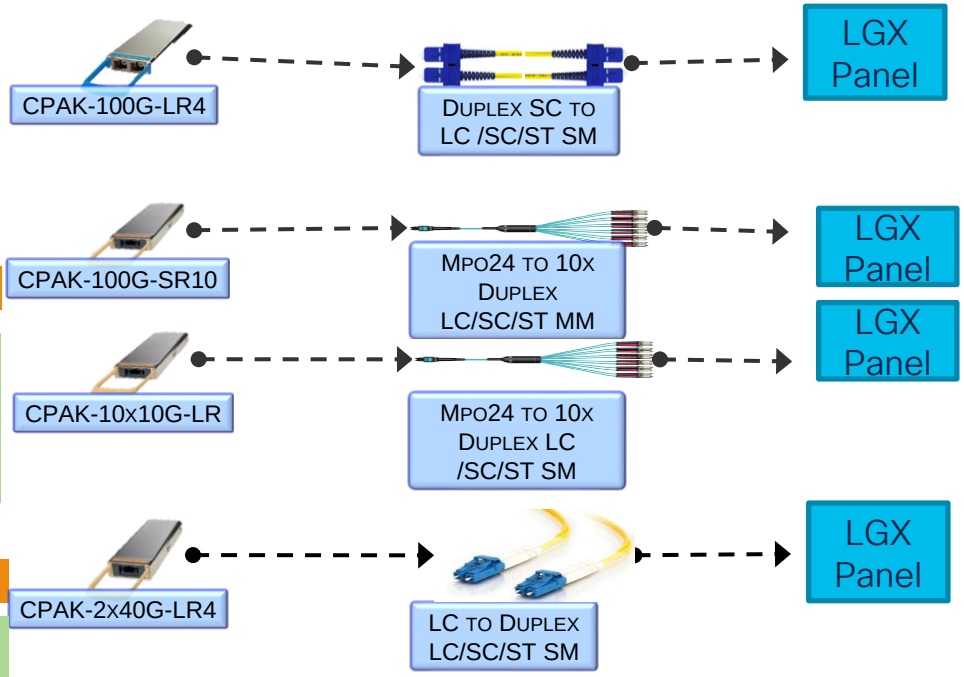
hw-module 0/x/cpu0 port z breakout 10xTenGigE

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]

A9K-MOD400

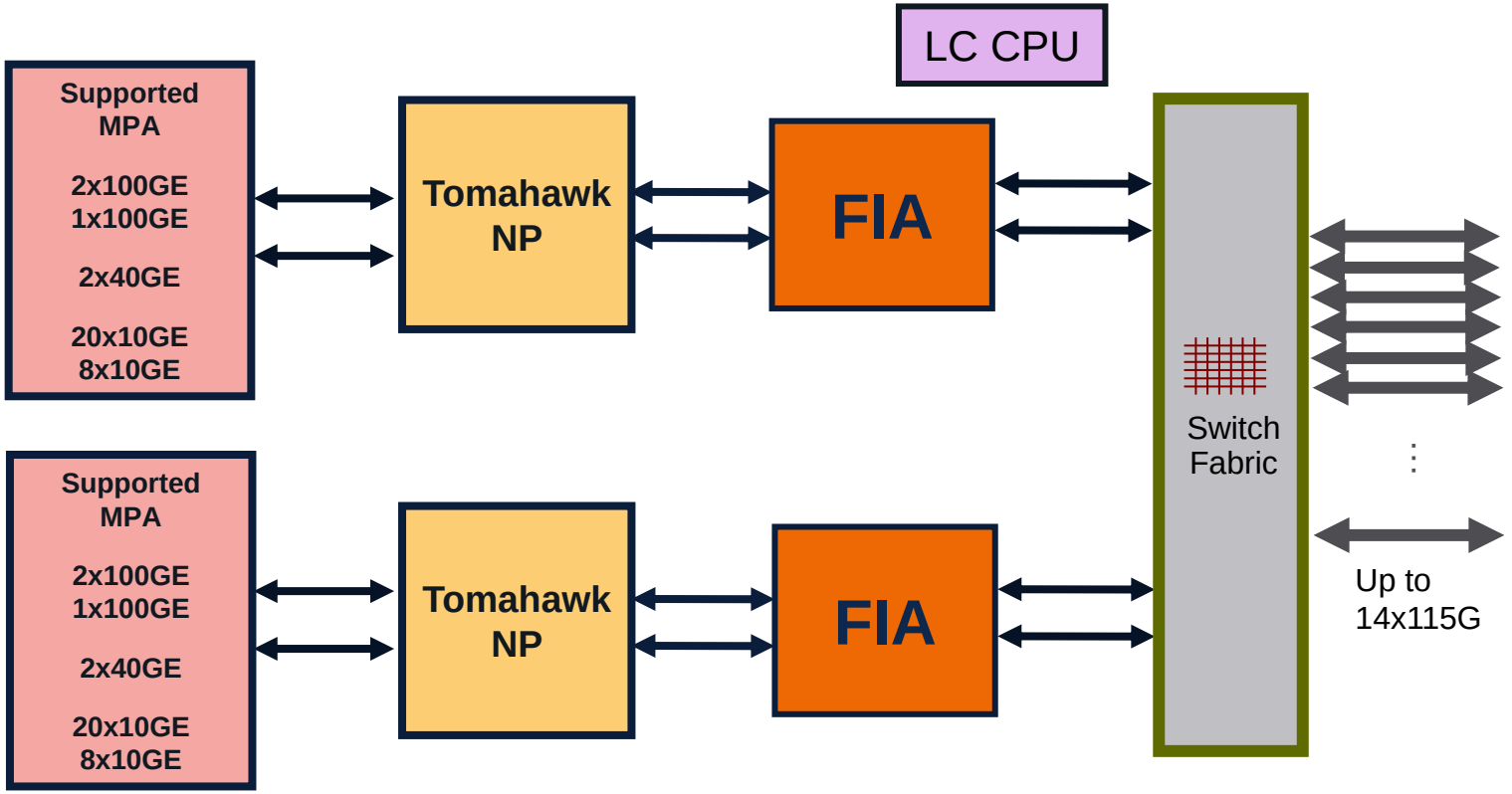
A9K-MPA-2X100GE

A9K-MPA-20X10GE

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

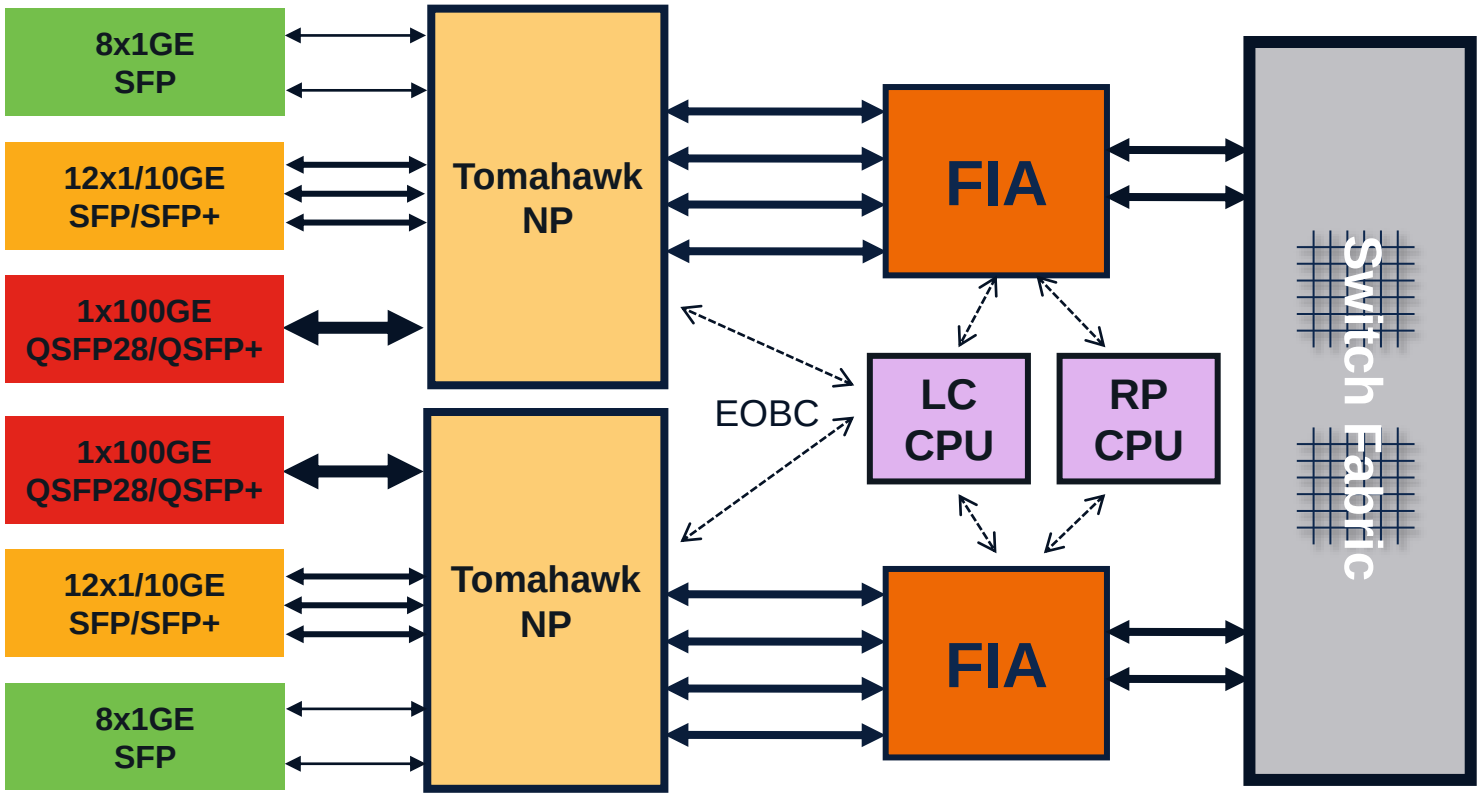
Line Card Architecture

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



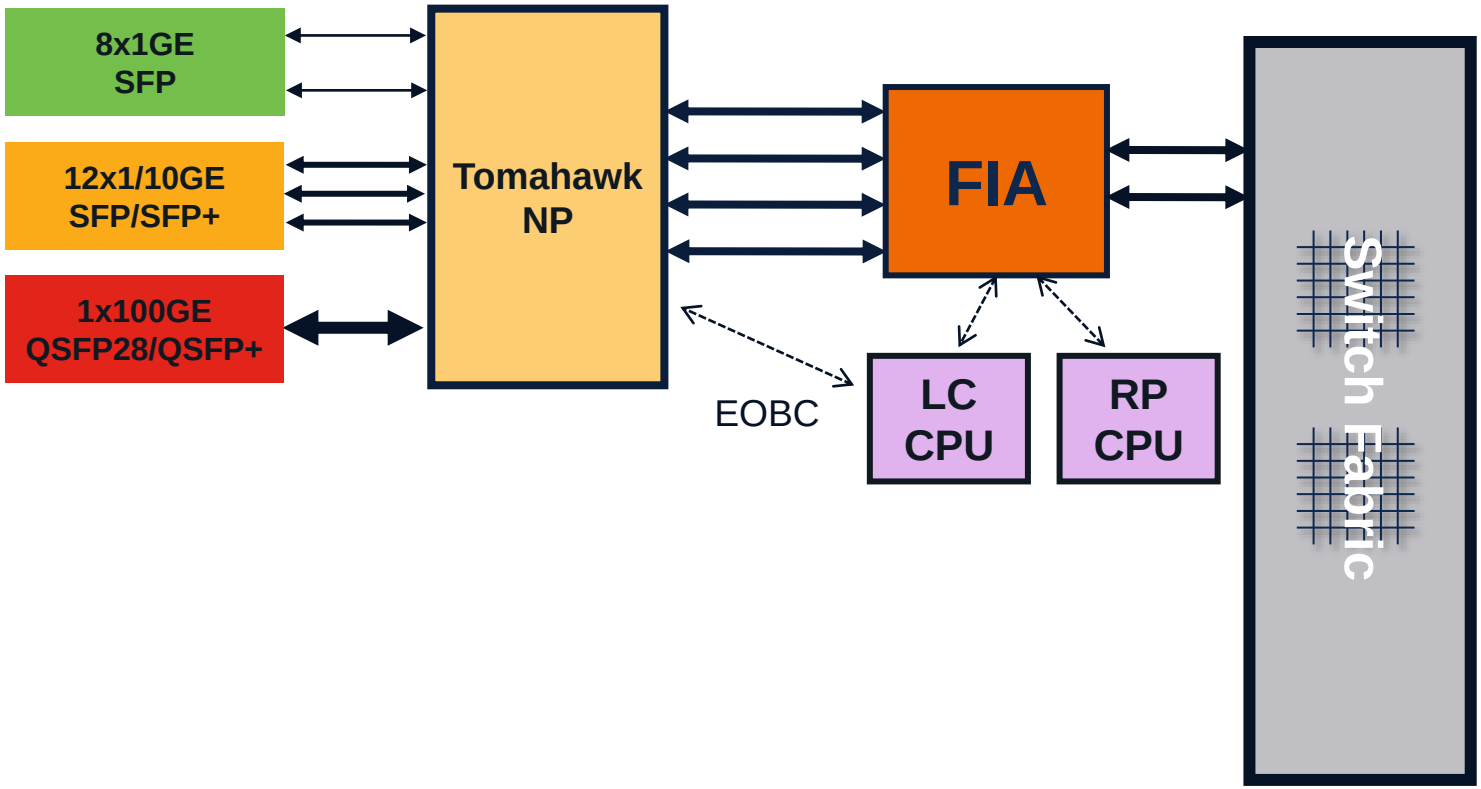
ASR 9901 Architecture

A router + LC in 2 RU

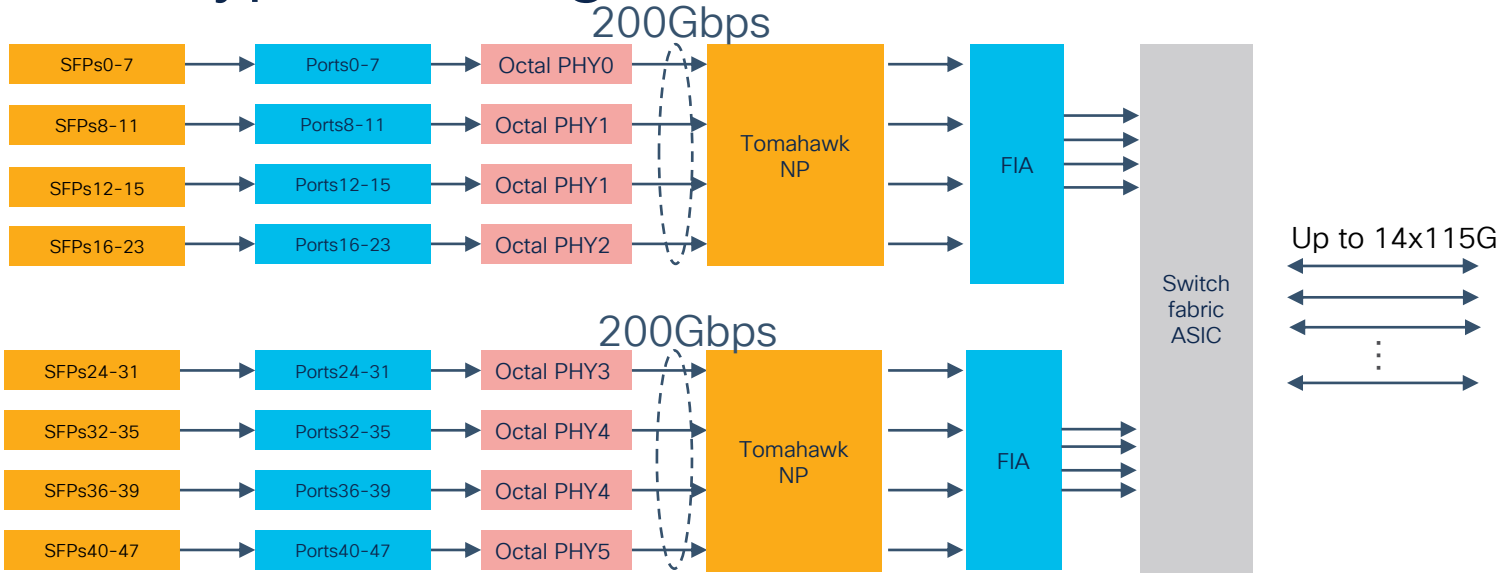


ASR 9901-S Architecture

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	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	12X1,12X10
10G	10G	10G	10G	1G	1G	1G	1G	1G	1G	1G	1G	10G	10G	10G	10G	10G	10G	10G	10G	1G	1G	1G	1G	4X10,8X1,8X10,4X1
10G	10G	10G	10G	10G	10G	10G	10G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	8X10,16X1
10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	1G	1G	1G	1G	10G	10G	10G	10G	16X10,4X1,4X10
10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	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	1G	1G	1G	1G	1G	1G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	12X1,12X10,12X1,12X10
10G	10G	10G	10G	1G	1G	1G	1G	1G	1G	1G	1G	10G	10G	10G	10G	10G	10G	10G	10G	1G	1G	1G	1G	10G	10G	10G	10G	1G	1G	1G	1G	1G	1G	1G	1G	10G	10G	10G	10G	10G	10G	10G	10G	1G	1G	1G	1G	4X10,8X1,8X10, 4X1,4X10,8X1,8X10,4X1
10G	10G	10G	10G	10G	10G	10G	10G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	10G	10G	10G	10G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	24X10,24X1
10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	1G	36X1,12X10
10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	10G	48X10

Line Cards: 2nd Generation [Typhoon NP]

Fixed Port Configuration & Modular Line Cards

A9K-24x10GE A9K-2x100GE, A9K-1x100GE

A9K-MOD80 A9K-MOD160

A9K-36x10GE

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

Line Cards: 2nd Generation [Typhoon NP]

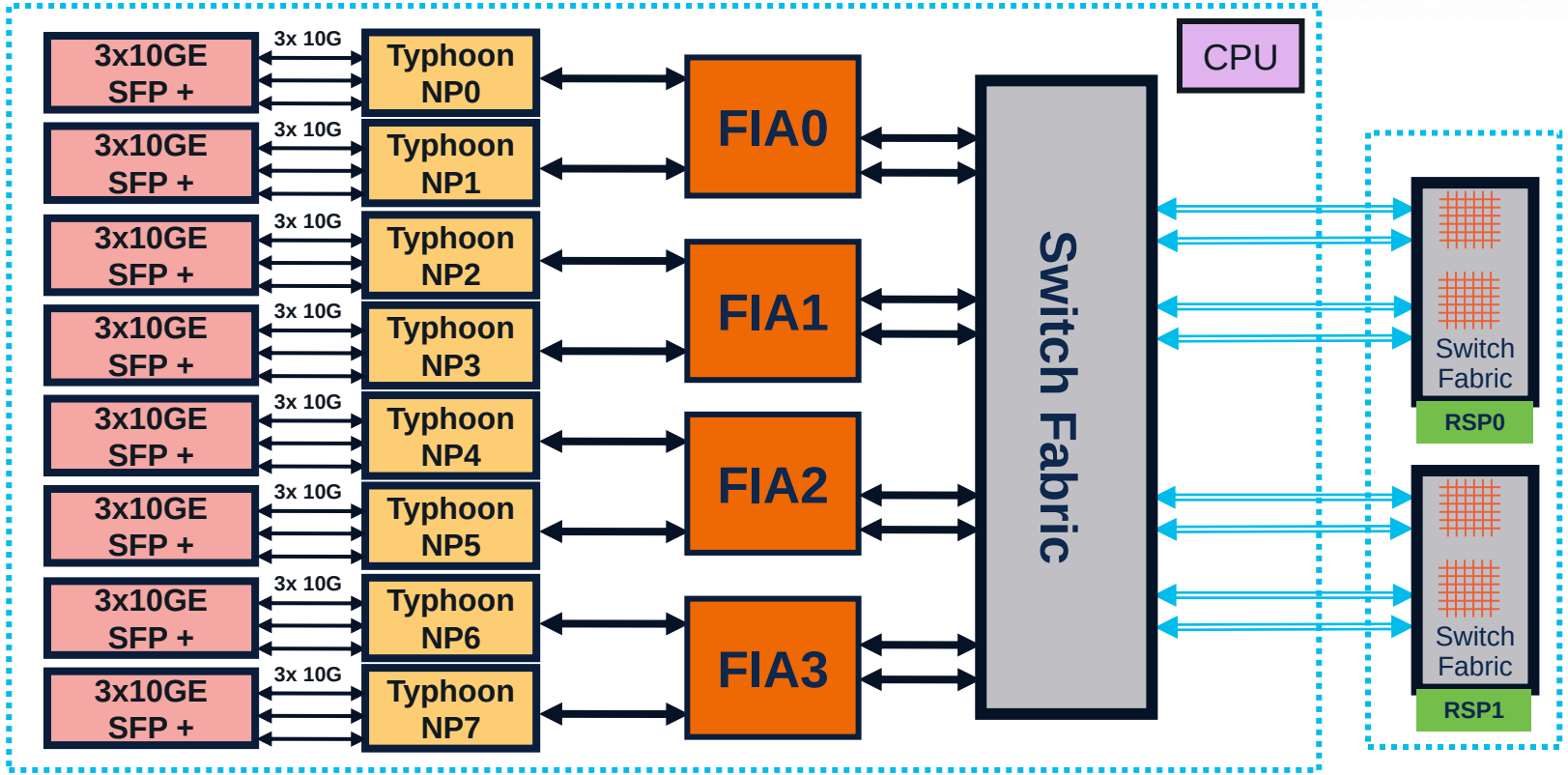
Fixed 1GE and 1/10GE Port Configuration

A9K-40GE

A9K-4T16GR

Line Cards: 2nd Generation (Typhoon)

