
CISCO
You make possible

Catalyst 9000 Switching Architecture

TECARC-2900

Cisco live!

June 9-13, 2019 • San Diego, CA

#CLUS

Cisco Webex Teams

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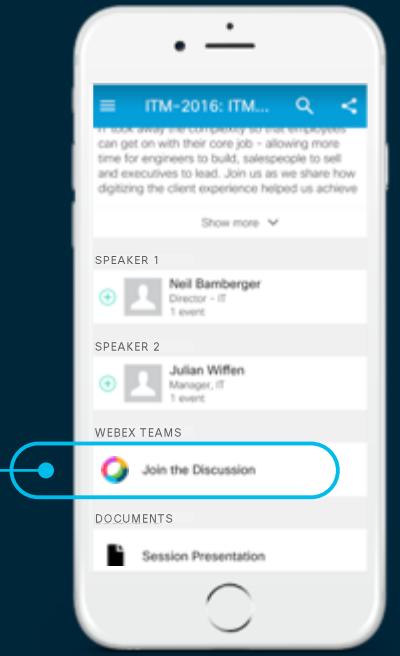
Use Cisco Webex Teams to chat
with the speaker after the session

How

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

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



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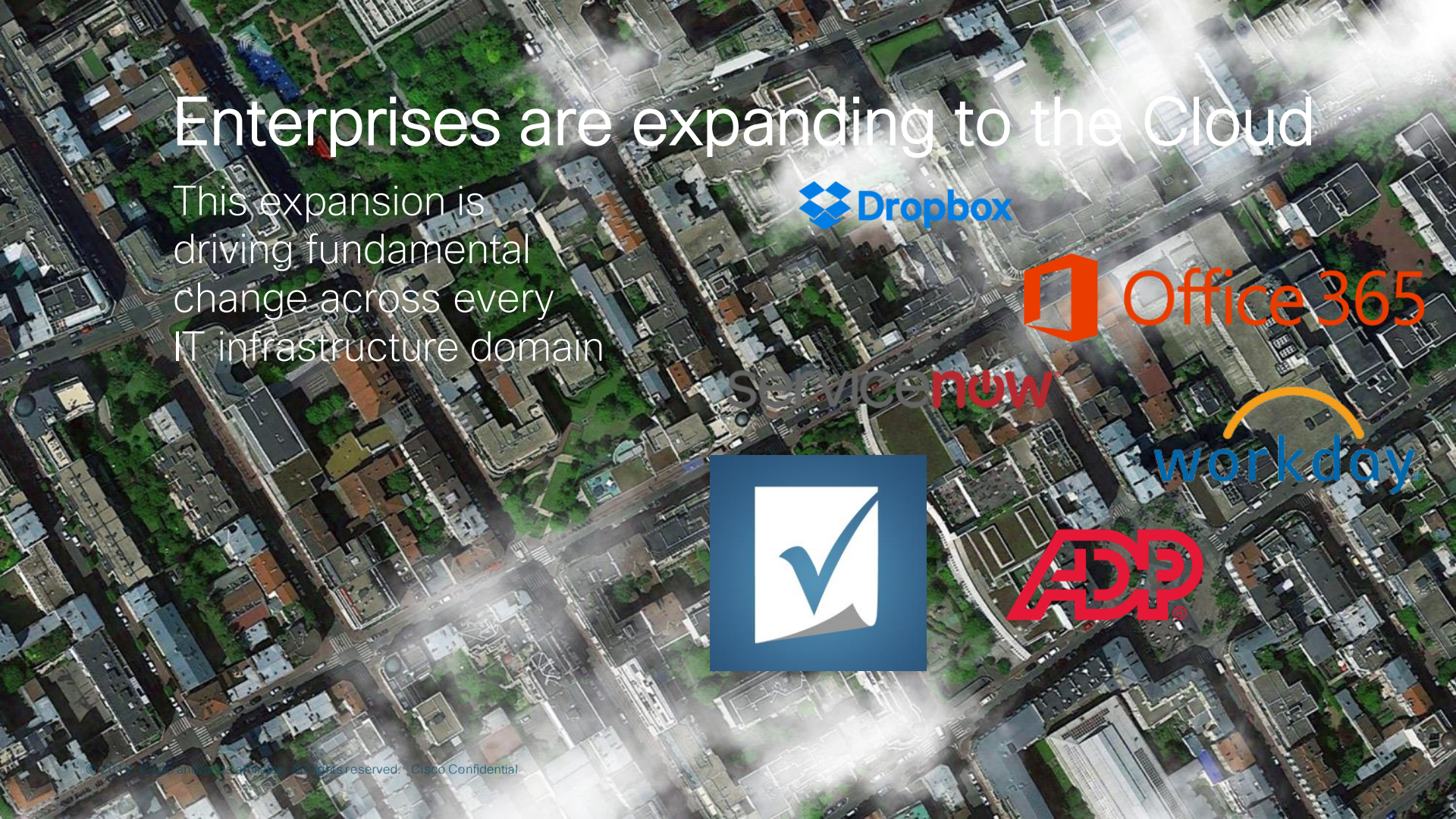
Campus of the Future

New Trends Drive New Requirements for the Network

Enterprises are expanding to the Cloud

This expansion is driving fundamental change across every IT infrastructure domain




1920x1080
Full HD
3840x2160
4K
8K Video
7680x4320

Augmented Reality

Virtual Reality

Mixed Reality

Latency Sensitive

Bandwidth Hungry

Compute Intensive

50 Billion

Connected Devices by 2020

Emerging New Protocols

60%

IOT devices
might NOT be WiFi

Wifi6


What does this really mean for Campus of the Future?

New Clients Connectivity Requirements for Campus of the Future

<100 ms

Latency

Up to 200 Mbps

Bandwidth

Design your Networks for Low Latency & Higher Speeds

Users

IoT Devices

BMS Devices

Secure On Boarding

Fingerprints & Identity

End to End Policy

Encryption

Design your Networks for End to End Security & Segmentation

- Data Analytics in Real Time
- Forensic Troubleshooting
- Telemetry Data
- Open Interfaces & Models