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



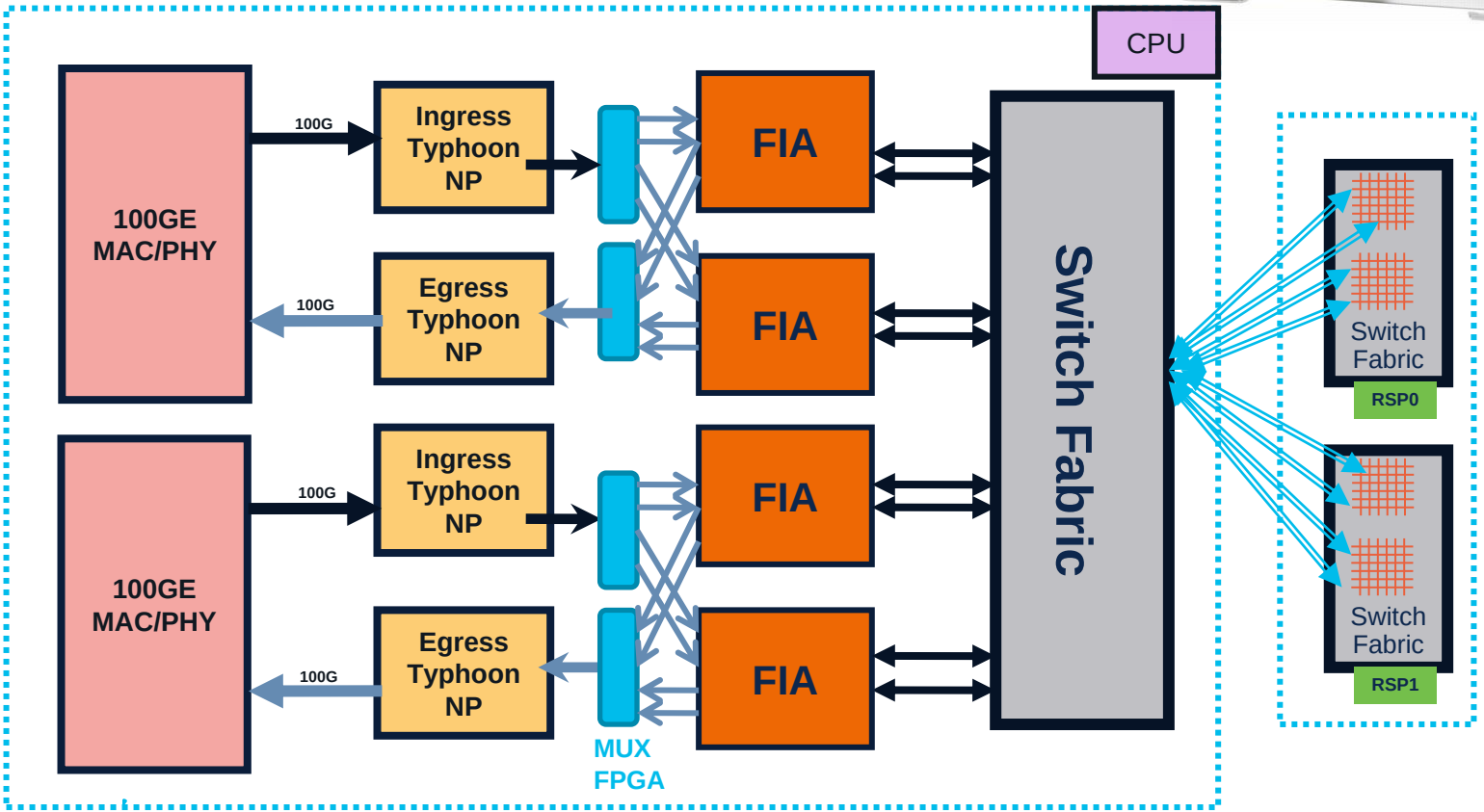
Line Cards

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

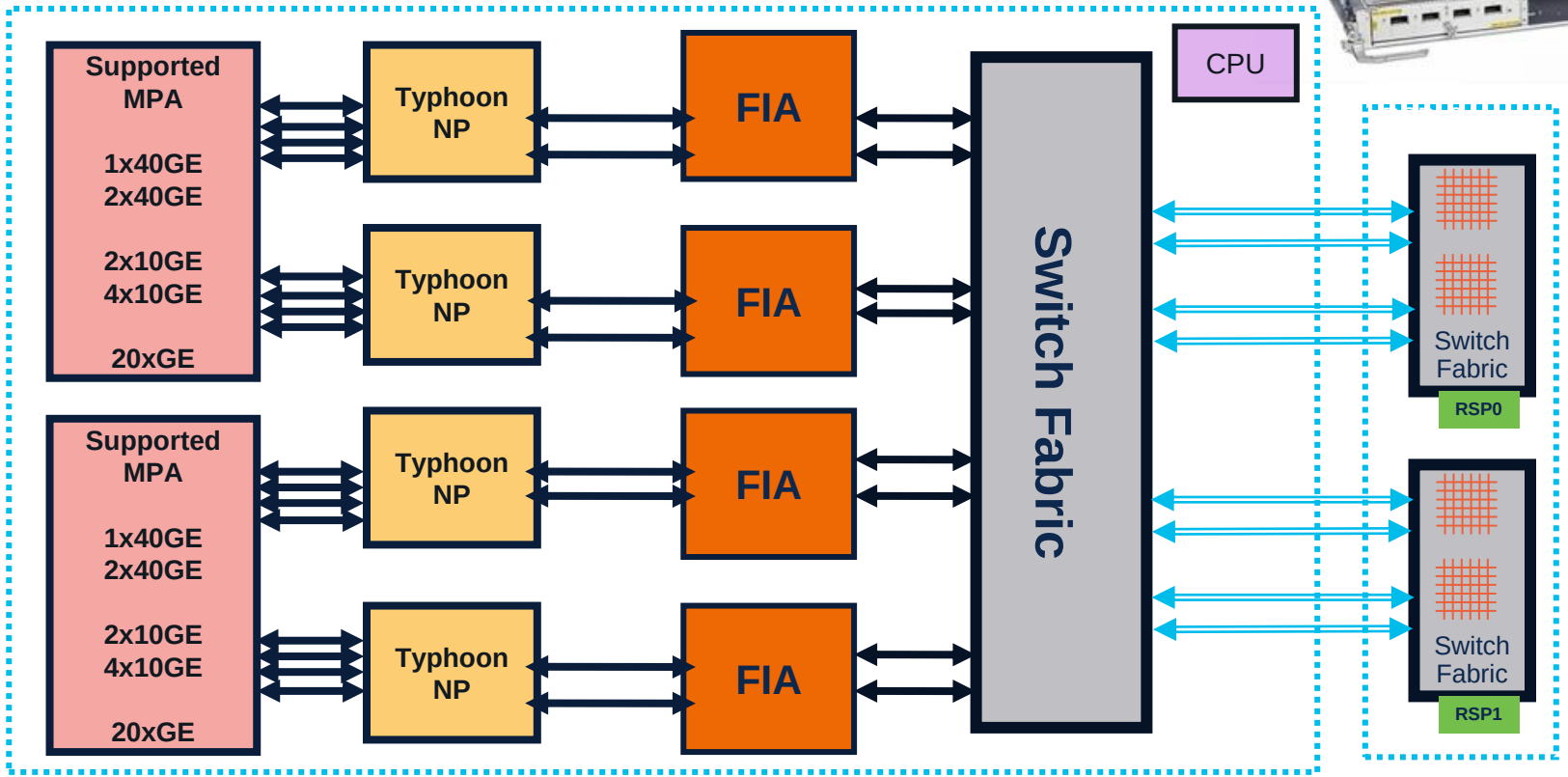
Line Card Architecture

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



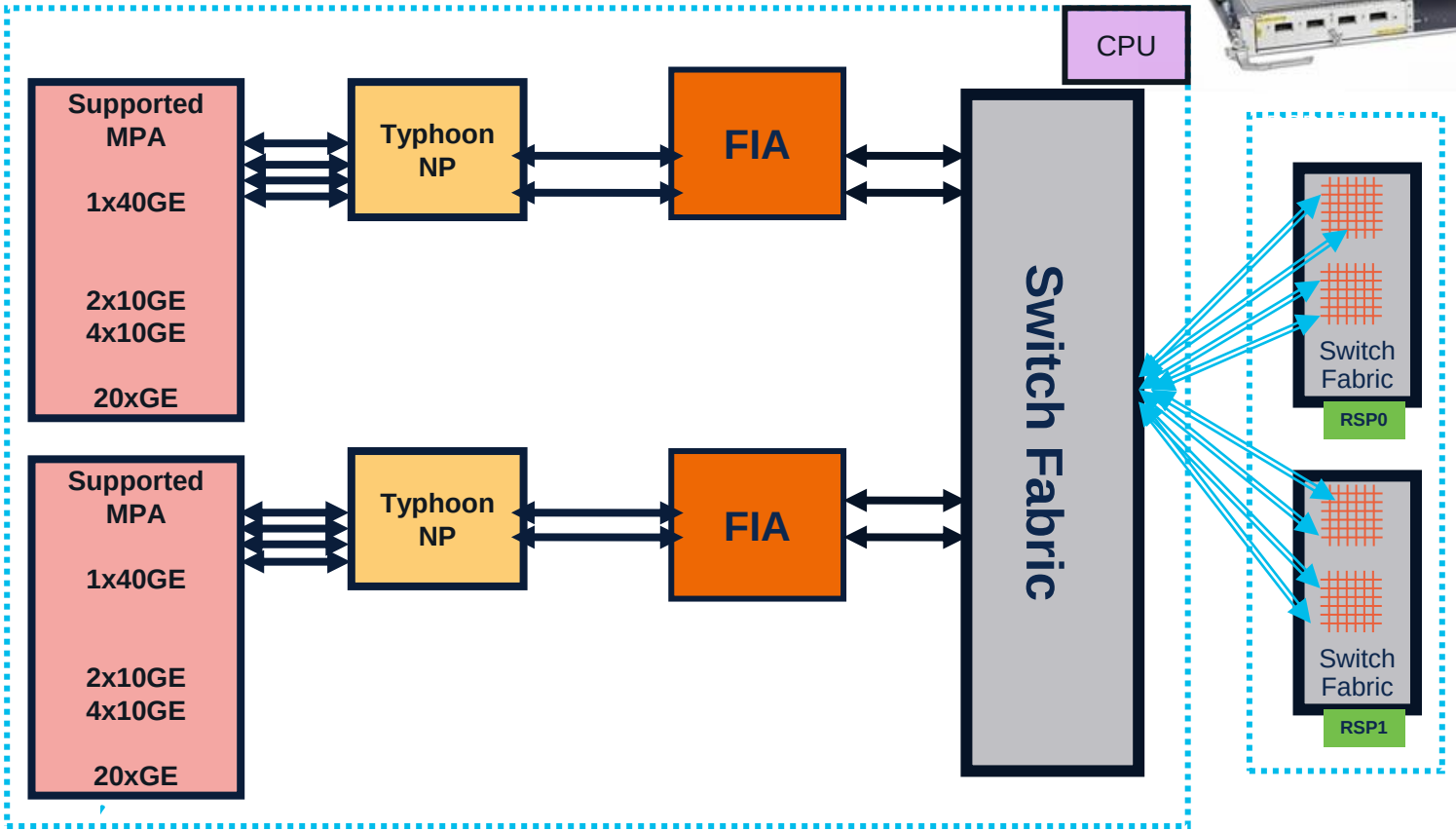
Line Card Architecture

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



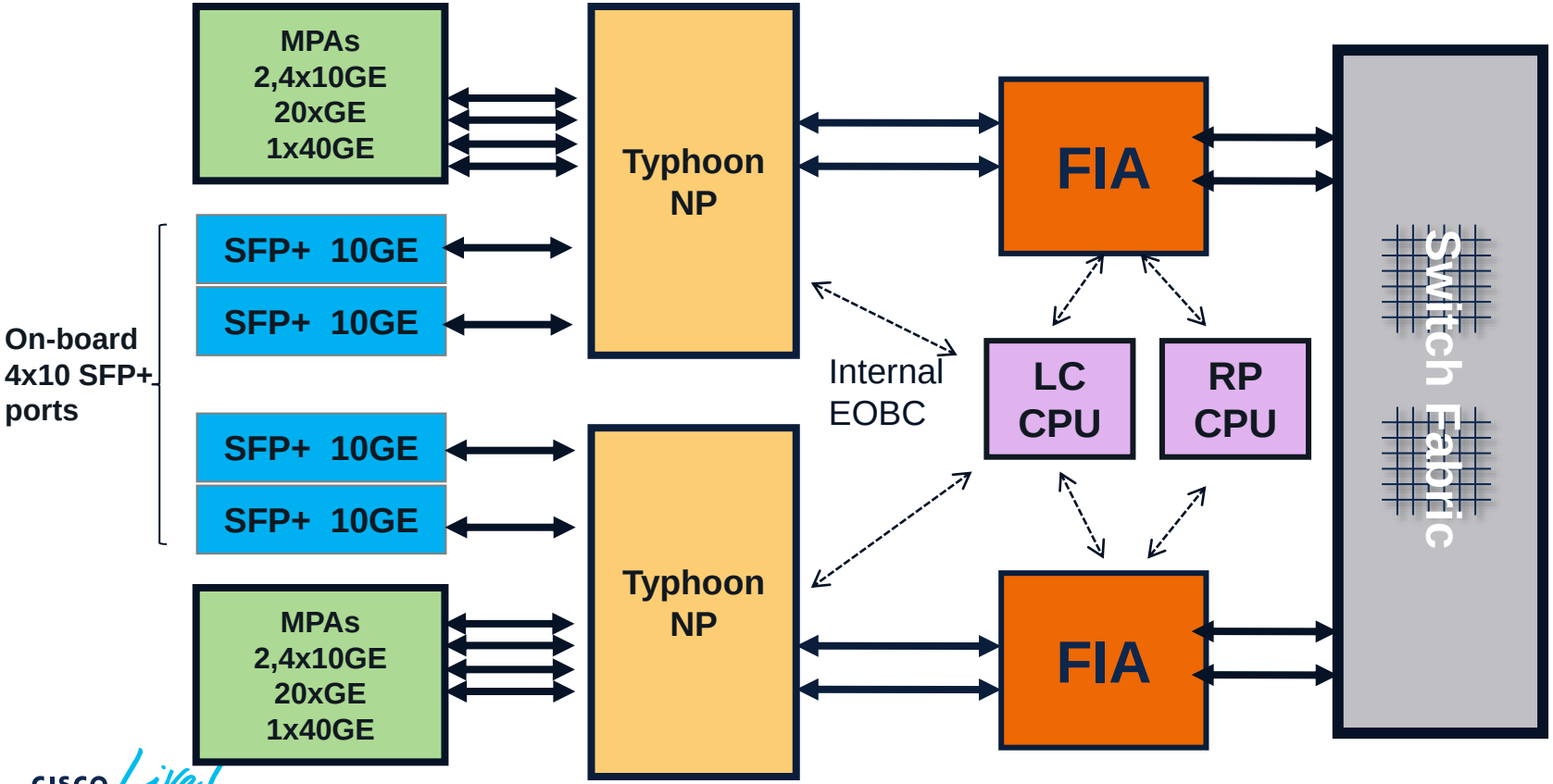
Line Card Architecture

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



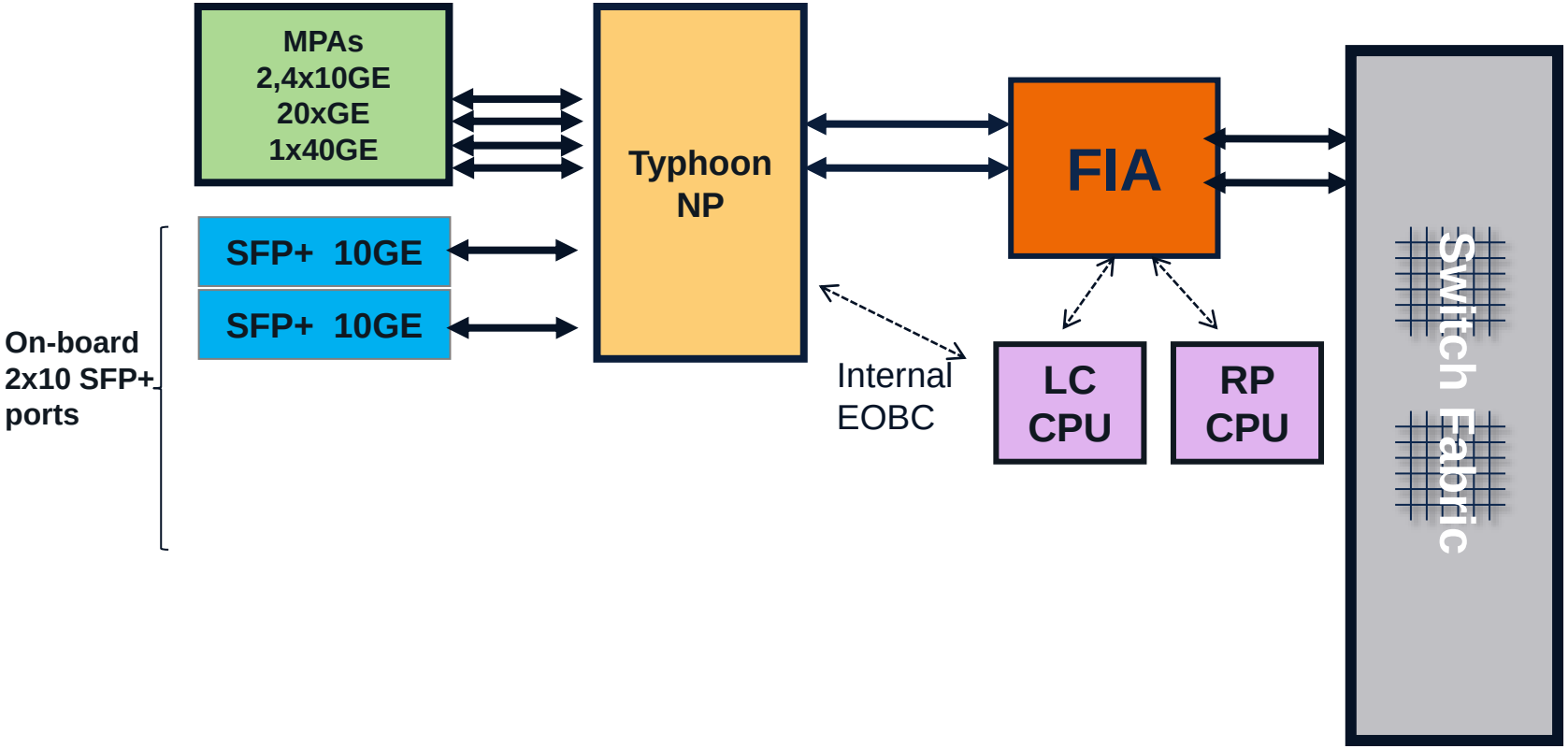
ASR 9001 Architecture

A router + LC in 2 RU



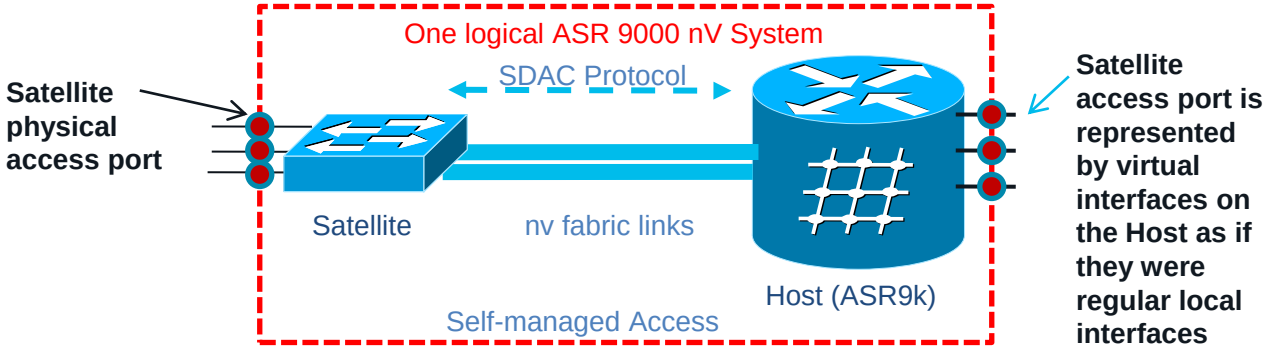
ASR 9001-S Architecture

A router + LC in 2 RU



nV Satellite

nV Satellite Overview
(Carrier class Virtual Chassis Fabric system)



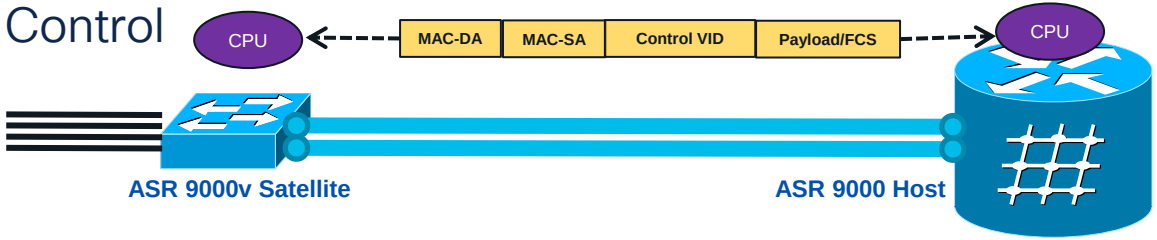
From end user point of view, satellite looks/feels/works like a ASR9K “remote or virtual” line card. The interfaces on the satellite looks/feels/works the same as the interfaces on the local ASR9K line cards

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

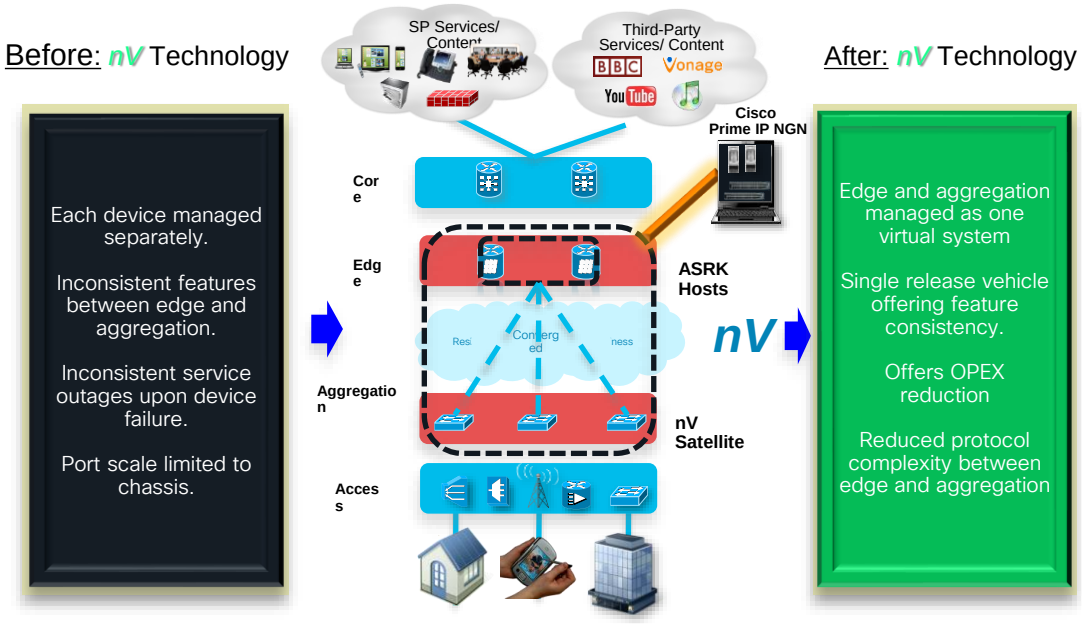
```
RP/0/RSP0/CPU0:rasr9000-2w-a#show nv satellite protocol discovery interface Bundle-
Ether 3 brief
Sat Dec 14 02:43:00.278 EST
Interface       Sat-ID  Status                          Discovered links
--------------  ------  ------------------------------  ----------------------
BE3             100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

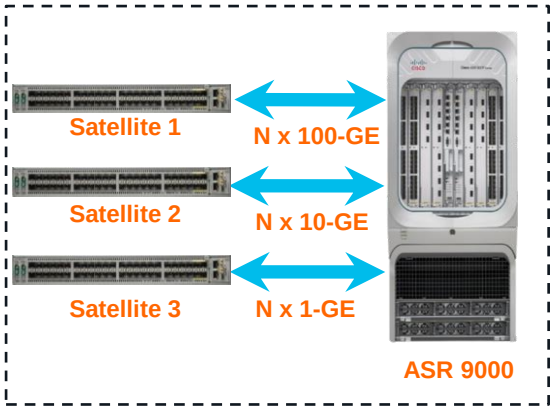
RP/0/RSP0/CPU0:rasr9000-2w-a#show nv satellite protocol control satellite 100 brief
Sat Dec 14 02:48:36.020 EST
Sat-ID  IP Address    Protocol state  Channels
------  ------------  --------------  ----------------------------------
100     10.100.111.100  Connected       Ctrl, If-Ext L1, If-Ext L2, X-link,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



The nV Satellite solution



A single logical switch / router built by interconnecting a **Host** router (ASR9K) and 1 or more smaller switches referred as "**satellites**"

Supported satellite HW: asr9000v and ncs5000

Port Density	• 400+ GigE and TenGE ports per slot, n x slot scale per chassis • Utilize Terabit scale LC capacity with flexible 1G/10G fan out and any choice of low/high power optics including DWDM and LR / ER optics
Opex Reduction	• Single point of chassis + services management - Fewer IP addresses, fewer routing adjacencies • Zero-touch provisioning, plug-n-play installation, network-wide image mgmt
Access network simplification	• Single auto-provisioned virtual switch / router system • Protocols run directly on the Hosts – Lesser protocol instances across the network
Feature consistency	•All current and upcoming IOS-XR features become immediately available on the access box at the same time. •Pre-qualified, pre-tested network level solution- Faster product qualification and faster time to revenue
New network capabilities	•New multi-chassis access redundancy •Better end to end QoS due to awareness of downstream congestion •Better NPU features from "on-loading" on the Host

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

cisco Live!

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                 Hu0/1/0/0
Hu0/1/0/1       100     Satellite ready                 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", DESCR: "Cisco NCS 5002 Series Router Fan Back"
PID: NCS-5002-FN-BK, VID: N/A, SN: N/A

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

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

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

NAME: "Satellite Chassis NCS5002 ID 100", DESCR: "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#
```

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

```
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

Always fetch "show tech-support sdac" first before the traces wrap!

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

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).
      .........
```

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

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

Show mapping from satellite Front ports to ICL port

```
RP/0/RP0/CPU0:Satellite#show l2vpn 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                    Segment 1                       Segment 2
Group      Name       ST    Description            ST       Description            ST
------------------------   ------------------------------   ------------------------------
2_6        2_6        UP    Te0/0/0/4              UP       Hu0/0/1/2.6            UP
------------------------------------------------------------------------------------------
```

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

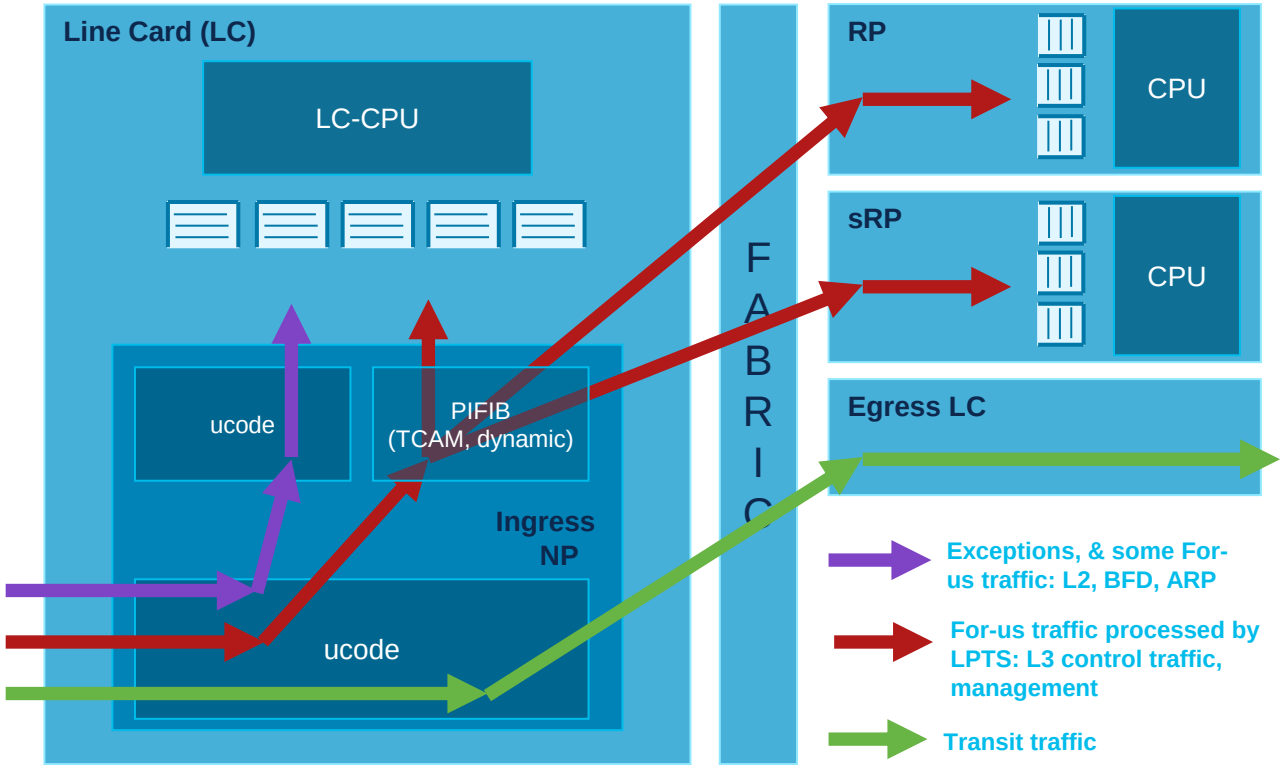
- **System architecture**
  Control and forwarding paths and components
- **Control and exception traffic**
  Internal forwarding, and security
- **Transit frame forwarding**
  L3/L2 unicast/multicast in hardware
- **MPLS operation**
  Forwarding & service labels in hardware
- **Troubleshooting**
  Counters, discards, and packet/frame capture

2 Control, Management, & Security

Traffic: Transit, For us, and Exceptions

Differentiate on ingress NP

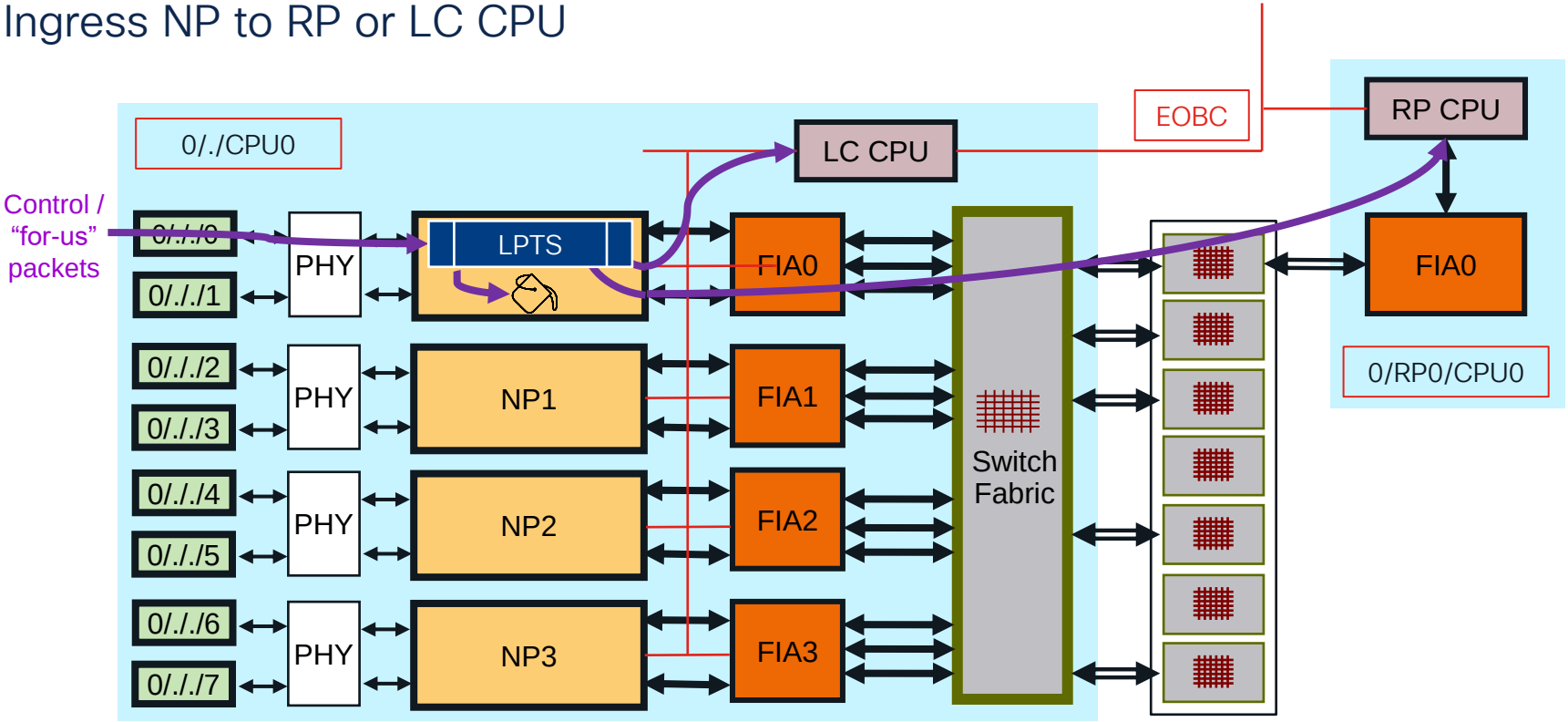
- Transit
  - Look up, re-write, forward
- For us
  - Destined to RP, or link local scope
  - Punt to RP or ingress LC CPU
- Exception
  - MTU failure, TTL failure, etc. Should have been transit
  - Punt to LC CPU



Control [For-us] Traffic

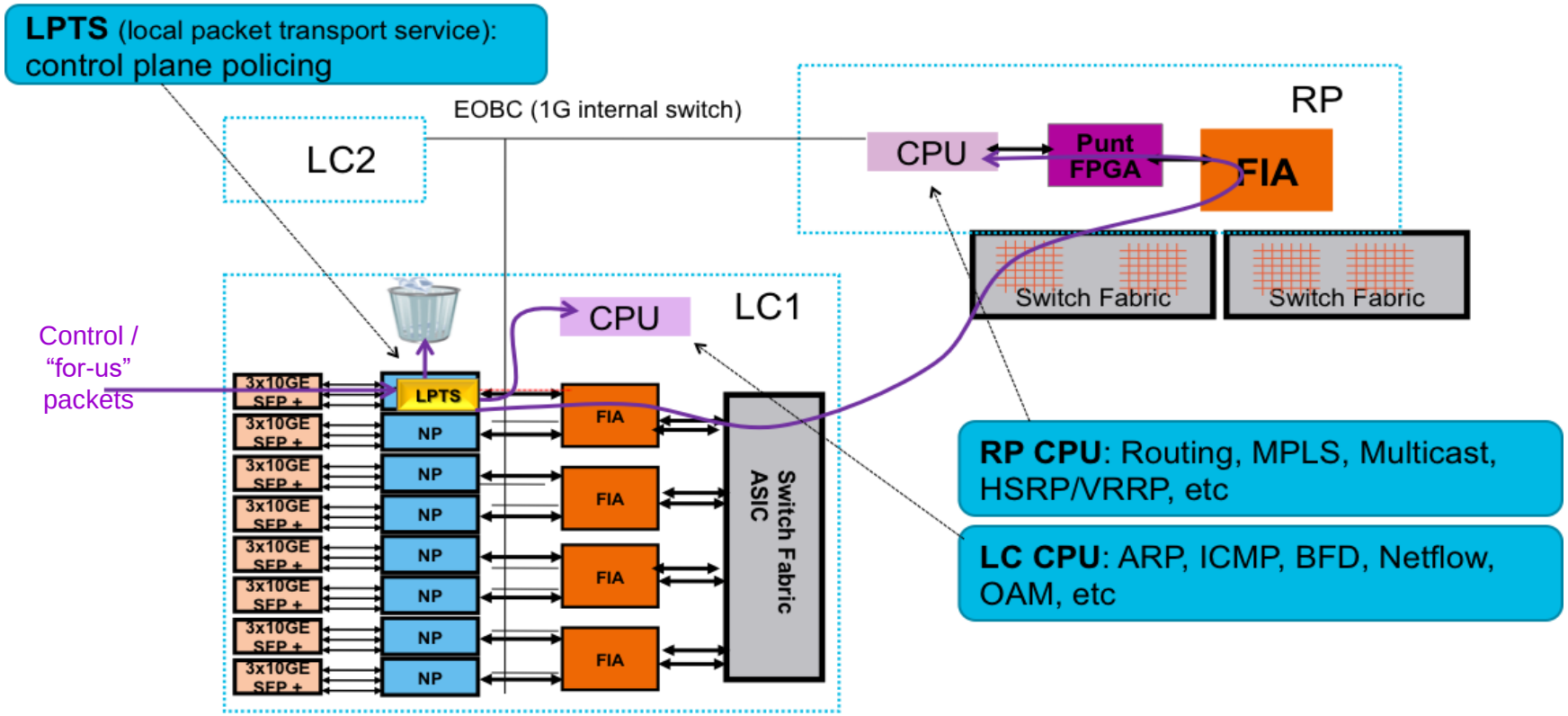
For Us Frame Path

Ingress NP to RP or LC CPU



For Us Frame Path

From ingress NP to RP CPU or LC CPU



For Us Frame Path

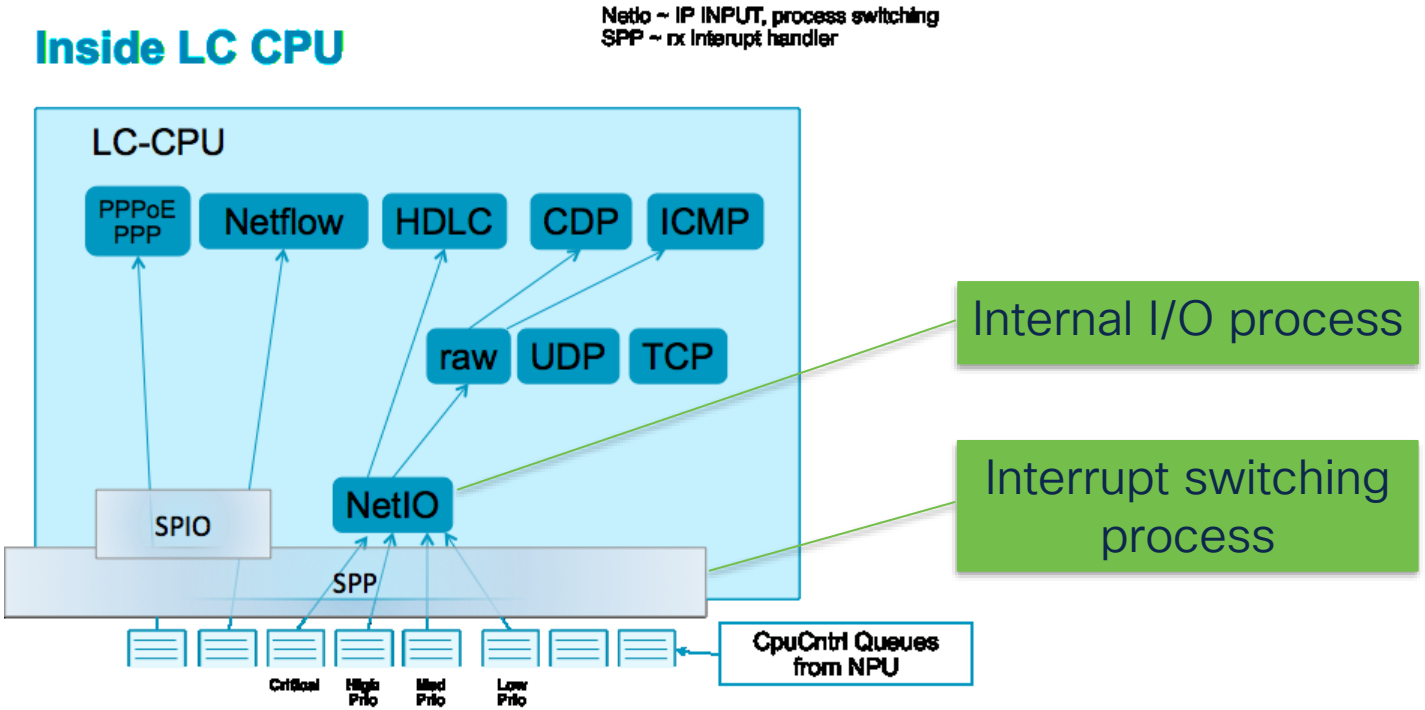
The internal FIB [IFIB]

```
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     3845915191
.
TCP-default      164     Local   150000     2000       49872016     8066163019
.
-------------------------
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
  Outpu
  Drive
```