Data is Essential to Operate & Manage the Networks

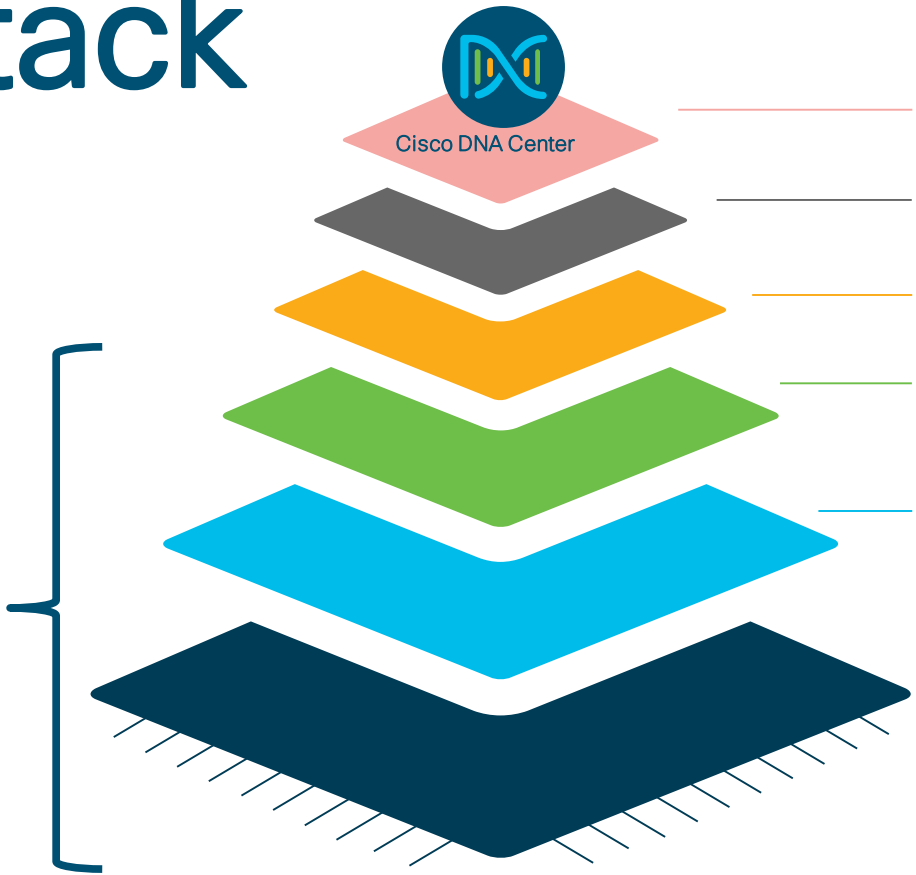
Availability Requirements
For Campus of the Future

Always ON

99.9999999 %
Availability

Always Available is the New Requirement

Full Stack



Applications

APIs

Domain controllers

Powered by Cisco IOS XE

Physical and virtual Infrastructure

Application-Specific Integrated Circuit (ASIC)

Catalyst 9K

Catalyst 9K Family

Built for Campus of the Future

The goal of this seminar is to give you an in-depth view of Catalyst 9000 Family of products, and how it enables a

"New Era of Networking"

Your Speakers Today!

Kenny Lei

Technical Marketing Engineer

Minhaj Uddin

Technical Marketing Engineer

Sai Zeya

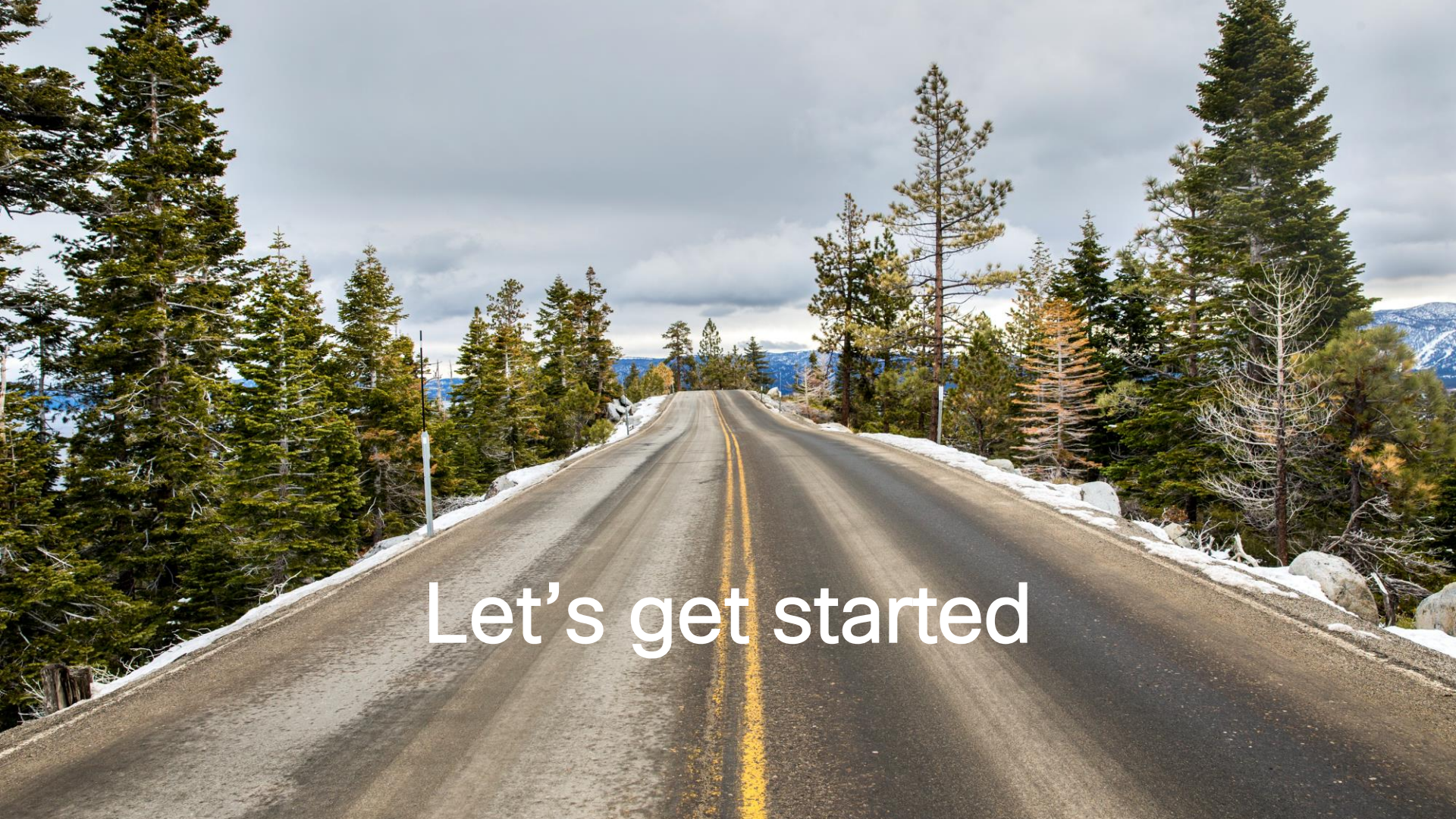
Technical Marketing Engineer

Muhammad Imam

Manager Technical Marketing

Agenda

	Sections	Duration	Time	Speaker
	Opening & Introduction	30 Mins	9:00 – 9:30	Muhammad
Modern Campus Platforms	Stackable Access Platforms	30 Mins	9:30 – 10:00	Minhaj
	Modular Acc/Agg Platforms	30 Mins	10:00 – 10:30	Sai
	Break -10:30 – 10:45			
	Fixed Core/Agg Platforms	30 Mins	10:45 – 11:15	Sai
	Modular Core Platforms	30 Mins	11:15– 11:45	Kenny
Architecture building blocks	UADP ASIC	45 Mins	11:45 – 12:30	Kenny
	IOS-XE Software	30 Mins	12:30 – 1:00	Muhammad
	Lunch – 1:00 – 2:00			
Foundational Features	High Availability	90 Mins	2:00 – 3:30	Minhaj
	Break – 3:30 - 3:45			
	Quality of Service	30 Mins	3:45 – 4:15	Muhammad
	Security	15 Mins	4:15-4:30	Kenny
Advance Managing and Analytic Features	Programmability	15 mins	4:30 – 4:45	Kenny
	Application Hosting	45 Mins	4:45 – 5:30	Sai
	Closing & Wrap up	30 Mins	5:30 to 6:00	Muhammad