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
  Drive
```

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

Control Plane Protection

LPTS flow type policers

```
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 policers

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

Configured peer packets

BGP packets from unknown

```
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
--------------------------------------------------------
FlowType          Policer Type  Cur. Rate Def. Rate  Accepted        Dropped
----------------- ------- ----- --------- ---------  --------------- -----------
.
BGP-known         106    Local  50000      2500       2590            0

BGP-cfg-peer      107    Static 2000       2000       13              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
-------------------------------------------------------
                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	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
ipv4 access-list
Thu Apr  3 18:21:35.034 EDT
ipv4 access-list PE
 10 remark PE LOOPBACKS
 20 permit ipv4 10.101.0.1 0.0.255.0 any
 40 deny ipv4 any any
!
ipv4 access-list CORE
 10 permit ipv4 10.100.0.0/16 any
 20 deny ipv4 any any
!
ipv4 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

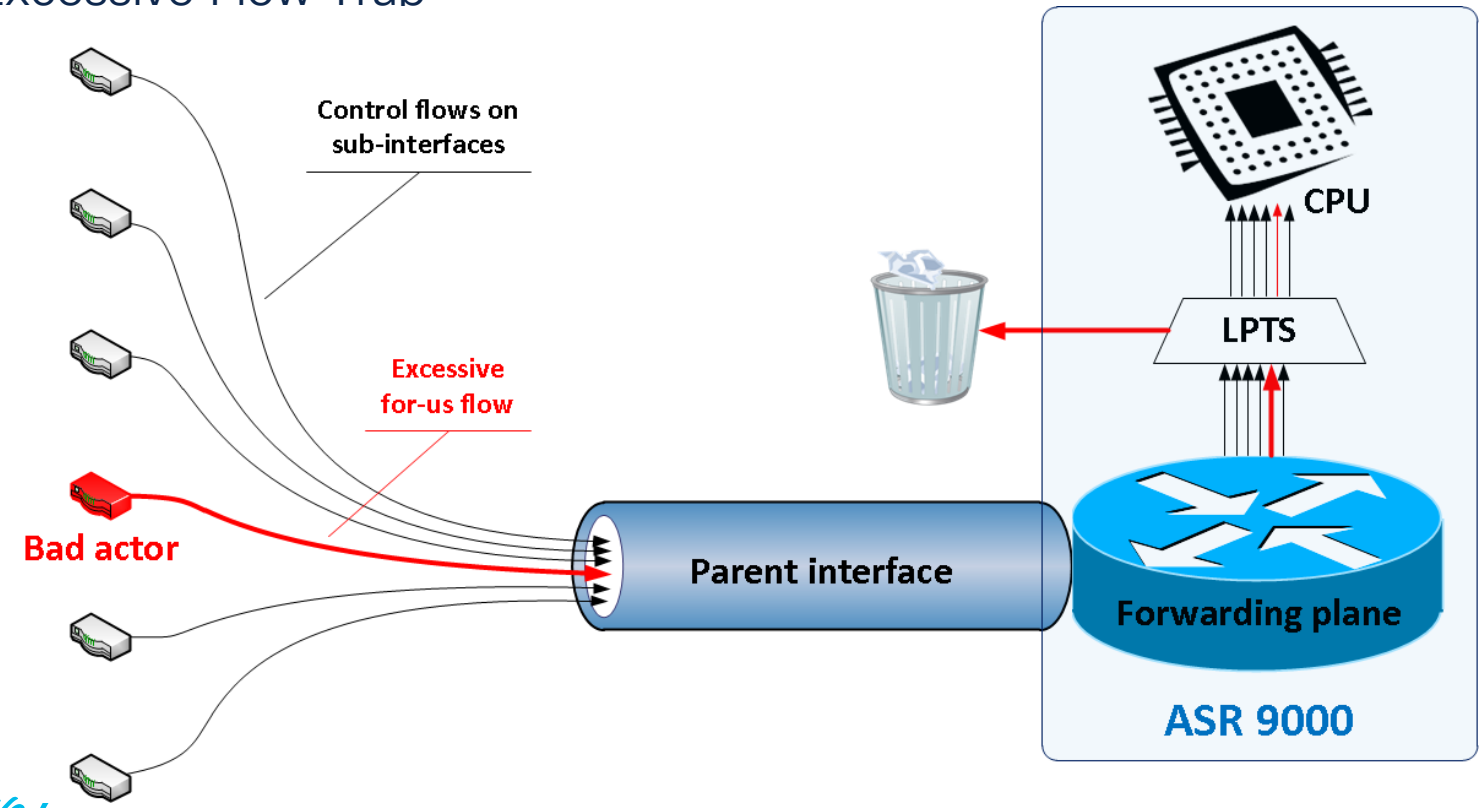
LPTS: PIFIB ACL-Based Policers

```
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
.
              Police          Penalty
              Rate (pps)      Timeout (mins)
 Protocol    Default Config   Default Config   Punt Reasons
 --------    --------------   --------------   ----------------
 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                          Location: 0/0/CPU0
            Protocol: ****                             Punt Reason: VRRP
       Penalty Rate: 10 pps                         Penalty Timeout: 15 mins
     Time Remaining: 8 mins 22 secs

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
```

Exception Punt

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 …

Management

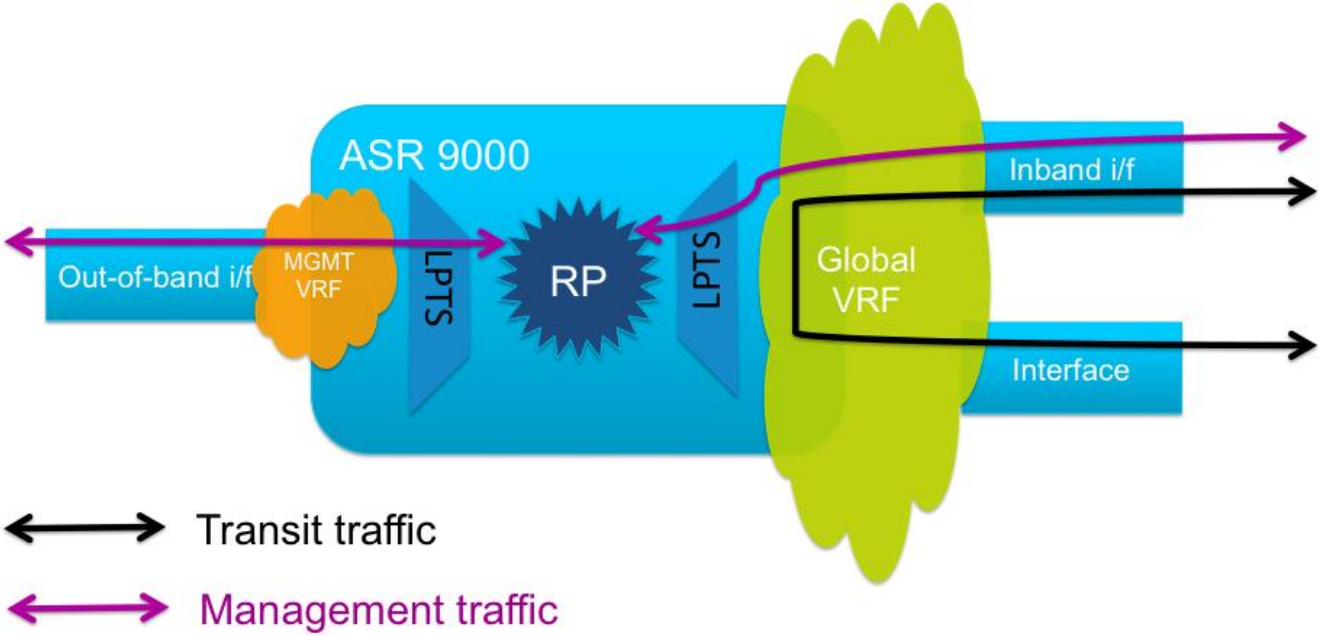
Management

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'
```

Agenda

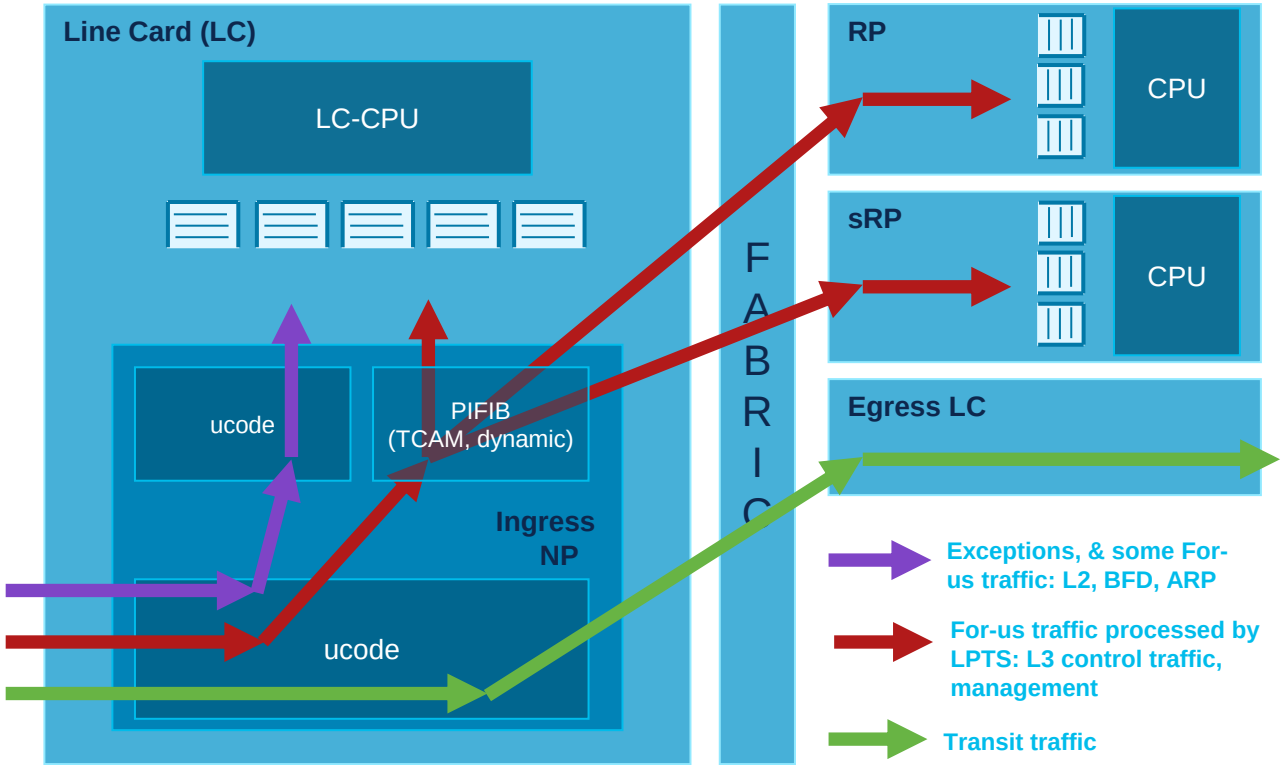
- System architecture
  Control and forwarding paths and components
- Control and exception traffic
  Internal forwarding, and security
- Transit frame forwarding
  L3/L2 unicast/multicast in hardware
- MPLS operation
  Forwarding & service labels in hardware
- Troubleshooting
  Counters, discards, and packet/frame capture

3 Transit Packet/Frame Journey

Traffic: Transit, For us, and Exceptions

Differentiate on ingress NP

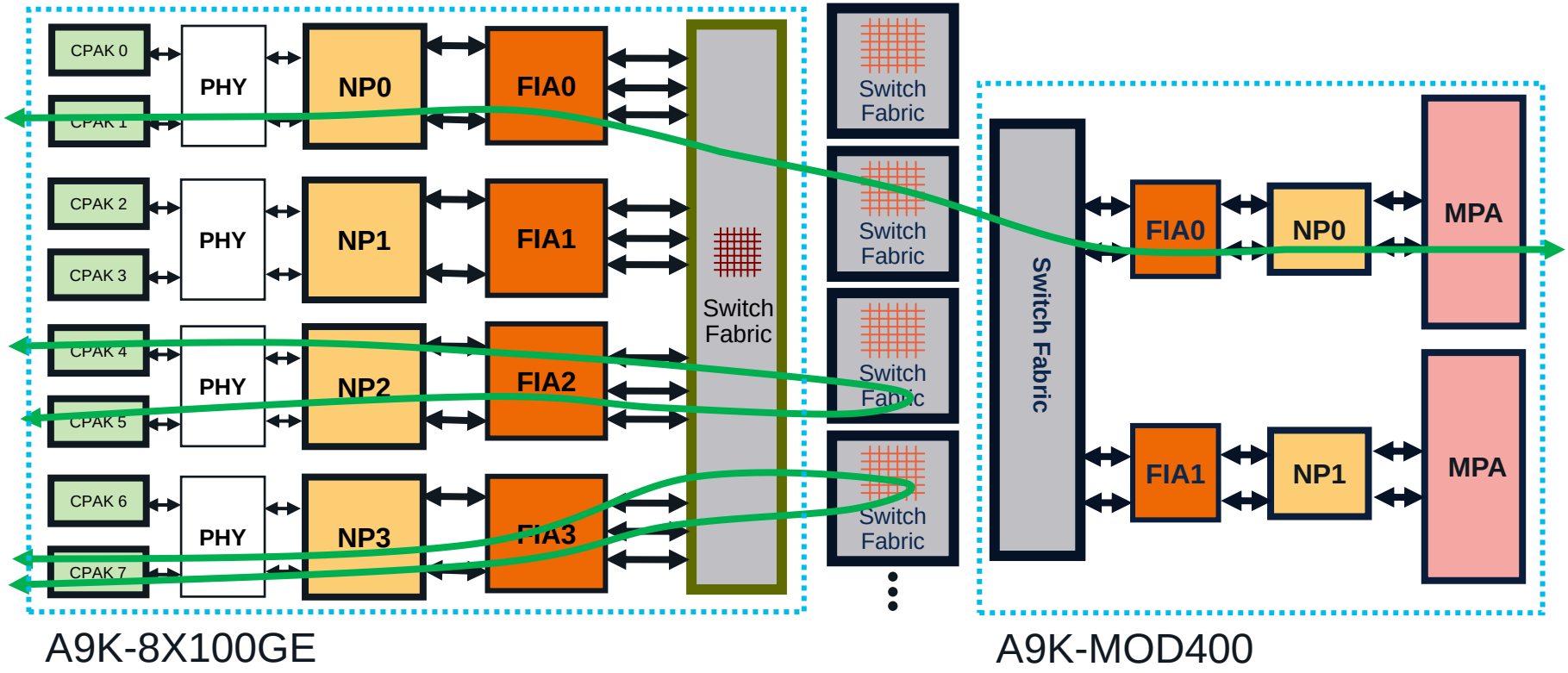
- Transit
  - Look up, re-write, forward
- For us
  - Destined to RP, or link local scope
  - Punt to RP or ingress LC CPU
- Exception
  - MTU failure, TTL failure, etc. Should have been transit
  - Punt to LC CPU



L3 Unicast Packet Forwarding

Unicast Transit Frame Path

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



Unicast Transit Frame Path

Forwarding

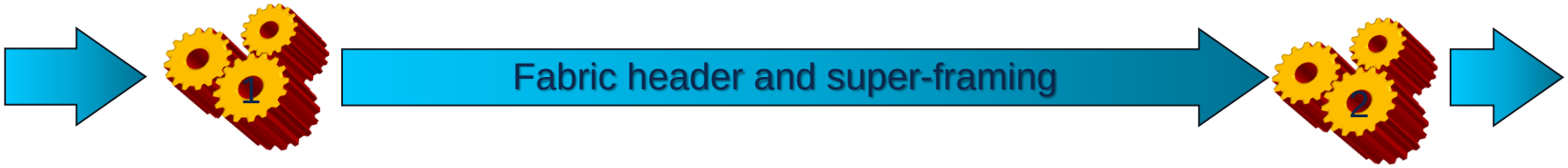
- All frames take same path stages
  - Ingress physical => ingress NP => FIA => fabric => FIA => egress NP => egress physical
  - Super-framing in fabric, and per super-frame load sharing
- Two stage forwarding
  - Ingress NP: to which egress port, ingress encap (if tunneling) and ingress features
  - 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

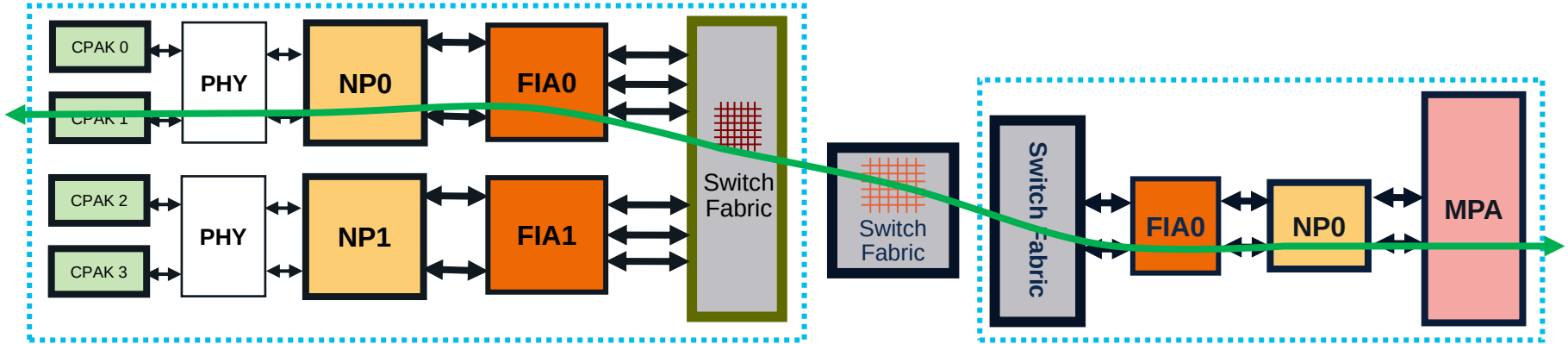
Unicast Two Stage Forwarding

By ingress NP and egress NP

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

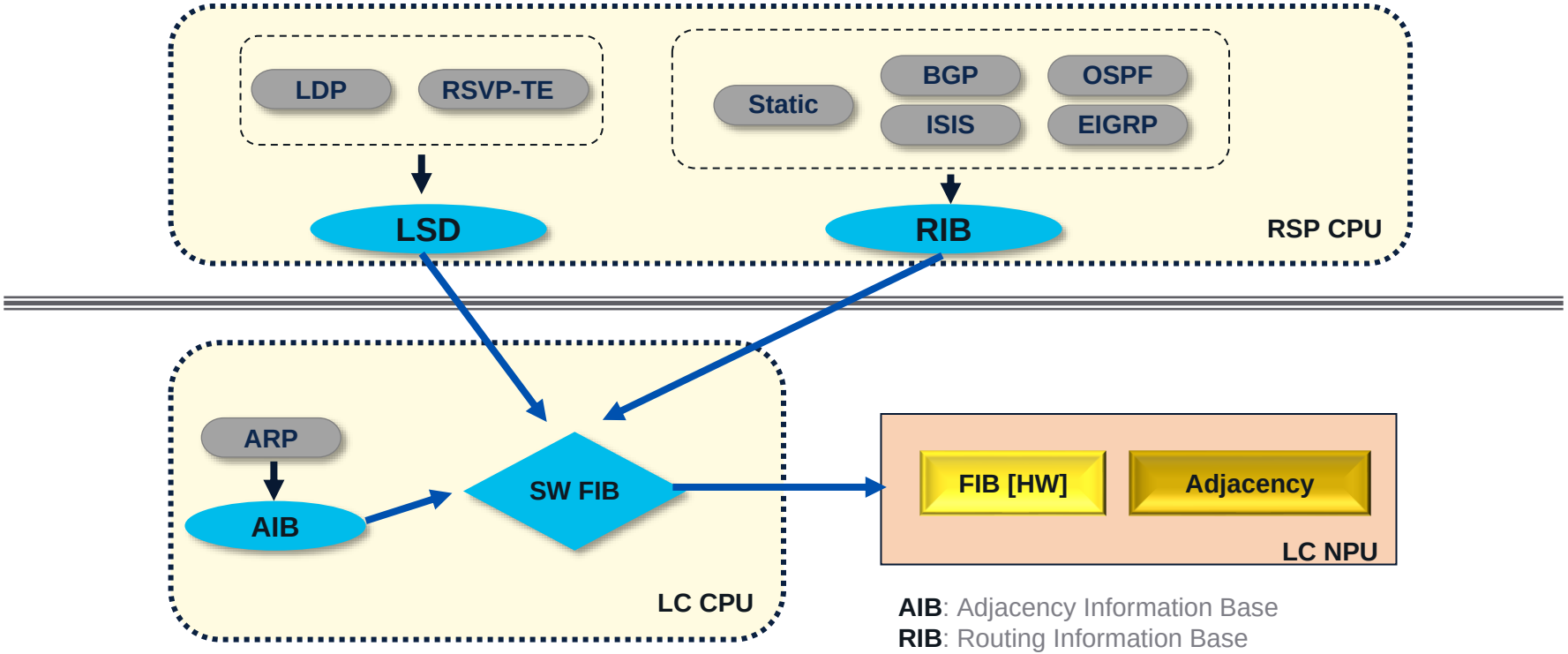
Second stage: lookup on **egress NPU** → Egress port and rewrite information





The NP FIB

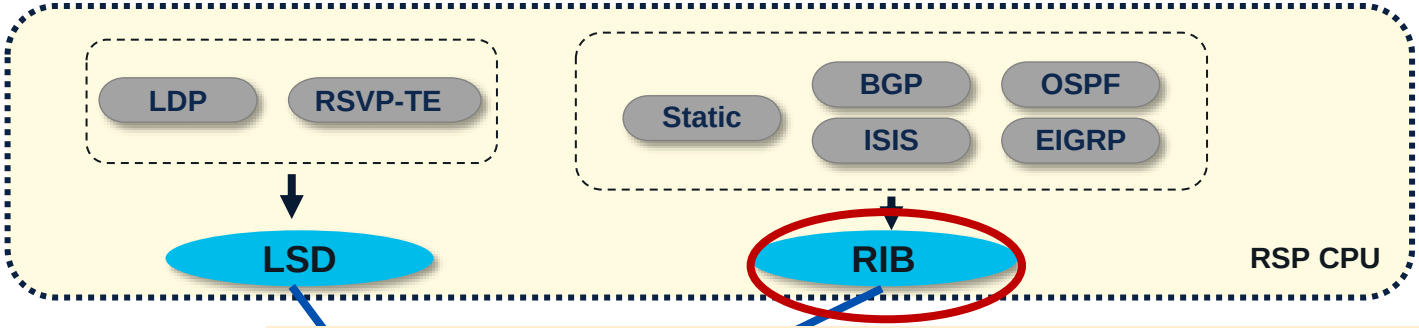
From RP control plane to data plane NP

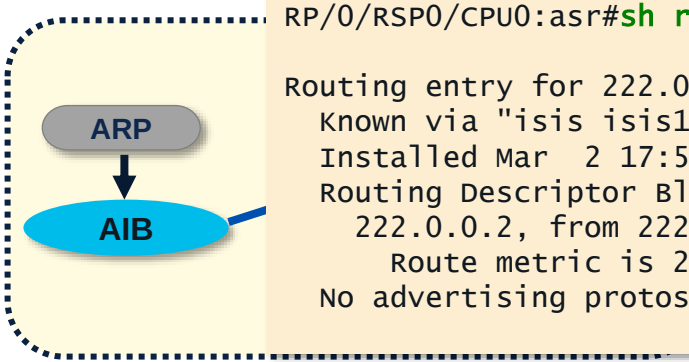


AIB: Adjacency Information Base
RIB: Routing Information Base
FIB: Forwarding Information Base
LSD: Label Switch Database

The NP FIB

RIB info: example





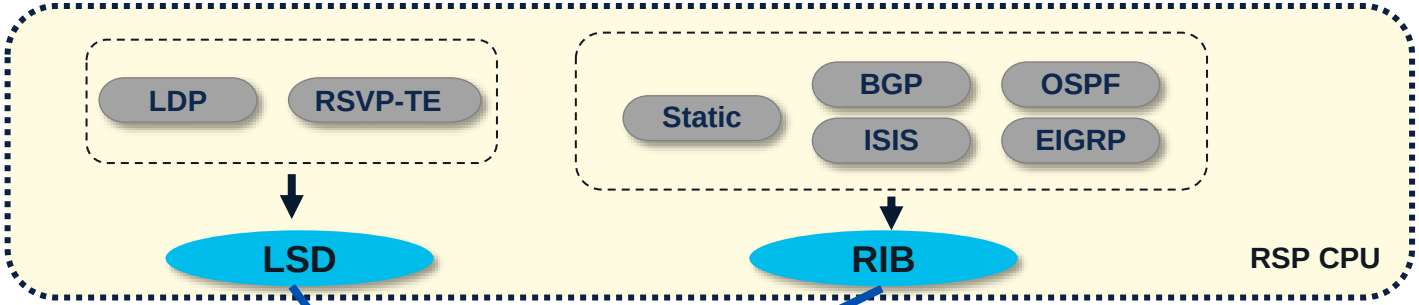

```
RP/0/RSP0/CPU0:asr#sh route 222.0.0.6/31

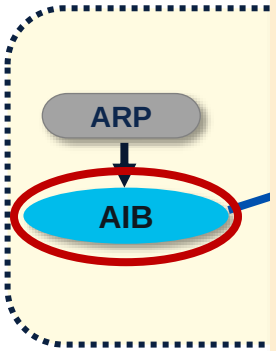
Routing entry for 222.0.0.6/31
  Known via "isis isis1", distance 115, metric 20, type level-1
  Installed Mar  2 17:58:12.251 for 00:00:47
  Routing Descriptor Blocks
    222.0.0.2, from 222.2.2.1, via TenGigE0/1/0/3
      Route metric is 20
  No advertising protos.
```

RIB: Routing Information Base
FIB: Forwarding Information Base
LSD: Label Switch Database

The NP FIB

Line card adjacency






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

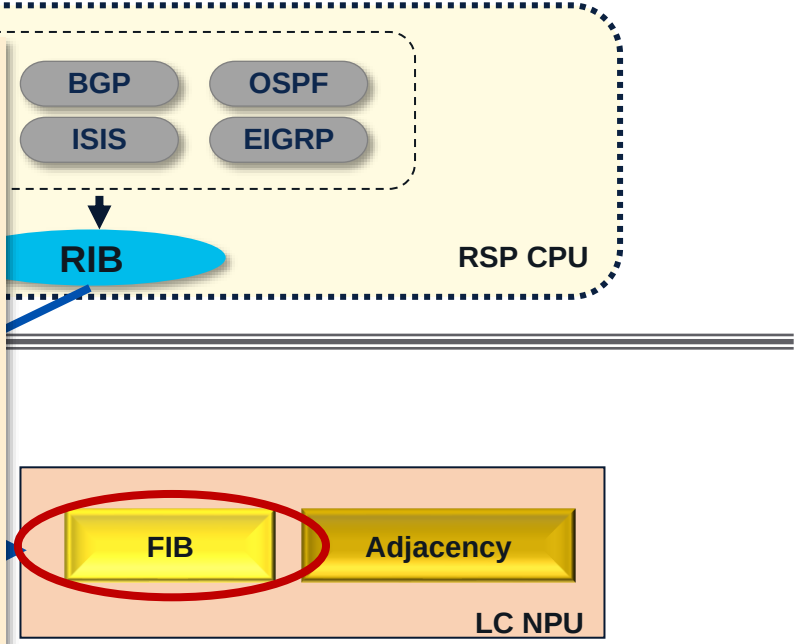
Adjacency table (version 26) has 19 adjacencies:
     11 complete adjacencies
      8 incomplete adjacencies
      0 deleted adjacencies in quarantine list
      8 adjacencies of type IPv4
          8 complete adjacencies of type IPv4
          0 incomplete adjacencies of type IPv4
          0 deleted adjacencies of type IPv4 in quarantine
list
          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

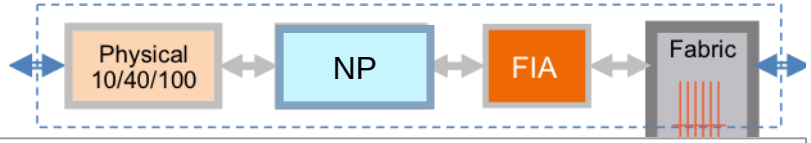
  Non Recursive Leaf:
  -------------------
    ldi ptr    : 10936 (0x2ab8)       igp statsptr:0
  rpf ptr :    0x0000
```



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

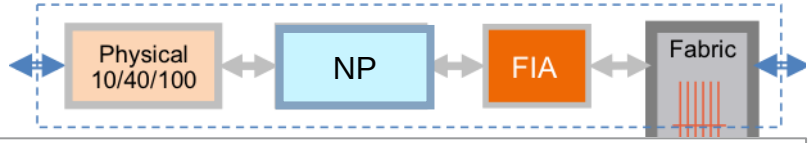
RP/0/RSP0/CPU0:rasr9k-1y#show controllers NP ports all location 0/0/CPU0
Fri Feb 22 15:57:32.307 UTC
                  Node: 0/0/CPU0:
----------------------------------------------------------------
NP Bridge Fia                          Ports
-- ------ --- -------------------------------------------------
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

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          0x0          0x0          0x0          0x0          0x0
0x0
out_tm_qid_fid1     0x0          0x0          0x0          0x0          0x0          0x0          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, TenGigE0/4/0/20.6, 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
                   iptunl_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
    l3_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
  l3_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
    rsvd flag bits: 0            encap_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
    l3_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
        rsvd flag bits   : 0        encap_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

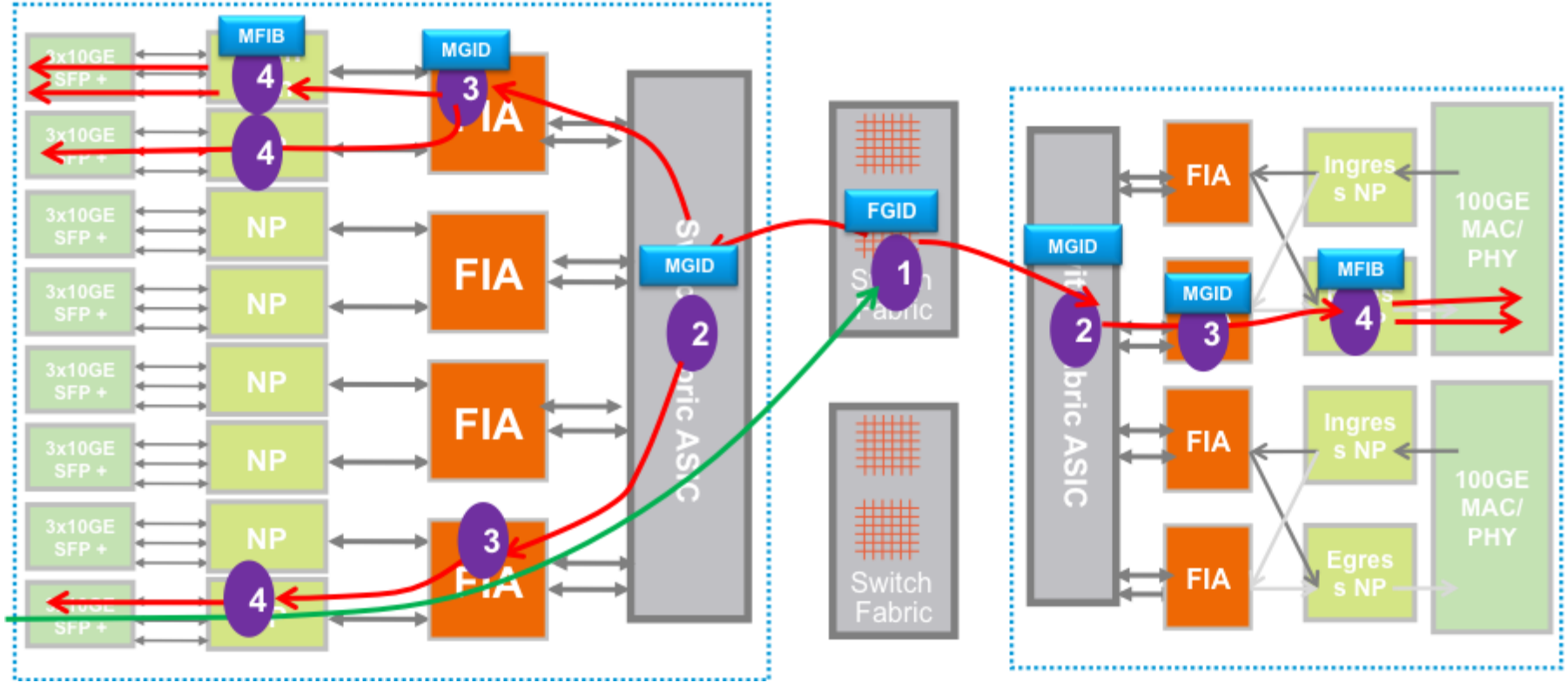
    adj_resolve_control_byte2
                    rx_lag_adj: 0
rx_adj_null0: 0
                   rp_destined: 0
rx_punt: 0
                       rx_drop: 0
    sfp/vqi          : 0x5c
    if_handle        : 0x640

.
```

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

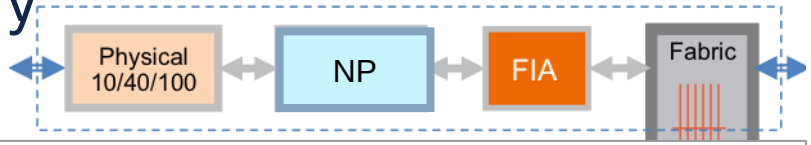
IP Multicast Routing Information Base
Entry flags: L - Domain-Local Source, E - External Source to the Domain,
.

(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



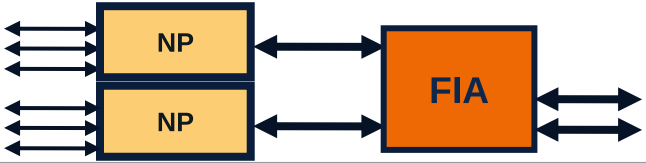

```
RP/0/RSP0/CPU0:rasr9k-1y#show mfib hardware route detail 232.1.1.1 172.30.1.1 location 0/4/CPU0
Tue Feb 26 18:09:54.515 UTC
LC Type: Typhoon A9K-24x10GE-TR
.
Source: 172.30.1.1       Group: 232.1.1.1       Mask: 64  RPF Int: Te0/0/0/2
MGID: 16903      MLI: 5          Fabric Slotmask: 0x41       FGID: 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  0x
  2  F  F  F  F  F  F  F  0x640       0  0    F  F  F  F  F  0x0  0x
  3  F  F  F  F  F  F  F  0x640       0  0    F  F  F  F  F  0x0  0x
  4  F  F  F  F  F  F  F  0x640       0  0    F  F  F  F  F  0x0  0x
  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
  ------------------------------------------------------------------------------

  Software MGID Information
  ------------------------------------------------
  MGID: 16903 Mask: 0x41  Old MGID: 0 Old Mask: 0x1
  ------------------------------------------------
```

Outgoing interface count per NP

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

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
```

MGID

Egress LC

Fabric to 1st & 2nd FIA

FIA to 2nd NP

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
  ------------------------------------------------------------------------
  Interface Statistics:
  ------------------------------------------------------------------------
  C   Interface       F/P/D (packets:bytes)
  ------------------------------------------------------------------------
  1   Gi100/0/0/9     18212651:4917382603 / 0:0 / 0:0
  ------------------------------------------------------------------------
```