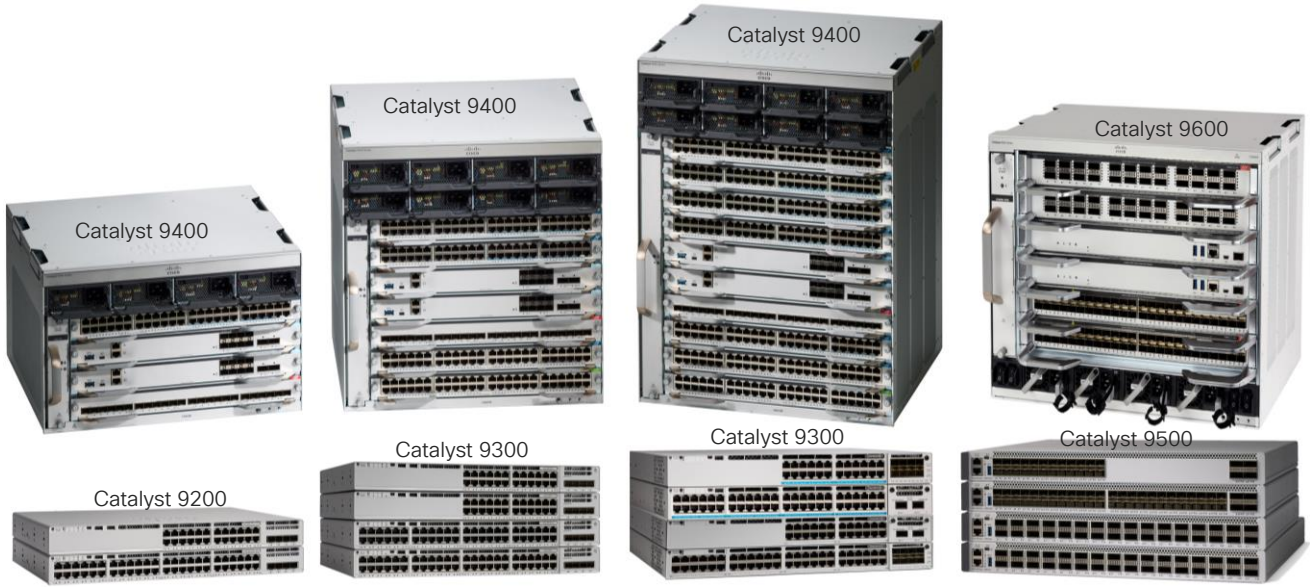

Let’s get started

Catalyst 9000 Family

You make networking **possible**

Cisco live!

Catalyst 9000 (9K) – A Growing Family



IOS-XE 16
Common Software Architecture

UADP 2.0
Common Hardware Architecture

The Latest Addition – Catalyst 9600

Modular Campus Core – Modernizing the Catalyst 6K

And there is one more Catalyst 9K

The First Catalyst Wireless LAN Controller

Outside the scope of this session

Catalyst 9100

[BRKEWN-2670 - Introduction to Cisco Catalyst 9800 Wireless Controller]