Received on NP0

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

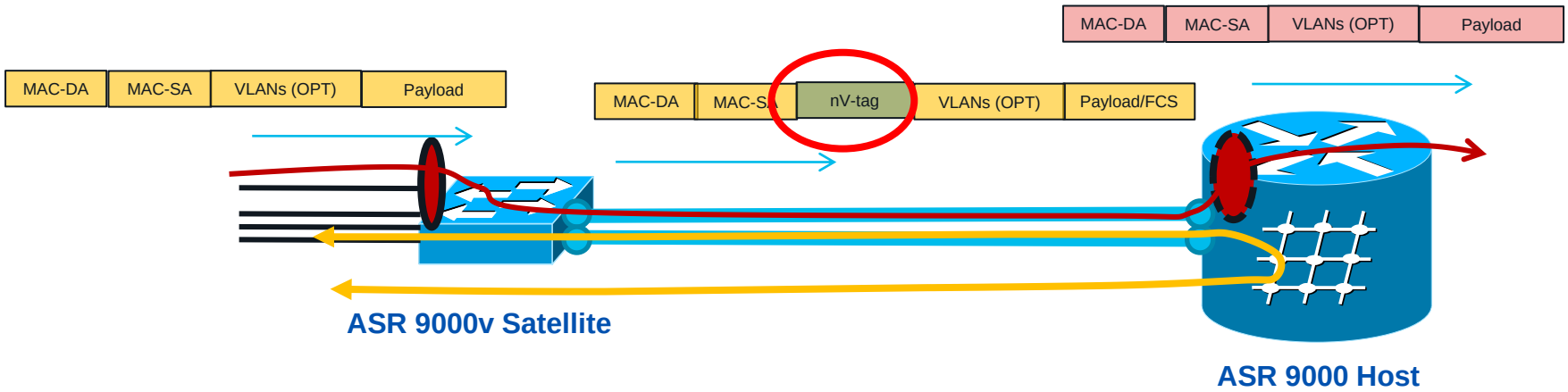
```
RP/0/RSP0/CPU0:rasr9k-1y#show l2vpn forwarding bridge-domain BRIDGES:DOMAIN-A mac-address
hardware ingress location 0/4/CPU0
Fri Feb 22 18:50:08.433 UTC
 To Resynchronize MAC table from the Network Processors, use the command...
    l2vpn resynchronize forwarding mac-address-table location <r/s/i>

Mac Address    Type    Learned from/Filtered on    LC learned Resync Age          Mapped to
--------------------------------------------------------------------------------
0000.c001.0167 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”

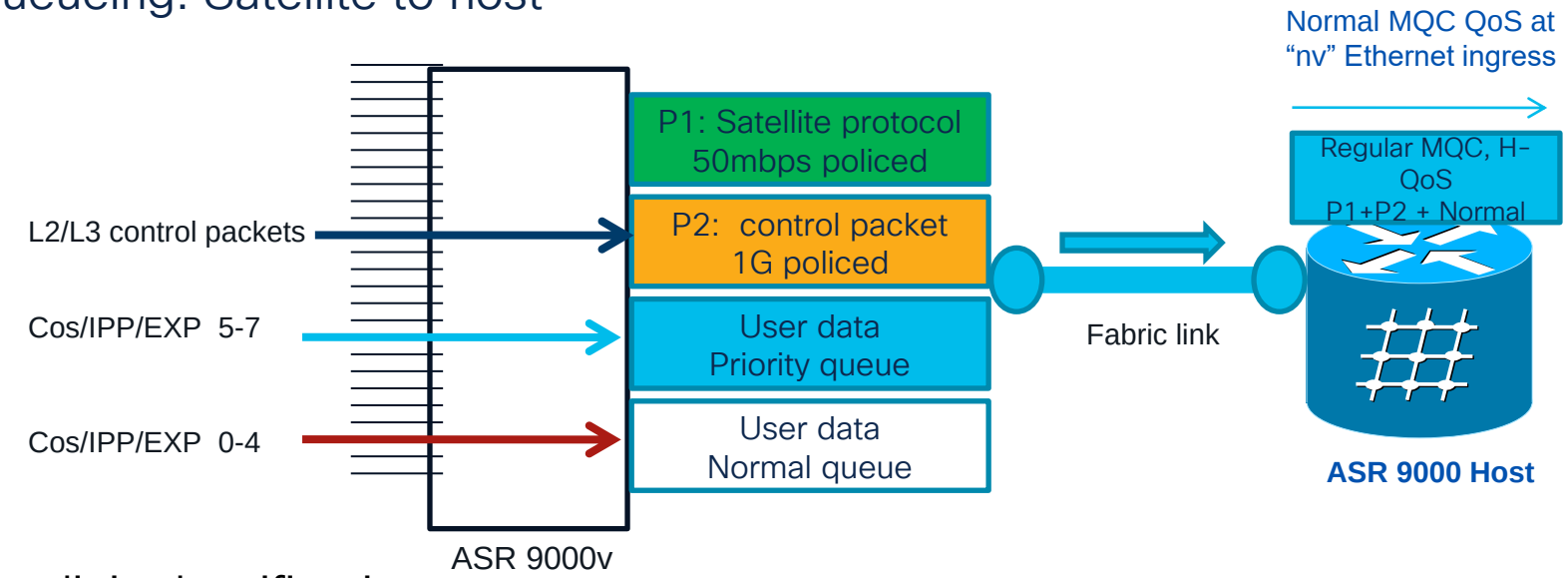
Traffic flow



- “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”

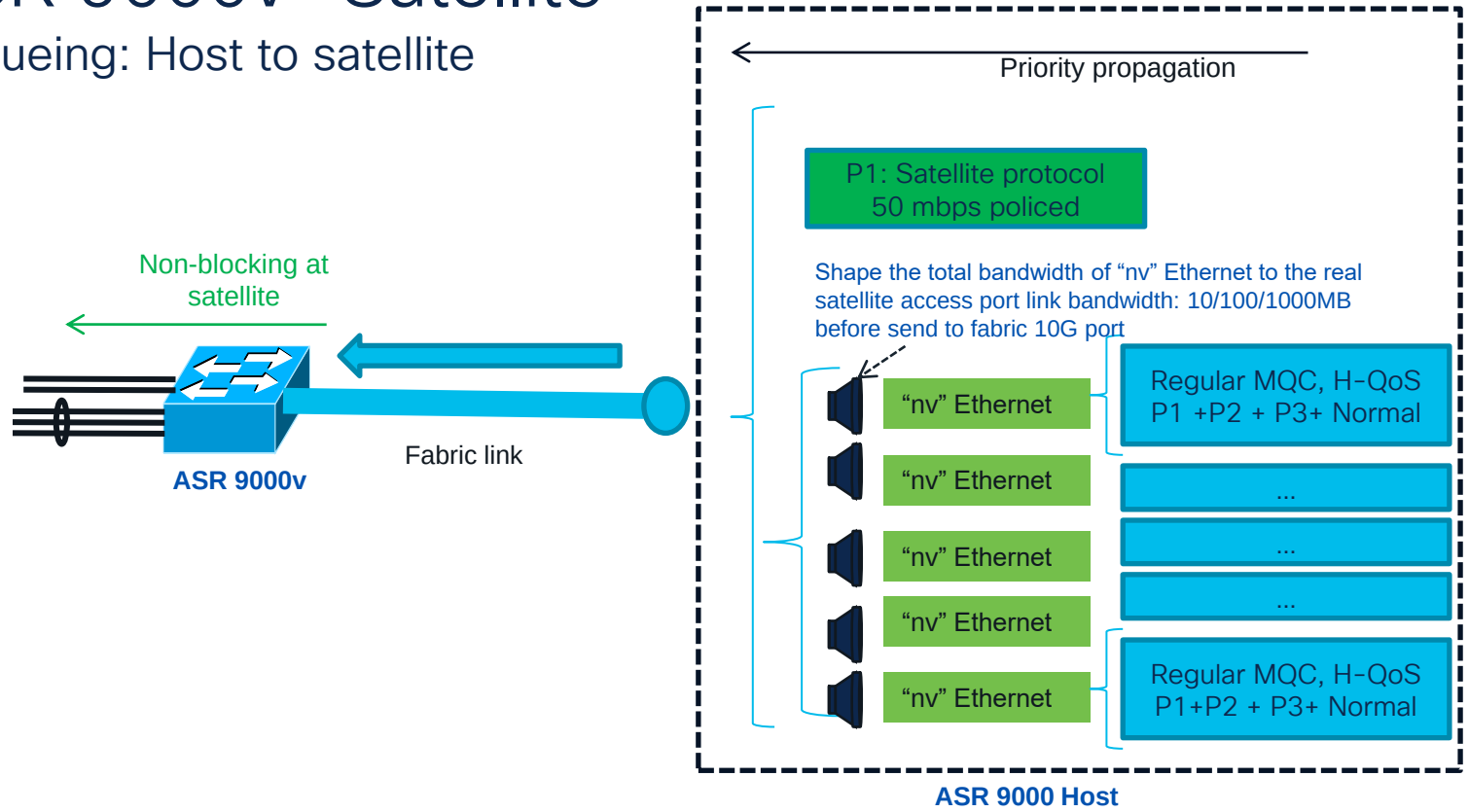
Queueing: Satellite to host



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

ASR 9000v “Satellite”

Queueing: Host to satellite

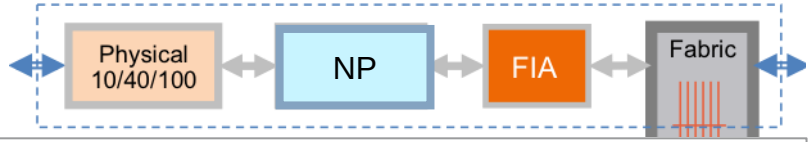


Under the Hood: Inside NP, FIA, and Fabric

cisco Live!

Frame Path: Stats & Drops

Reading the physical counters




```
RP/0/RSP0/CPU0:rasr9k-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

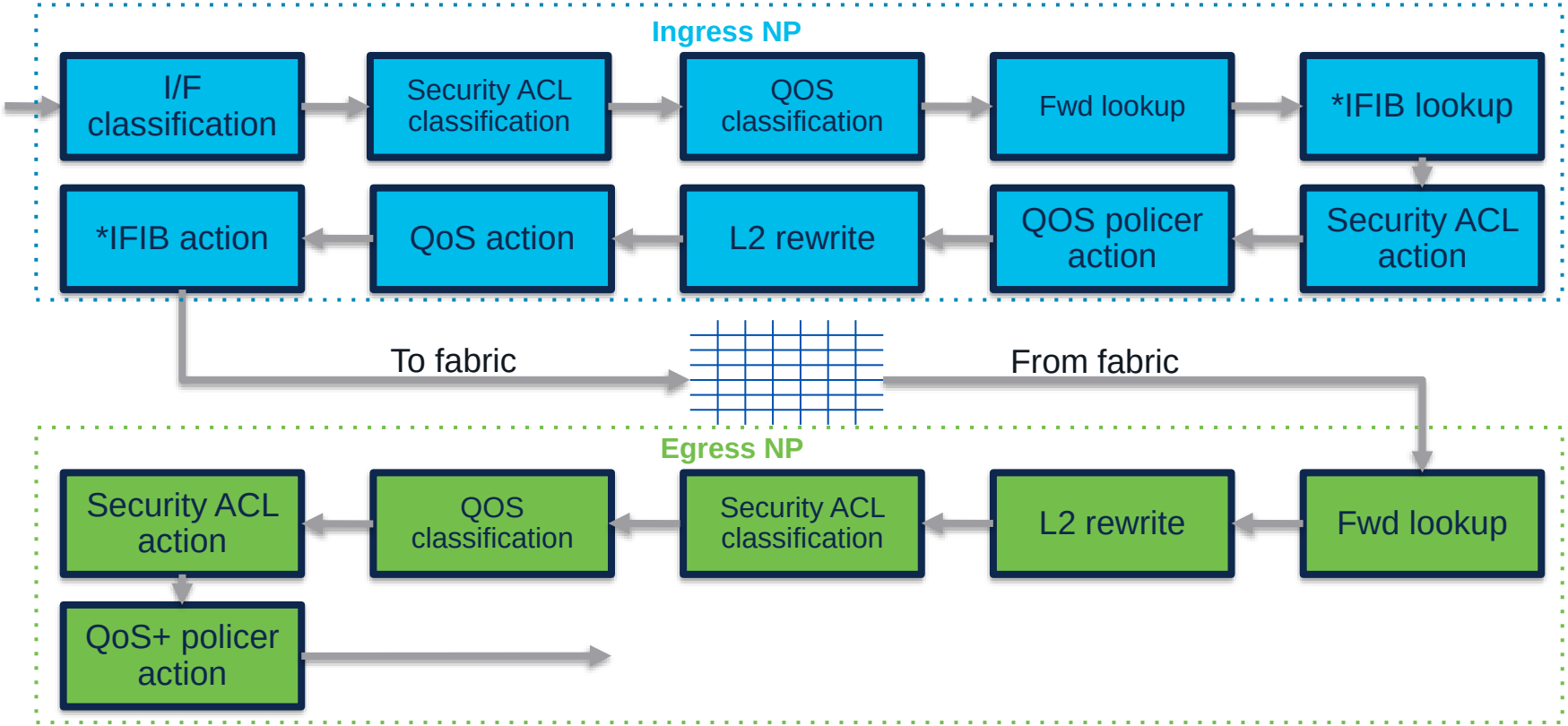
    Output total packets        = 21895707
    Output 802.1Q frames        = 0
    Output pause frames         = 0
    Output pkts 64 bytes        = 21665536
    Output pkts 65-127 bytes    = 21179
    Output pkts 128-255 bytes   = 168767
    Output pkts 256-511 bytes   = 40225
    Output pkts 512-1023 bytes  = 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_RCVD                                    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:
----------------------------------------------------------------

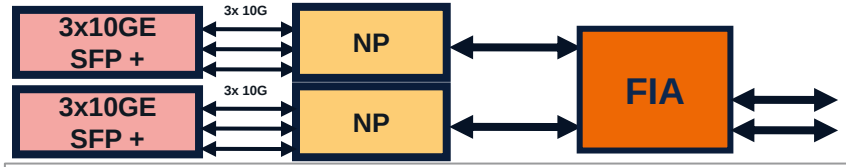
==== TM Counters (NP 1 TM 0) ====
 TM Counters:
xmt paks: 897909308598,  xmt bytes: 62723686013270
drop paks: 29466027670,  drop_bytes: 2003689898884
```

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 Spaui Drop-0                          0
                   accpt tbl-0                          0
                     ctl len-0                          0
                   short pkt-0                          0
                 max pkt len-0                          0
                 min pkt len-0                          0
             From Spaui Drop-1                          0
                   accpt 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
.
```

Back pressure from egress NP

Agenda

- System architecture
  Control and forwarding paths and components
- Control and exception traffic
  Internal forwarding, and security
- Transit frame forwarding
  L3/L2 unicast/multicast in hardware
- MPLS operation
  Forwarding & service labels in hardware
- Troubleshooting
  Counters, discards, and packet/frame capture

4 MPLS Operation

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

MPLS in the Data Plane

Forwarding

Without label: IP in > IP out

```
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: IP/MPLS in > MPLS out

IP in

```
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      labels imposed {101000}
```

MPLS in

MPLS out

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 [0xacc9d674 0x0]
    next hop 10.100.108.1
    local adjacency
     local label 101000      labels imposed {108000}

RP/0/0/CPU0:P101#show mpls forwarding
Thu Jun  6 09:16:22.581 EDT
Local  Outgoing    Prefix             Outgoing      Next Hop        Bytes
Label  Label       or ID              Interface                     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
.
```

Push

Swap

Pop top label

Unlabeled: Pop all to bottom of stack

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
Mon Jun 17 21:05:46.166 EDT
Local  Outgoing    Prefix            Outgoing     Next Hop        Bytes
Label  Label       or ID             Interface                    Switched
------ ----------- ----------------- ------------ --------------- ------------
.
111007 101000      10.101.188.1/32   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                       6320
111016 Unlabelled  172.20.210.0/24[V] Gi0/1/0/3.200 172.20.200.2    0
```

Pop topmost & forward

Pop & lookup

Pop all labels & forward

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  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    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

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 & lookup

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  Outgoing    Prefix            Outgoing     Next Hop        Bytes
Label  Label       or ID             Interface                    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

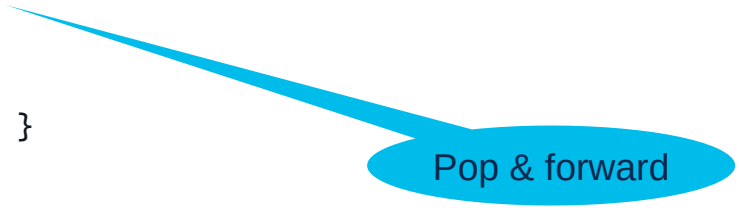
Non-Aggregate Label: Example

```
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
.

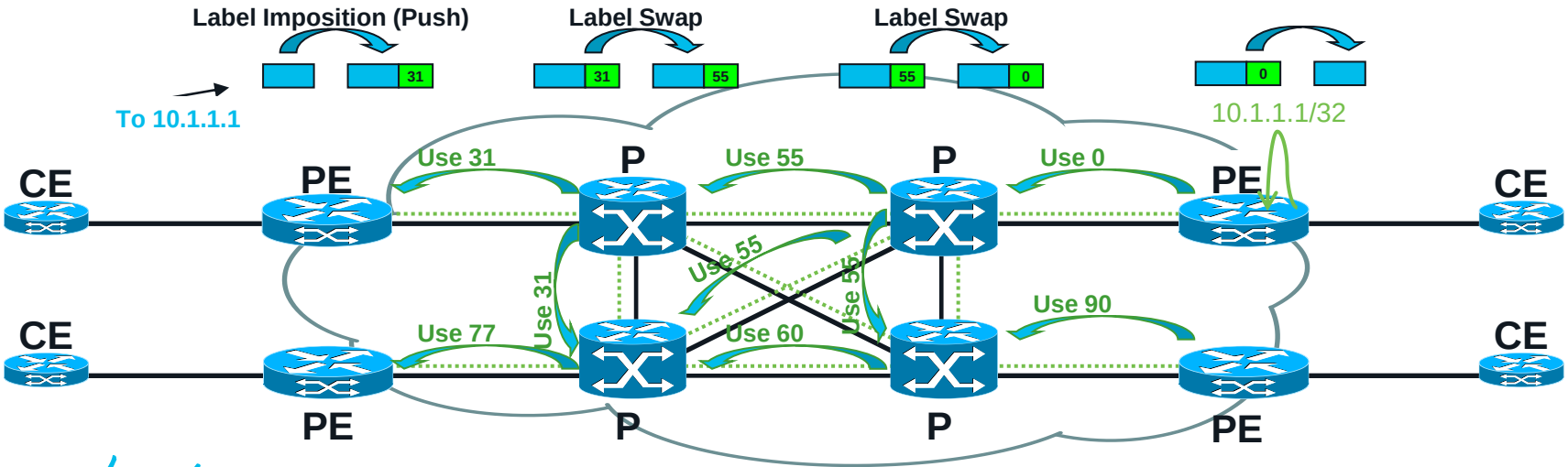
111016 Unlabelled  172.20.210.0/24[V] Gi0/1/0/3.200 172.20.200.2    0
     Updated Jun 17 21:23:42.495
     Version: 47, Priority: 3
     MAC/Encaps: 18/18, MTU: 1500
     Label Stack (Top -> Bottom): { Unlabelled }
     Packets Switched: 0
```



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         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
```

My potential dest prefixes through this neighbor as next hop

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
```

Use the one matching IGP route, if any

```
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
.
```

LDP: Forwarding: FIB and LFIB

```
RP/0/RSP0/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 (0x71635290), 0x450
(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}

RP/0/RSP0/CPU0:rasr9000-2w-b#show mpls forwarding labels 188017 detail
Wed Mar 19 12:25:05.202 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    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
```

IPv4 in

MPLS in

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  Outgoing    Prefix           Outgoing     Next Hop        Bytes
Label  Label       or ID            Interface                    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}

RP/0/0/CPU0:P103#show mpls forwarding labels 16178 detail
Fri Dec 15 11:37:14.297 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    2870087
     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
```

IPv4 in

MPLS in

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)
----------- ------------ ------------- -------------------- -------------
Gi0/0/0/0.124         38G             38G              3G (  7%)             0
Gi0/0/0/0.134         38G             38G              2G (  5%)             0
tt10452               0               0              0 (  0%)             0
Gi0/0/0/0.145         38G             38G                0 (  0%)             0
Gi0/0/0/0.146         38G             38G               5G ( 13%)             0
tt10454               0               0              0 (  0%)             0
Gi0/0/0/0.1424       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

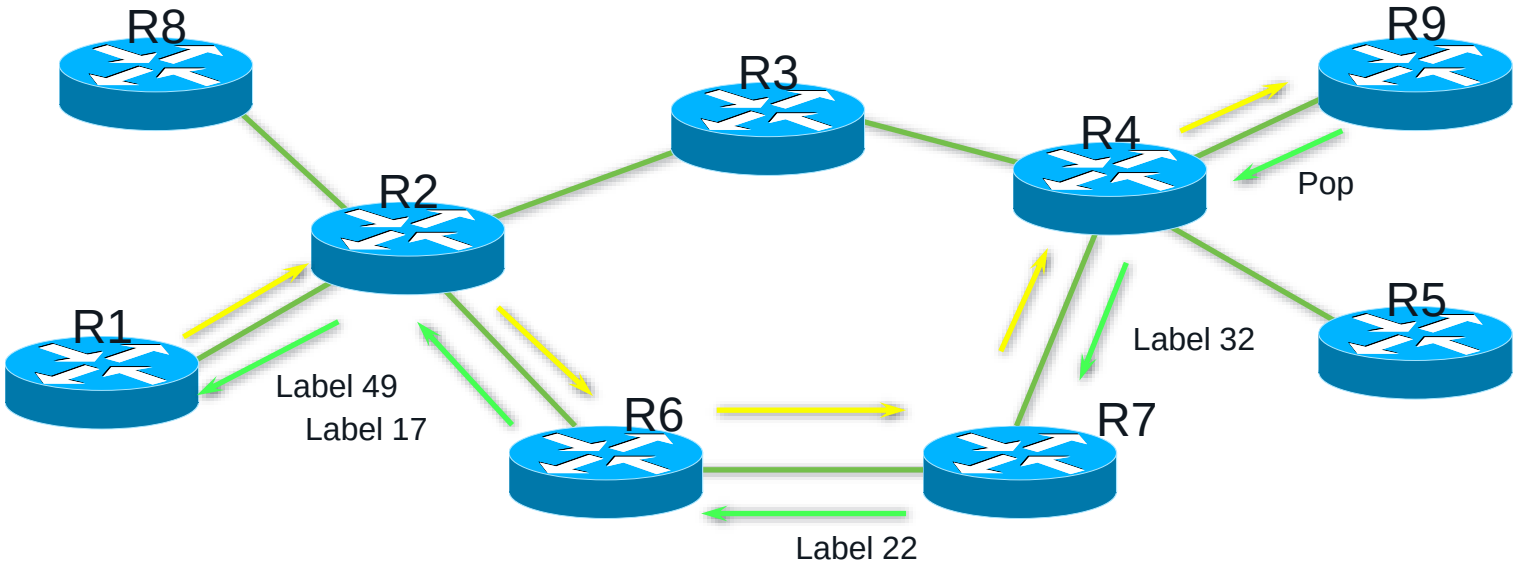
Signalling error holddown: 10 sec Global Link Generation 5292918

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
```

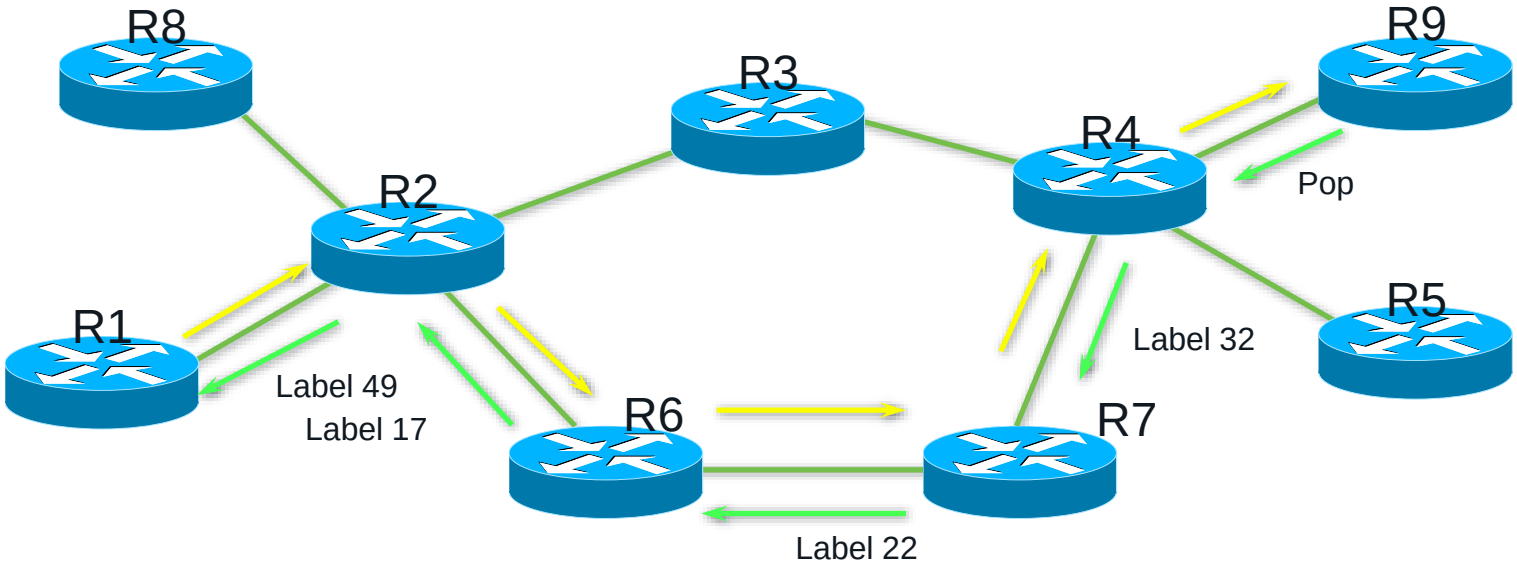
TE: The Label Exchange



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    LSP      Destination          Source    Tun     FRR  LSP  Path
              Name     ID         Address         Address  State  State Role  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    Outgoing    Outgoing     Next Hop        Bytes
Name      Label       Interface                    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    Outgoing    Outgoing     Next Hop        Bytes
Name      Label       Interface                    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/RSP0/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_ldi: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
.
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 :
.
```

Egress interface

TE: Forwarding: Midpoint

```
RP/0/0/CPU0:P104#show mpls forwarding
Tue Jun 11 07:04:03.137 EDT
Local  Outgoing    Prefix            Outgoing     Next Hop        Bytes
Label  Label       or ID             Interface                    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  Outgoing    Prefix            Outgoing     Next Hop        Bytes
Label  Label       or ID             Interface                    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

 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

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

 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
```

TE label

TE tunnel

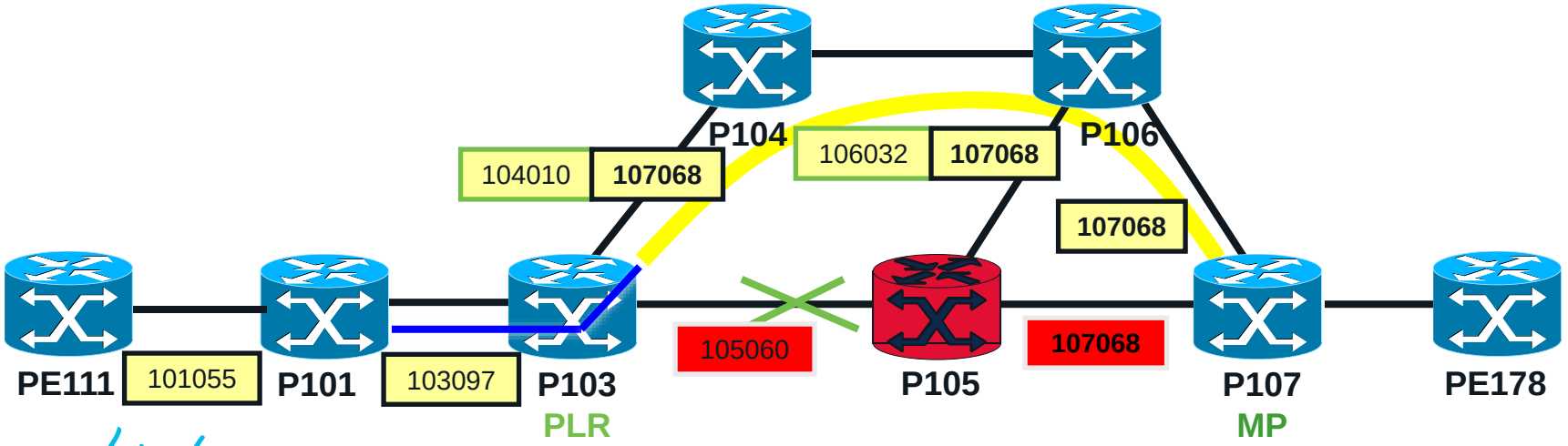
LDP explicit null

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  2 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  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
103097 105052      11111              Gi0/0/0/0.135 10.100.135.5    N/A
     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  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    Switched
------ ----------- ------------------ ------------ --------------- ------------
103097 107068      11111              tt10352      10.100.135.5    N/A
     Updated Jun 11 12:51:26.135
     Version: 1675, Priority: 2
     MAC/Encaps: 18/26, MTU: 4456
     Label Stack (Top -> Bottom): { 104010 107068 }
.
```

FRR Ready

FRR Active

Labels in Labels: LDP in TE at Headend

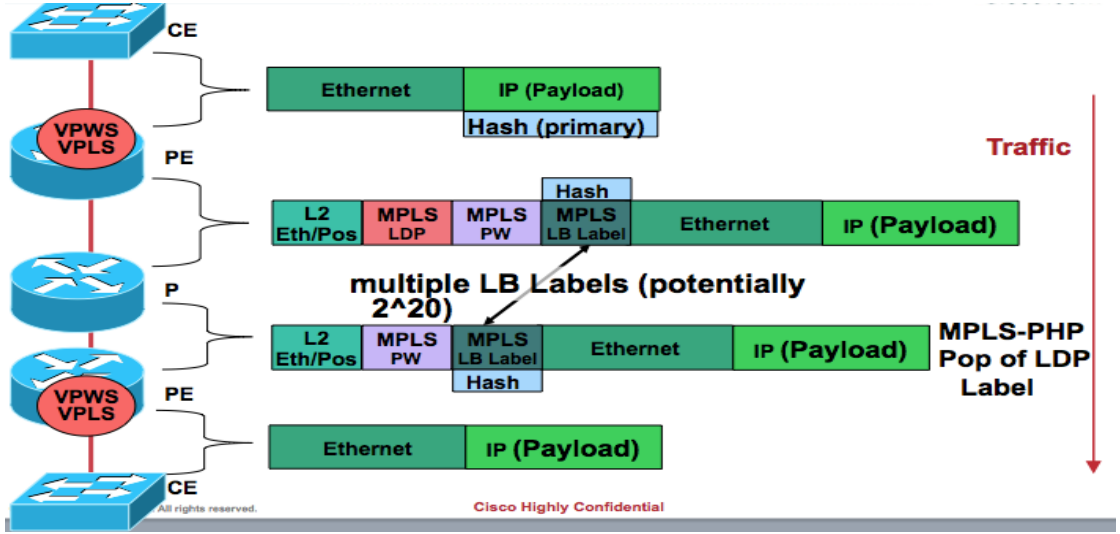
```
RP/0/RSP0/CPU0:rasr9000-2w-a#show cef ipv4 10.101.178.1/32 hardware egress location 0/1/CPU0
Tue Jun 11 21:41:12.866 EDT
10.101.178.1/32, version 285, internal 0x4004001 (ptr 0x8854bcf8) [1], 0x0 (0x876e74a0), 0x450
(0x89cb6110)
 Updated Jun 11 21:12:35.330
 Prefix Len 32, traffic index 0, precedence 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}
.
 TE-NH H/W Result for 1st NP:0 (index: 0x34 (BE)):

    Raw Data0: 0x5100001b 1ac118ab f138145f 0000008a
    Raw Data1: 0x02000000 16000000 00000000 00000000
.
    TE_tunnel_label:
                        label: 101055
                          exp: 0                    eos: 1
         te_nh_stats_ptr: 0x38145f
    merge_point_label:
                        label: 0
.
```

LDP label

TE label [topmost]

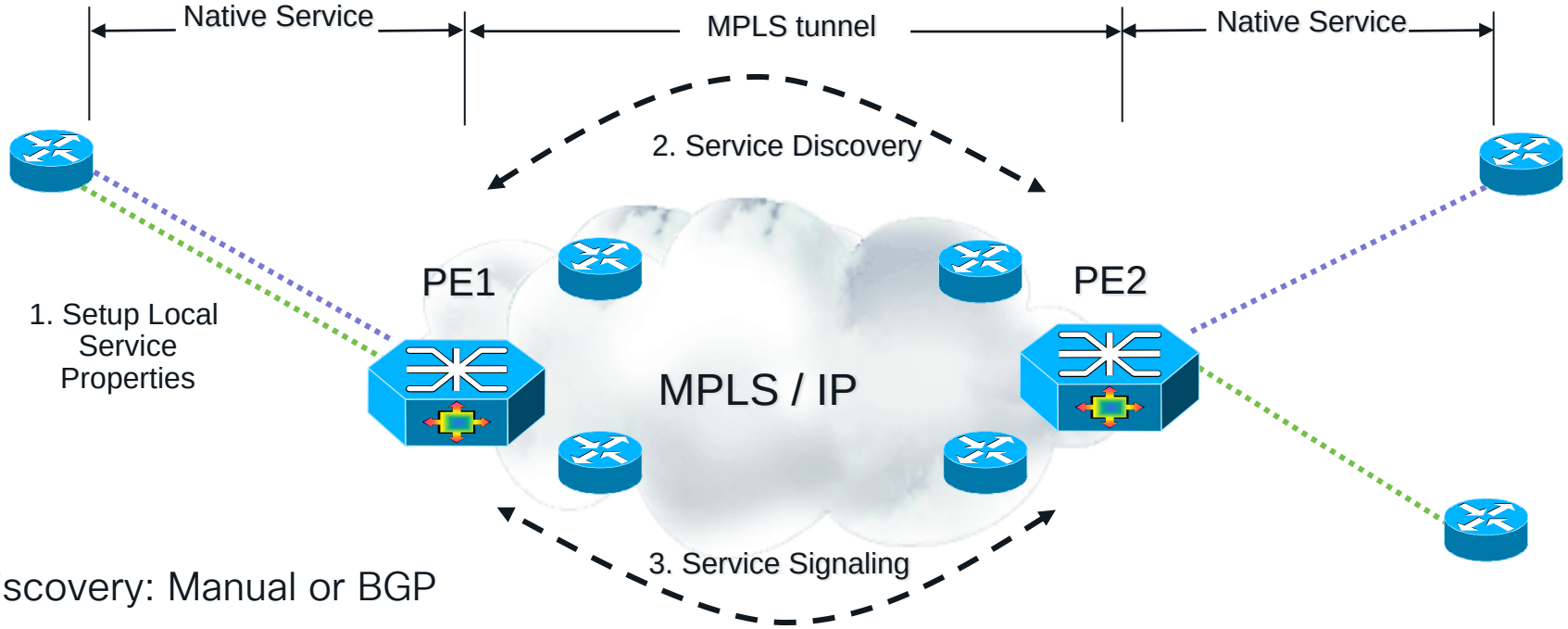
Labels in Labels: More Forwarding Labels



- 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/lesc43p2mps.html#wp1339194
  - Used for forwarding hashing, but it is at bottom of stack.

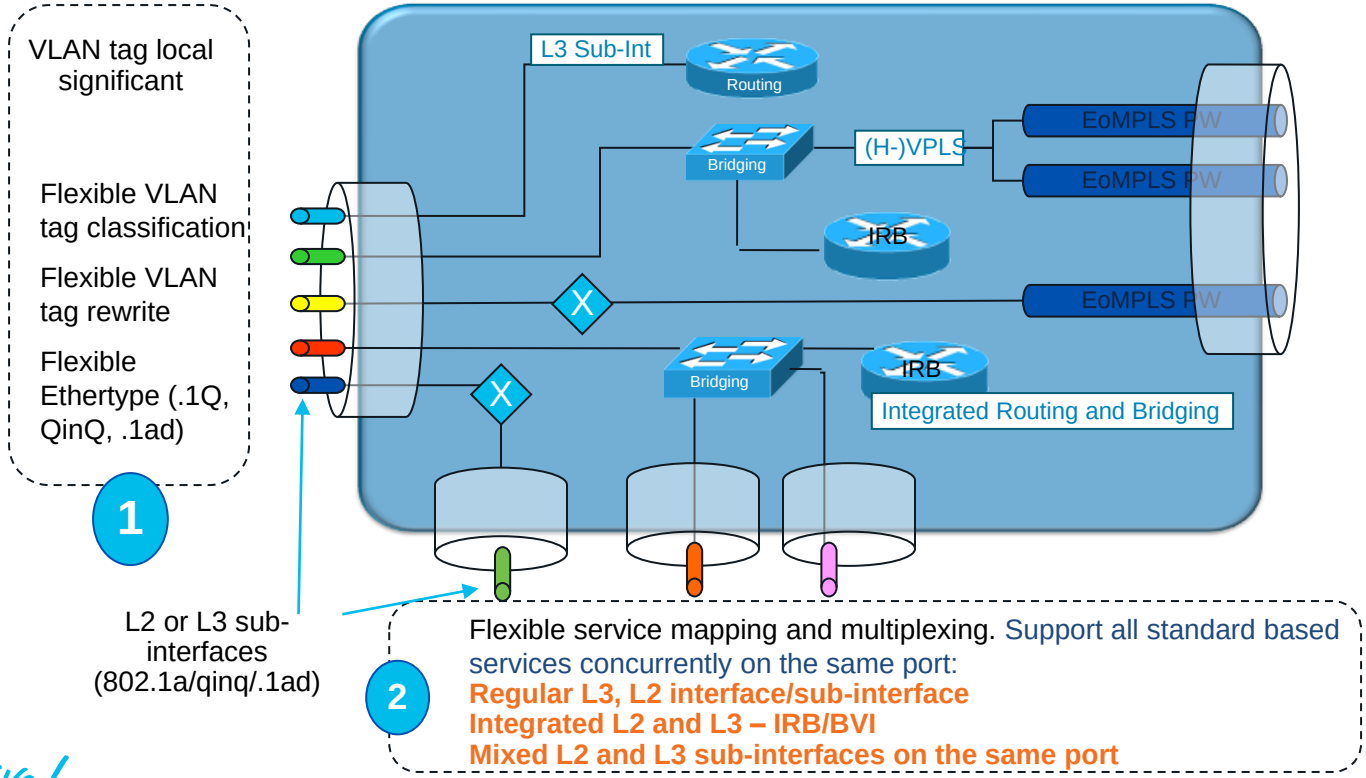
Service Labels

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 l2vpn 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
      MPLS          Local                          Remote
      ------------ ------------------------------ ------------------------------
      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                            0x2
                    (LSP ping verification)        (LSP ping verification)
.
```

Advertised

Received

Forwarding: AC to PW

```
RP/0/RSP0/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 l2vpn 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, l2vpn 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

Processed 4 prefixes, 6 paths
```

Advertised

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_requir: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] Gi0/1/0/3.200 172.20.200.2     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_vpls: 0                  match: 1
                       rsvd: 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/RSP0/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 12:13:20.504 EST
10.10.3.0/24, version 33, internal 0x4000001 (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/RSP0/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/RSP0/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 l2vpn 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/RSP0/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 l2vpn 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...
    l2vpn 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
.
```

Local AC

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
  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
.
```

PW label

Forwarding: VPLS Bridge: VFI to EFP

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show mpls forwarding
Tue Jun 18 06:37:43.199 EDT
Local  Outgoing    Prefix             Outgoing     Next Hop        Bytes
Label  Label       or ID              Interface                    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)   \
                                      BD=0         point2point     0
188097 Pop         PW(10.101.137.1:300)   \
                                      BD=0         point2point     0
```

Pop label

Forwarding: VPLS Bridge: VFI to EFP

```
RP/0/RSP0/CPU0:rasr9000-2w-b#show l2vpn 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...
    l2vpn 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
  Control and forwarding paths and components
- Control and exception traffic
  Internal forwarding, and security
- Transit frame forwarding
  L3/L2 unicast/multicast in hardware
- MPLS operation
  Forwarding & service labels in hardware
- Troubleshooting
  Counters, discards, and packet/frame capture

5 Troubleshooting

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

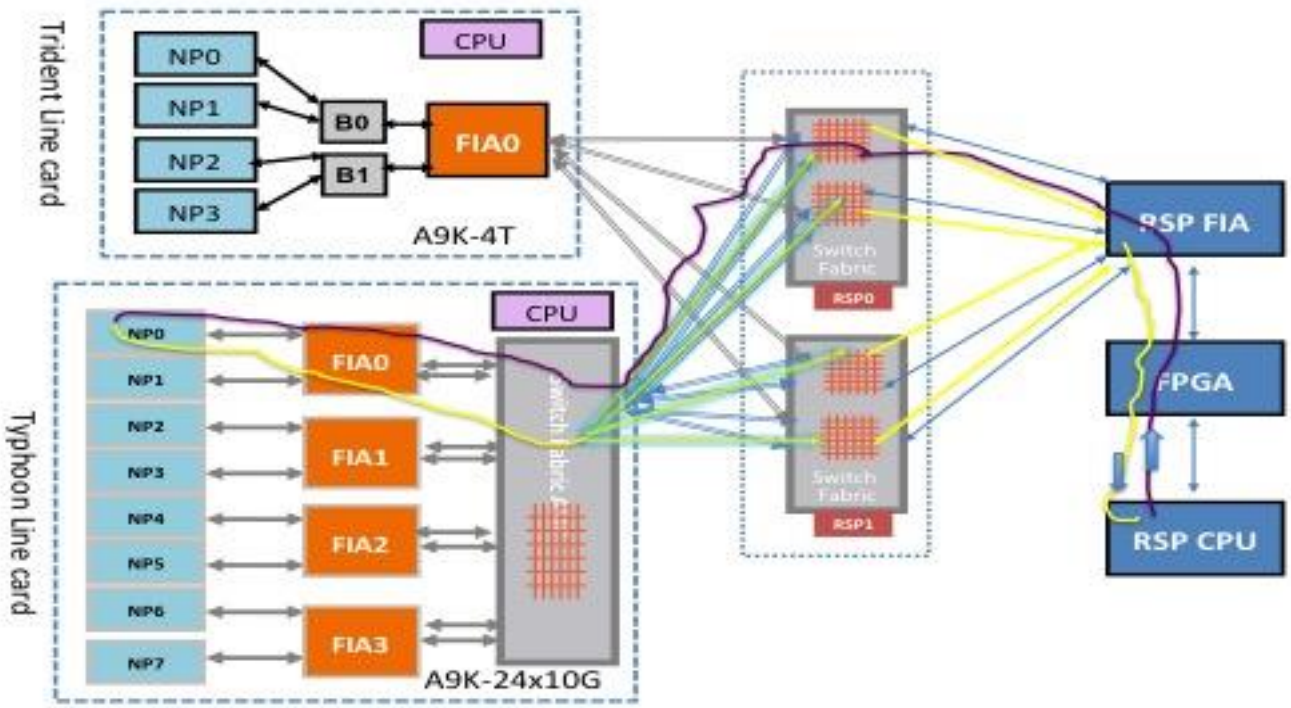
                                                            Test Interval     Thre-
  ID   Test Name                          Attributes       (day hh:mm:ss.ms shold)
  ==== ================================== ============ ================= =====
    1) CPUCtrlScratchRegister ----------> ***N****A      000 00:01:00.000 1
    2) ClkCtrlScratchRegister ----------> ***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
```

Every minute or every 5 seconds

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/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

                                                          Test Interval    Thre-
  ID   Test Name                                Attributes  (day hh:mm:ss.ms shold)
  ==== ================================== ============ ================= =====
    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:rasr9000-2w-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_lc[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_lc[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 - NP0
                ------------------------------------------
                    Set       Modify       Clear        Get      Get Info    Delete All      In use
                    T/F         T/F          T/F        T/F         T/F          T/F          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     < 1 ms     < 1 ms     < 1 ms     < 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
0x101745f8 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:
```