Catalyst 9800 Powered by IOS XE

Building Blocks

You make security **possible**

Catalyst 9K – Common Building Blocks

UADP

2.0/3.0

Programmable pipeline
Flexible tables

Open and Extensible
IOS-XE

Model-Driven APIs
Streaming telemetry

Building Blocks to Face the challenges of Campus of the Future

UADP – Next Generation of ASIC Innovation

Investment Protection
Flexible Pipeline

Universal Deployments
Adaptable Tables

Enhanced Scale/Buffering
Multicore resource share

Up to 384K Flex Counters

Shared Lookup

Up to 1.6T Bandwidth

Up to 2X to 4X Forwarding + TCAM

Up to 20B Transistors

16nm Technology with latest ASIC

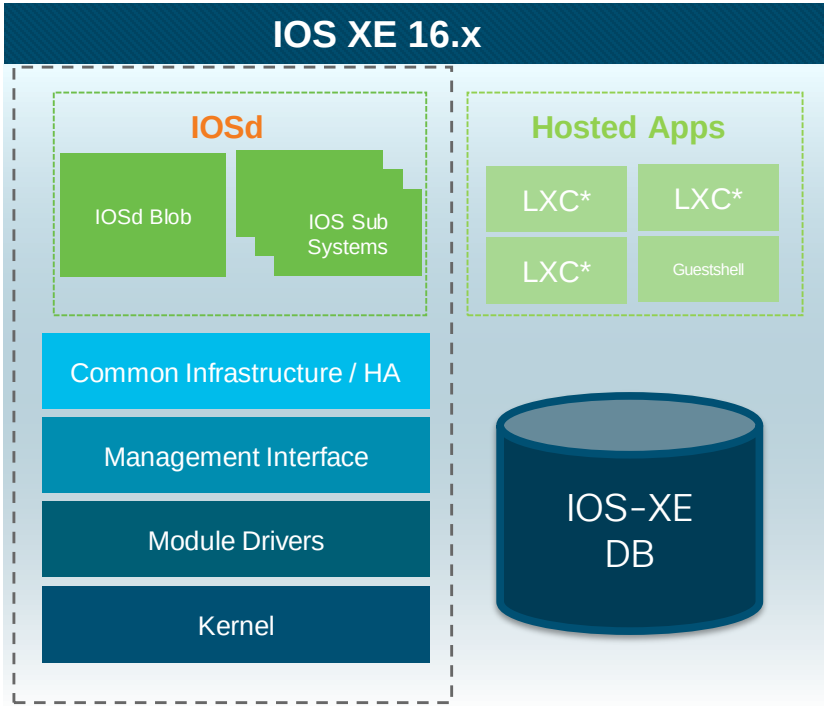
Embedded Microprocessors

Up to 36MB Packet Buffer

Up to 64K x2 Netflow Records

Flexible & Programmable ASIC – Adapts to the New Technologies

Open IOS XE – A Modern Operating System



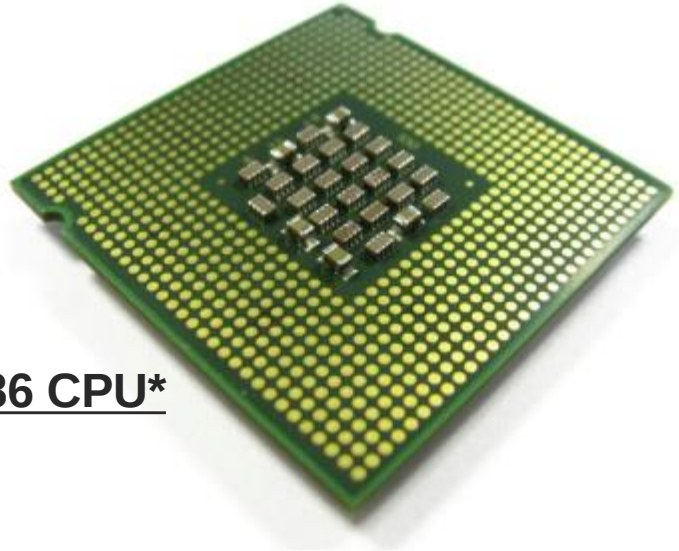
IOS Sub Systems
Resiliency & HA

IOS XE Database
Programmability & Open Models

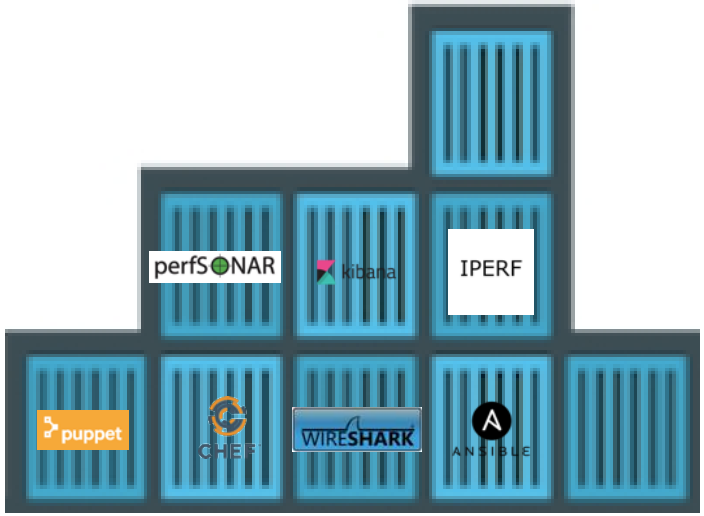
Container Support
3rd Party App Hosting

Open, Model Driven & Secure Operating System

Catalyst 9K Family – x86 CPU



x86 CPU*



x86 based 3rd Party Apps

*Catalyst 9200 has Embedded CPU in the UADP ASIC

x86 CPU enables hosting containers and 3rd party apps

Catalyst 9K Family – External Storage Options

M2 SATA

Internal – Plugs into Sup

External – Hot Swappable

Up to 1 TB

USB 3.0

External – Hot Swappable

Up to 120 GB

For Local Logging – 3rd Party App Hosting - Containers

User Centric Design of Catalyst 9K

You make security **possible**

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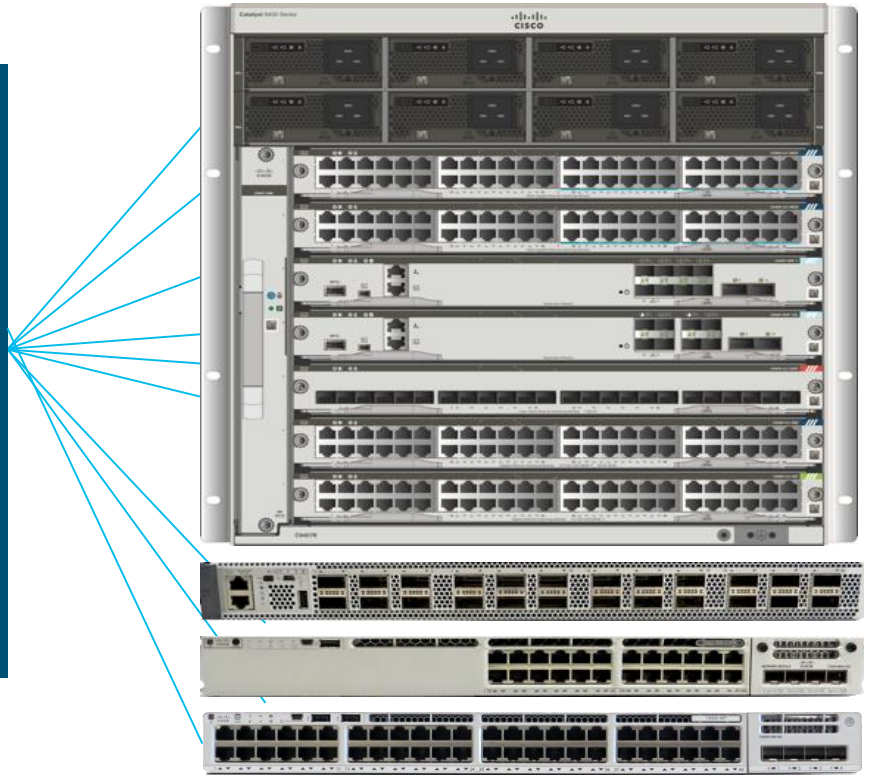
Catalyst 9K Family – Blue Beacon

Blue Beacon
on Every System & Components



Identification of Devices has never been Easier

Catalyst 9K Family with Built-in RFID

RFID on Every Device and FRUable Components of Catalyst 9400

Inventory Management (Tracking) has never been Easier

Catalyst 9400 – Cool Fan Trays

Fan Trays Serviceable from Front and Back

Barometer

Temprature Sensors

Variable Speed Fans

Flexibility in Cabling & Maintenance

Catalyst 9K Family – Industrial Design & Ergonomics

Circle Pattern
Hex Packing

Silver/Nickel Based.
Smooth finish

Cisco Medium Gray
Smooth finish

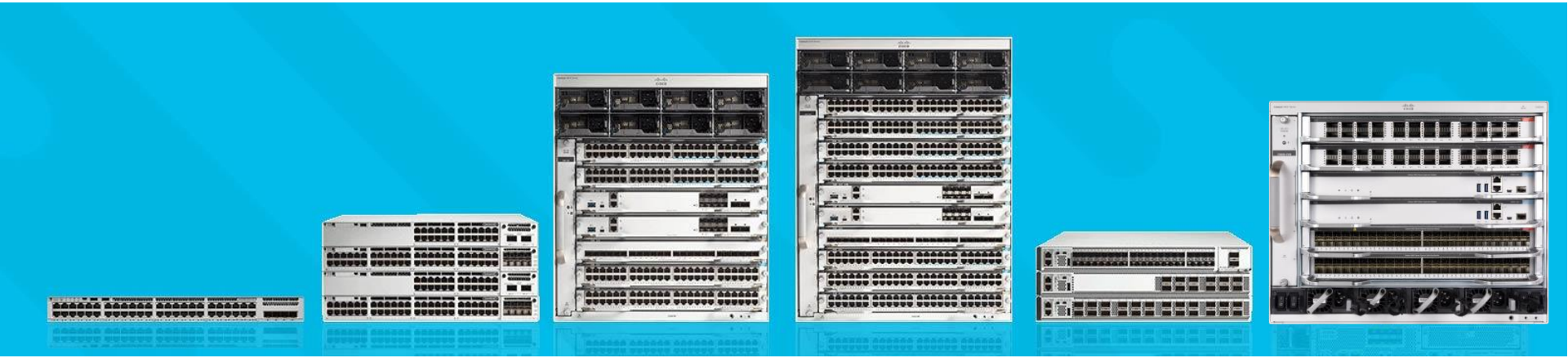
Grab area in
molded plastic

Rounded Frame

2.5 mm.

Best Safety Certifications

The Catalyst 9K Family



Catalyst 9200	Catalyst 9300	Catalyst 9400	Catalyst 9500	Catalyst 9600
Fixed Access Switches		Modular Access & Distribution Switches	Fixed Core & Distribution Switches	Modular Core & Distribution

Built on Cisco's Innovative Hardware & Open IOS-XE

Catalyst 9300

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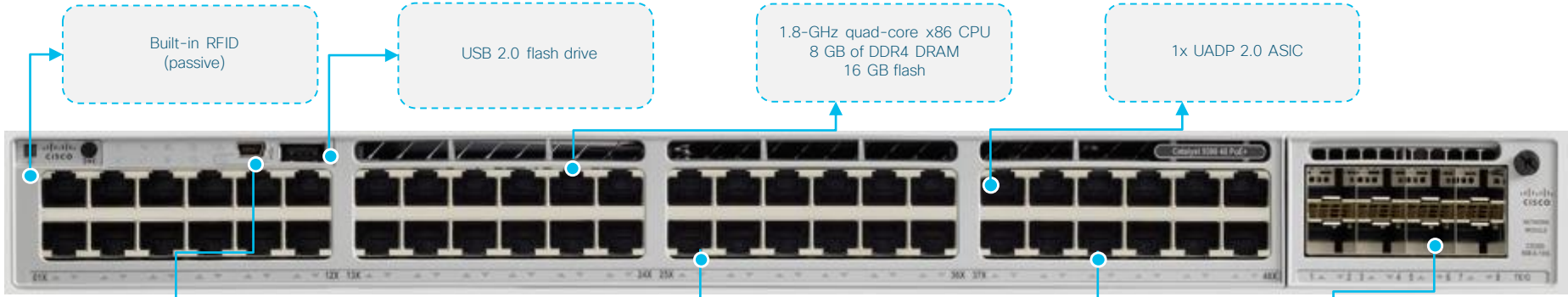
Catalyst 9300 – Leading Fixed Access Switch



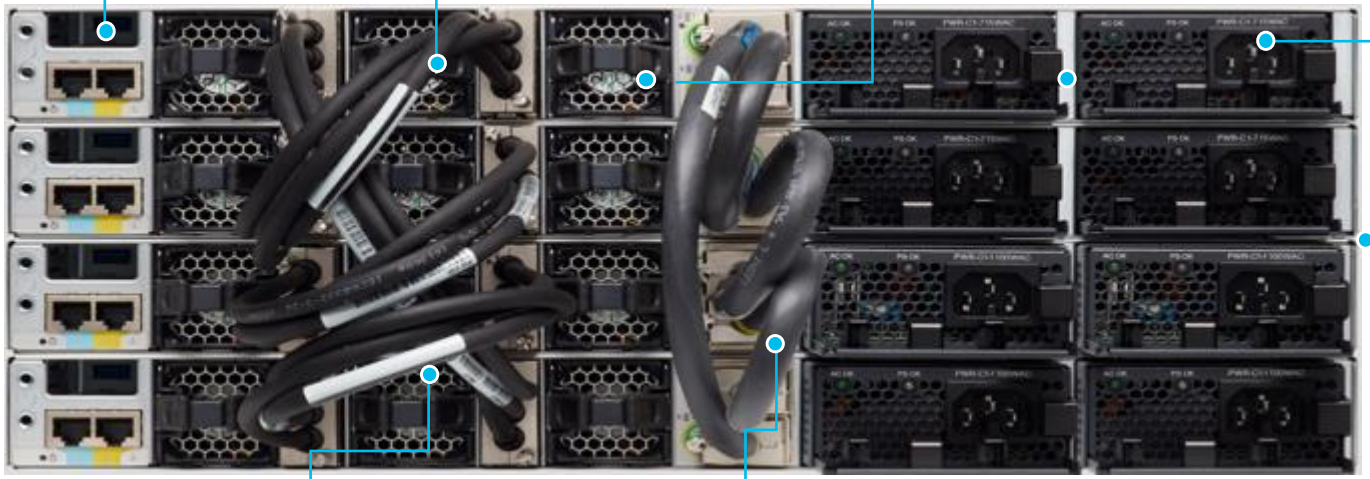
Catalyst 9300– Back View

External Storage
USB 3.0 Removable storage
(120GB SSD)

Stack Cables

Redundant Fans

Redundant Power



Stackwise-480/320

Stackpower*

Optional Power Supplies
(AC+DC)

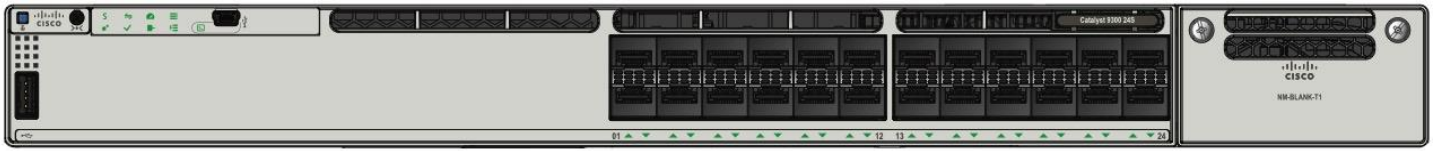
* Supported only on Cisco Catalyst 9300 Series modular uplink models (C9300 SKUs).

Cisco Catalyst 9300 Series Switches

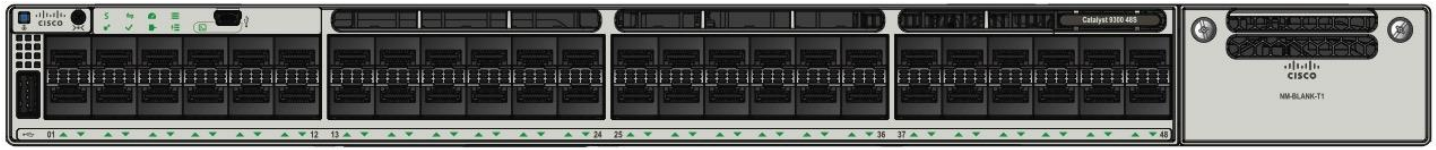
1G fiber models – expanding to FTTD and 1G fiber aggregation applications