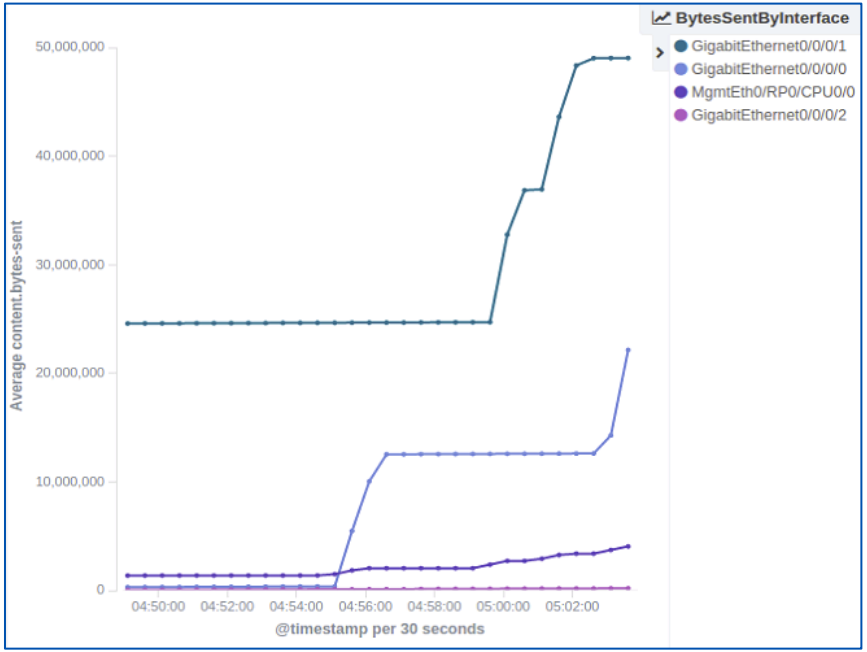
Troubleshooting: Forwarding Path

Telemetry

Streaming YANG model telemetry (push subscription model)

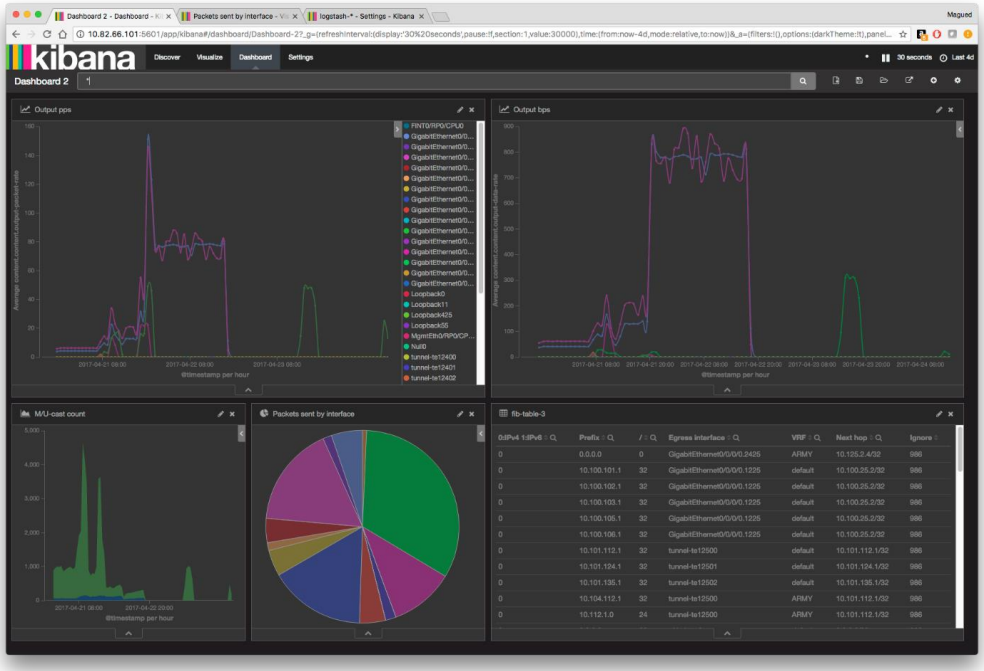
```
RP/0/RP0/CPU0:PE125#show running-config telemetry
model-driven
Tue Feb 14 13:06:18.261 UTC
telemetry model-driven
 destination-group COLL1
  address family ipv4 192.168.30.101 port 2103
   encoding self-describing-gpb
   protocol tcp
  !
 !
 sensor-group YD1
  sensor-path Cisco-IOS-XR-infra-statsd-oper:infra-
statistics/interfaces/interface/latest/generic-counters
 !
 subscription SUB1
  sensor-group-id YD1 sample-interval 60000
  destination-id COLL1
 !
!
```

YANG sub-tree



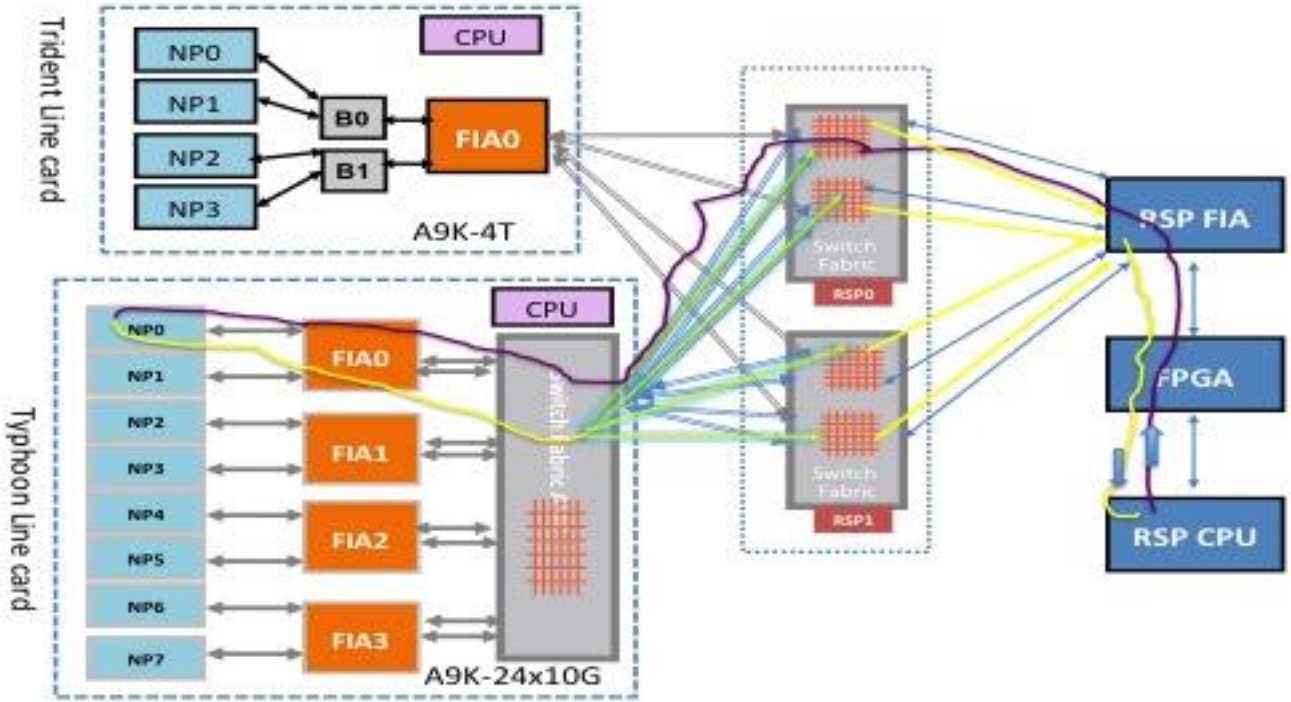
Telemetry

Build your own dashboard



Background Diagnostics

PuntFabricDataPath



- Looping the path between RP CPU and each NP, every minute

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)
```

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%)

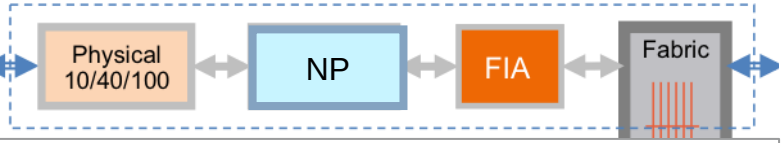
Errors Stats:
  Input  Total:                              1                       0
  Input  CRC:                                0                       0
  Input  Frame:                              0                       0
  Input  Overrun:                            0                       0
  Output 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:rasr9k-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

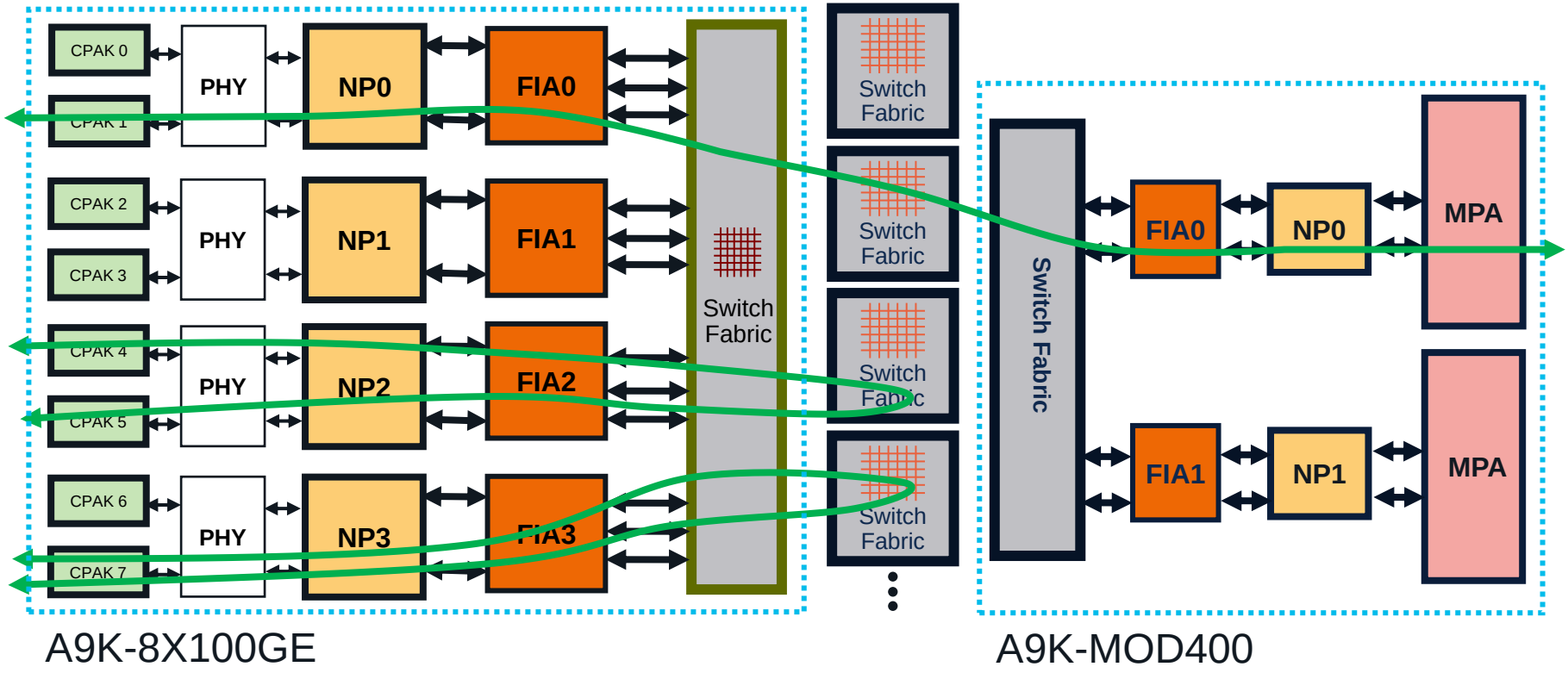
```
RP/0/RSP0/CPU0:rasr9000-2w-b#show ethernet hardware
interface TenGigE 0/0/0/2.200 location 0/0/CPU0
Tue Jan 21 21:45:18.351 EST
------------------------------------------------------------------------
Physical port                 : 2
Interface name                : TenGigE0/0/0/2.200
Ifhandle                      : 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  FF  FF  00  F0
FF  00  00  BB  BB  BB
TCAM value:
 01  00  00  81  00  00  00  00  00  00  00  00  C8  00
00  04  00  00  00  00
```

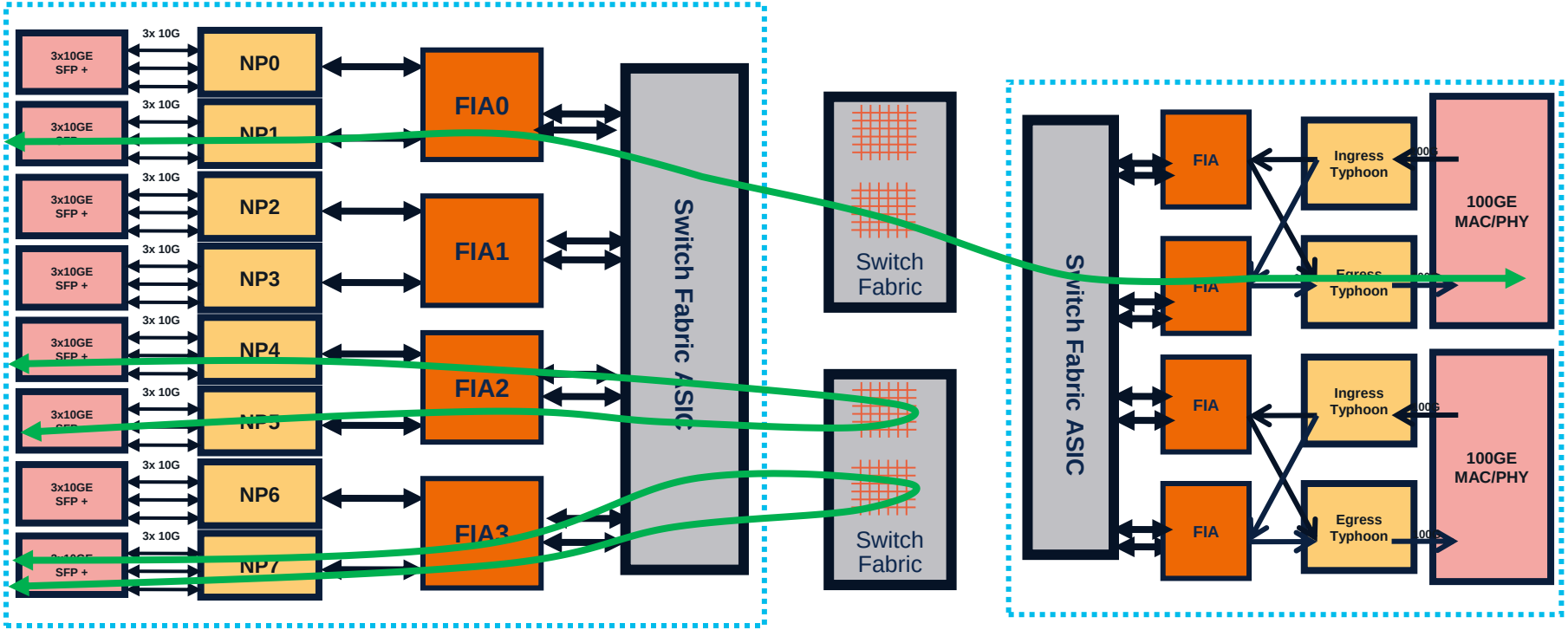
Unicast Transit Frame Path

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



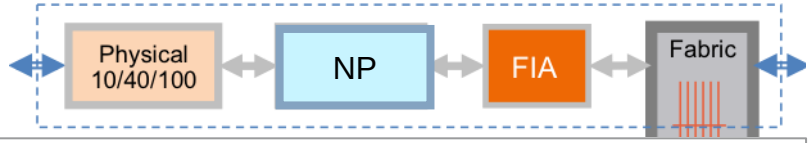
Unicast Transit Frame Path

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: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                                        FullValue   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: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, 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                                          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_RCVD                                    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                                        FrameValue   Rate (pps)
--------------------------------------------------------------------------------
1171  MDF_PUNT_POLICE_DROP                          7924962277743           21
(Count 1 of 3)

              ****  Thu Jul  7 04:49:34 2016 ****

Monitor 0 non-zero NP0 counter:  TenGigE0_0_0_1
Offset  Counter                                        FrameValue   Rate (pps)
--------------------------------------------------------------------------------
1171  MDF_PUNT_POLICE_DROP                          7924962277933           19
(Count 2 of 3)

              ****  Thu Jul  7 04:49:44 2016 ****

Monitor 0 non-zero NP0 counter:  TenGigE0_0_0_1
Offset  Counter                                        FrameValue   Rate (pps)
--------------------------------------------------------------------------------
1171  MDF_PUNT_POLICE_DROP                          7924962278163           23
(Count 3 of 3)
RP/0/RSP0/CPU0:ASR9006-2w-a.PE2#
```

Non-intrusive

Total per interface

Rate since last read [10 seconds]

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

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:

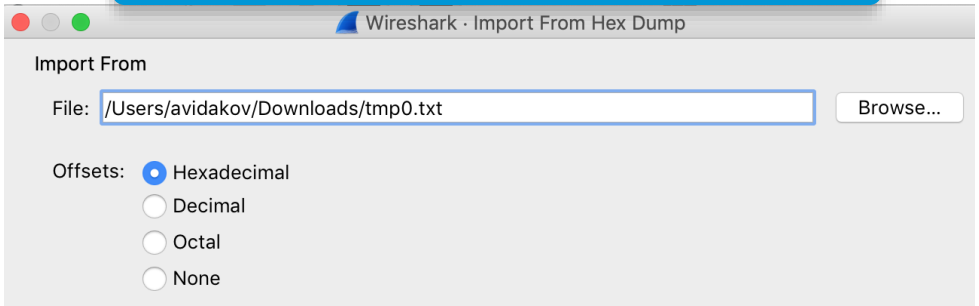
```
sh controllers np capture np1 filter …
```

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

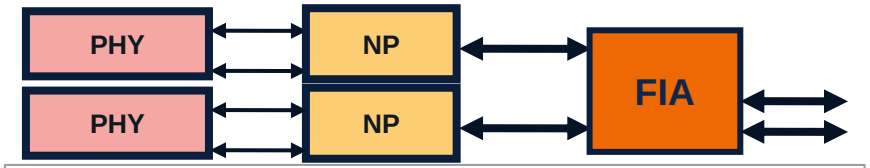
RP/0/RSP0/CPU0:rasr9000-2w-b#
RP/0/RSP0/CPU0:rasr9000-2w-b#
RP/0/RSP0/CPU0:rasr9000-2w-b#show controllers NP tm counters np1 location 0/0/CPU0
Tue Dec 10 14:40:49.816 EST

                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 Spaui Drop-0                          0
                  accpt tbl-0                           0
                    ctl len-0                           0
                  short pkt-0                           0
                max pkt len-0                           0
                min pkt len-0                           0
             From Spaui Drop-1                          0
                  accpt 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/libipv4_fib_switch.dll: 4043
[netio:Interface: GigabitEthernet0/1/0/10]
packet_null_action: 305


show controller np counters:
[np:NP0] RSV_DROP_IN_L3_NOT_MYMAC: 137015
[np:NP0] MODIFY_PUNT_REASON_MISS_DROP: 2
[np:NP0] PARSE_DROP_IN_UIDB_TCAM_MISS: 60198
[np:NP0] PARSE_DROP_IN_UIDB_DOWN: 15
[np:NP0] PARSE_DROP_IPV4_MCAST_NOT_ENABLED: 332431
[np:NP0] 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 ~150ms 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 ~150ms traffic outage. Links will s
 Proceed y/n [y] >
 Monitor RSV_ING_VPWS_ERR_DROP on NP0 ... (Ctrl-C to quit)
Sat Jan 18 19:02:44 2014 -- NP0 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             .............
```

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   ..@.............
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   ................
00e0: 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
```

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
!
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
!
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/C
ACL_CAPTURE_NO_SPAN
Sat Jan 18 20:14:34.597 EST
 477   ACL_CAPTURE_NO_SPAN                                7124969        37991
```

Count in NP

Let all else go!

Apply to transit

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 ~150ms traffic outage. Links will stay Up.
 Proceed y/n [y] >
```

Packet Capture: Transit Packets

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         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 ~150ms 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 -- NP0 packet
 From TenGigE0/0/0/2: 250 byte packet, bytes[0-3] 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    .l....@=(.@.....
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               ............
            (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

```
00 11 0b 00 61 92 00 00 c0 04 01 02 08 00 45 60
00 ec 00 00 00 00 40 3d a8 08 c0 04 01 02 0a 0a
06 5d 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
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
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_04:01:02 (00:00:c0:04:01:02), Dst: Franklin_00:61:92 (00:11:0b:00:61:92)
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)
```

Agenda

- **System architecture**
  Control and forwarding paths and components
- **Control and exception traffic**
  Internal forwarding, and security
- **Transit frame forwarding**
  L3/L2 unicast/multicast in hardware
- **MPLS operation**
  Forwarding & service labels in hardware
- **Troubleshooting**
  Counters, discards, and packet/frame capture

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ALL IN

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 Informatin 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]
LCRBUS	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 Robbin
XML	Extensible Markup Language