NEW

24 ports 1G fiber C9300-24S



48 ports 1G fiber C9300-48S



Stackable with all C9300 Models

Cisco Catalyst 9300 Series Switches
C9300L Fixed Uplink models

24 Port Data/PoE Model C9300L-24

48 Port Data/PoE Model C9300L-48

Stackable with all C9300L Models

Cisco Catalyst 9300 Series Switches

New generation of fixed access

Modular uplinks
(C9300 SKUs)

Copper – 24/48 Ports

Data-Only

POE+ – 30W

UPOE – 60W

Fiber SFP

NEW

Data-Only

Fixed uplinks
(C9300L SKUs)

NEW

Copper – 24/48 Ports

Data Or POE+

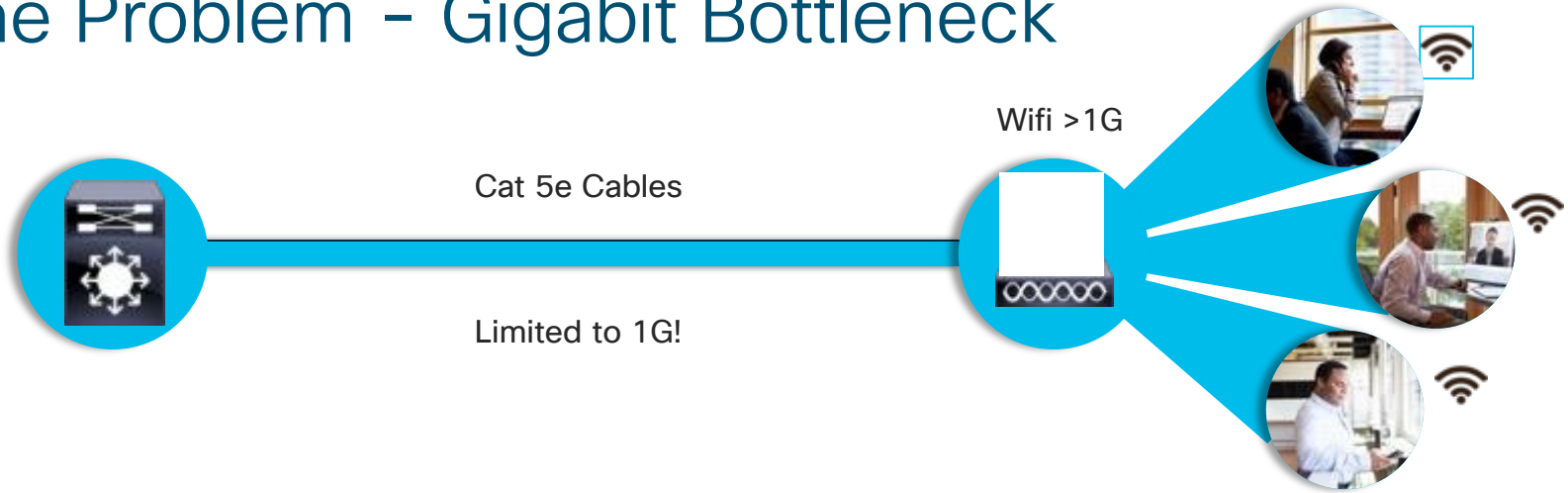
C9300L Stack kit

* Modular uplinks only

Multigigabit Ethernet

You make security **possible**

The Problem – Gigabit Bottleneck

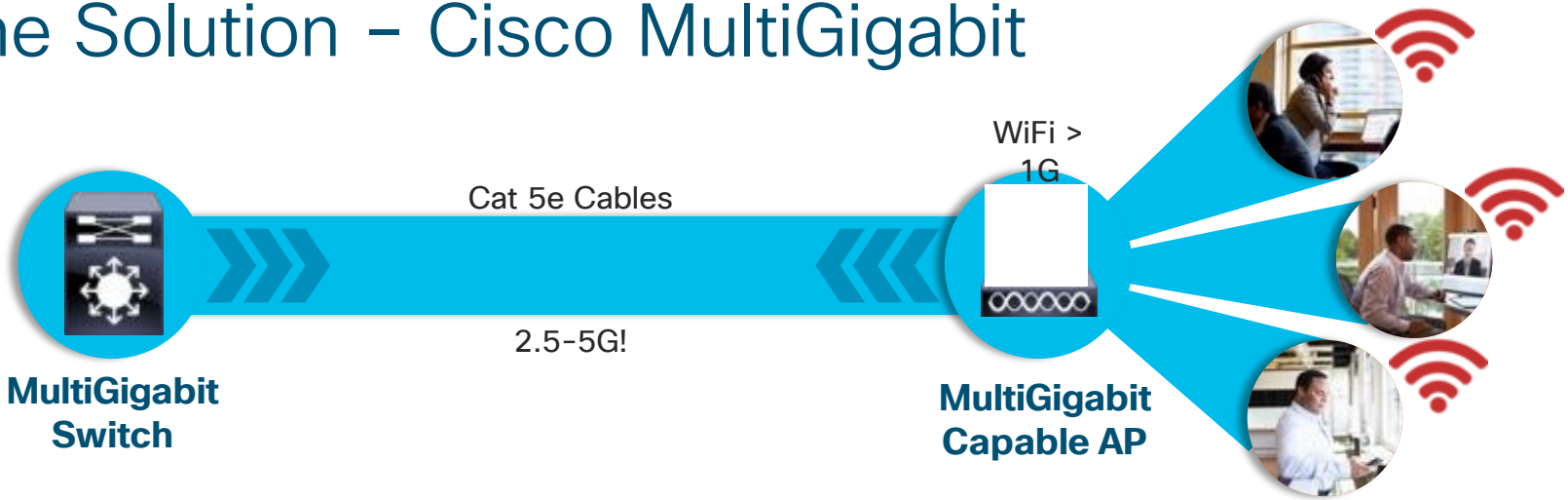


Existing Gigabit infrastructure is insufficient to handle .11ac growth beyond 1Gbps

Gigabit Ethernet has been around since 1999 and has now become the bottleneck

Market needs an innovative technology to support >1Gbps over existing cables

The Solution – Cisco MultiGigabit



Cisco MultiGigabit

Is a game-changing innovation allowing enterprise networks to evolve beyond 1G	Enables 2.5 and 5 Gbps up to 100m on legacy cables	Supports all PoE standards up to 60W

Delivers up to 5X Speeds in Enterprise without replacing Cabling Infrastructure

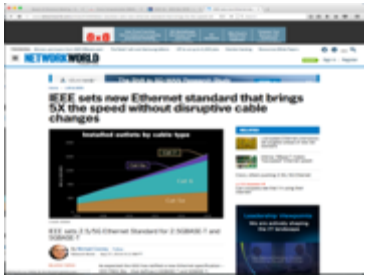
Multigigabit – IEEE Standard

IEEE

802.3bz

Multigigabit Speeds are now IEEE Standard!

Cisco Blog:
http://blogs.cisco.com/enterprise/nbase-t-alliance-achieving-a-new-industry-standard



Network World:
http://www.networkworld.com/article/3124948/lan-wan/ieee-sets-new-ethernet-standard-that-brings-5x-the-speed-without-disruptive-cable-changes.html

EEE Post:
http://standards.ieee.org/findstds/standard/802.3bz-2016.html

Ethernet Alliance
http://www.ethernetalliance.org/wp-content/uploads/2016/09/EA_IEEE802bz_FINAL_26Sep16.pdf

What Speeds Are Supported on MultiGigabit Ports?

MultiGigabit Phys Are Different than 1Gigabit Phys

MultiGigabit Ports Are Capable of the Following Speeds

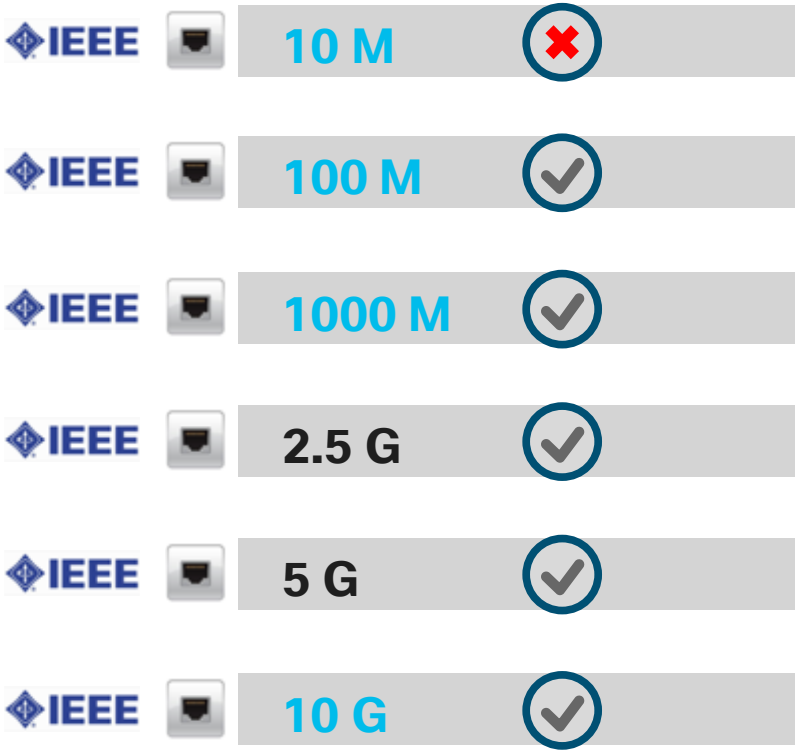
100M / 1Gig / 2.5Gig / 5Gig / 10Gig
No 10M on MultiGigabit Ports

2.5Gig and 5Gig Are now standard

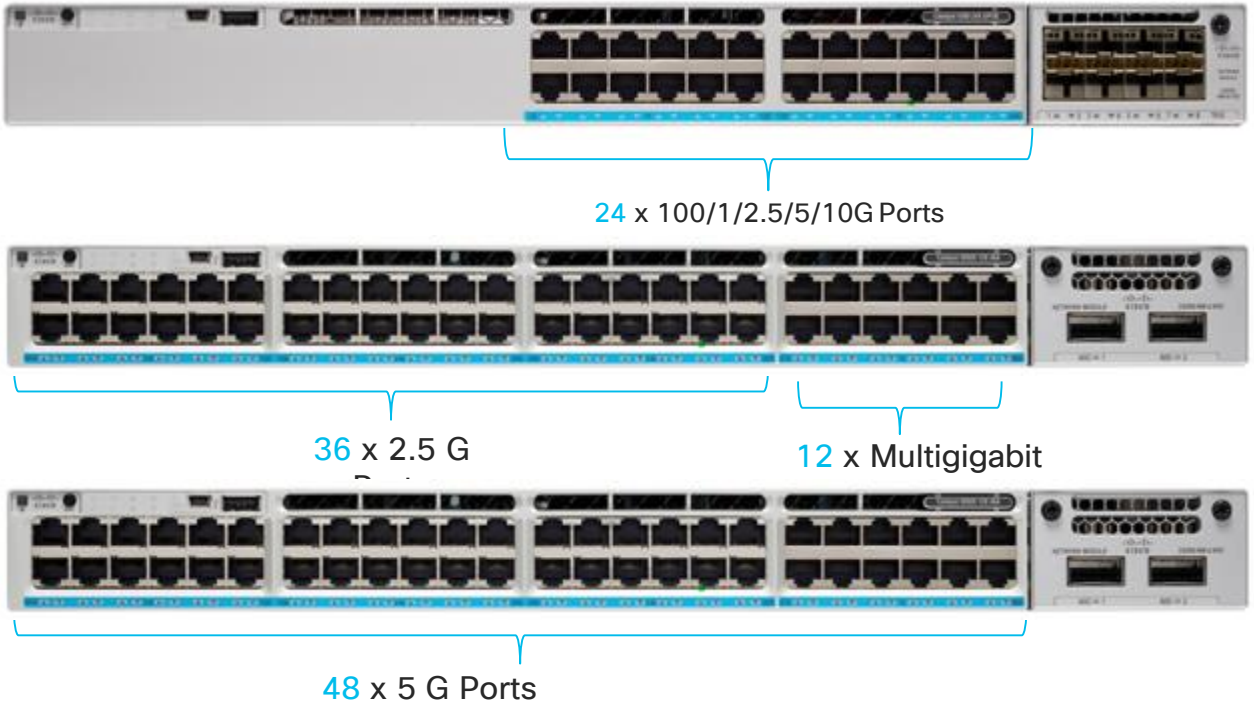
The Non-MultiGigabit Ports Are the Same as Previous Line Cards / Products – Support 10M/100M/1Gig Speeds

MultiGigabit Phys Are Same on Across our MultiGigabit Switch Family

Half Duplex on Multigigabit ports is **not supported**



Catalyst 9300 Multigigabit Family



Highest 2.5G & mGig Density in the Industry

Cisco Catalyst 9300 Series Switches
Uplink options

Cisco® Catalyst® 9300 Series
modular uplink models

4x Multigigabit copper

C9300-NM-4M

4x 1 Gbps SFP

C9300-NM-4G

8x 10 Gbps SFP/SFP+

C9300-NM-8X

2x 1/10/25 Gbps SFP/SFP+

C9300-NM-2Y

2x 40 Gbps QSFP

C9300-NM-2Q

Cisco Catalyst 9300 Series
fixed uplink models

4x 1G fixed uplinks

4x 10G fixed uplinks

Modular Uplink options on all C9300 SKUs

Fixed uplink option on C9300L SKUs

Catalyst 9300 – Power Supplies & Stacking

Power Supplies

Platinum Rated

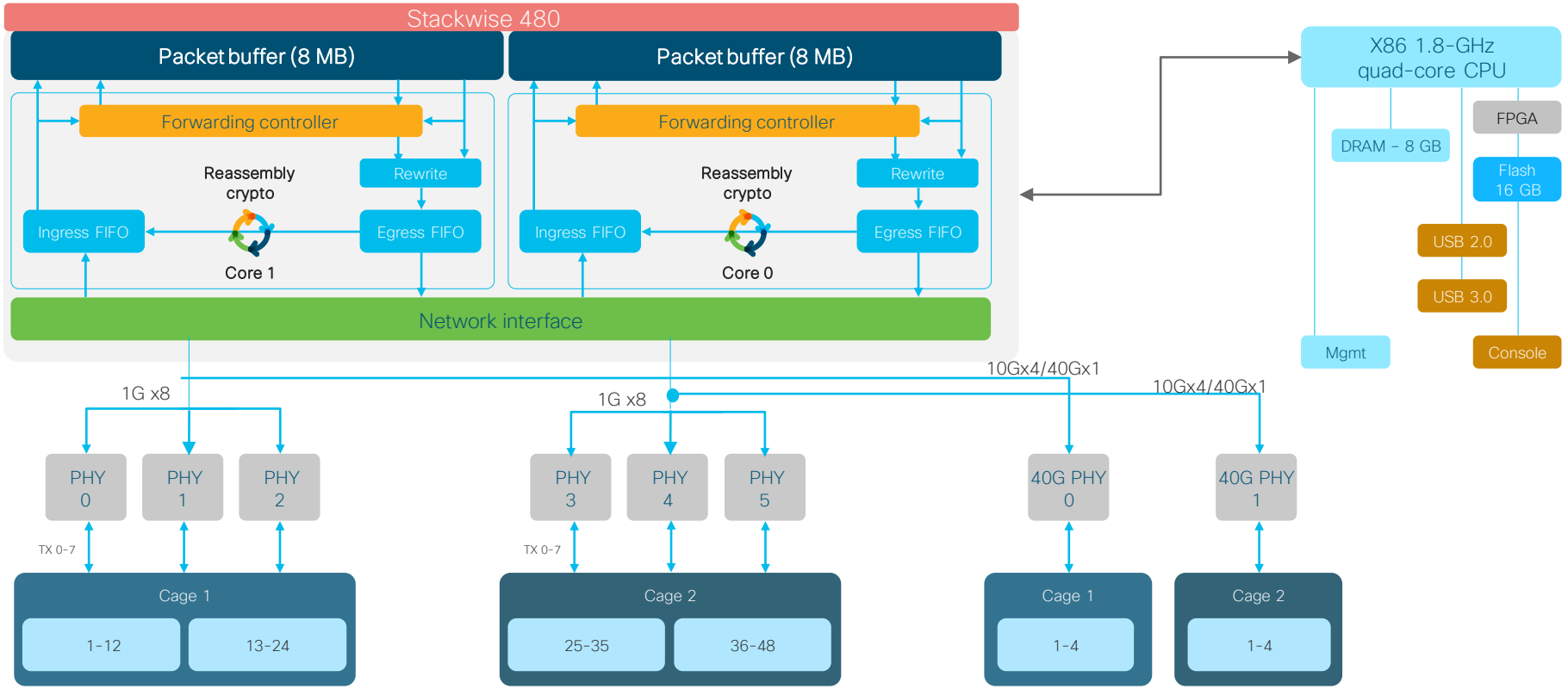
Stacking

C9300

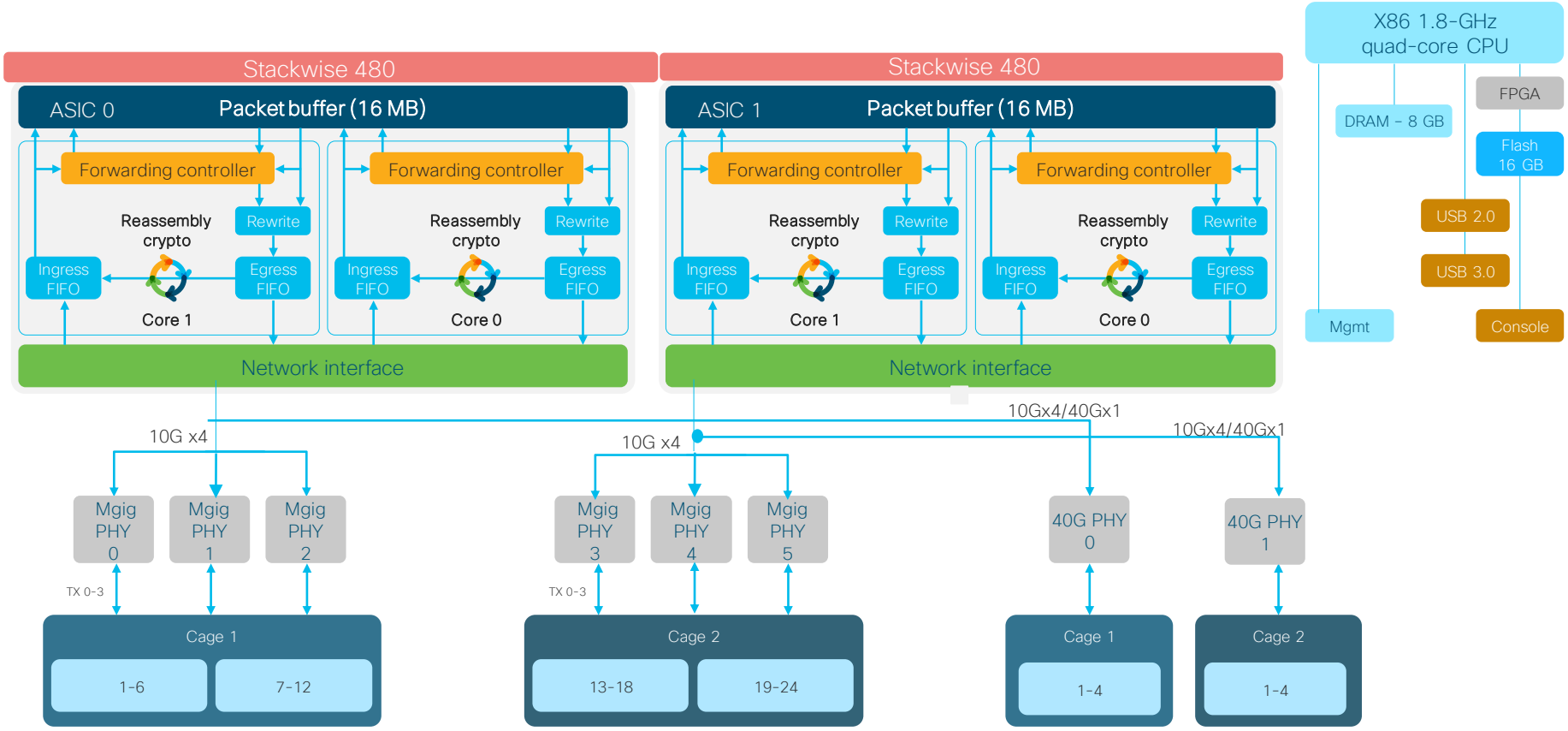
C9300L

0.5, 1 and 3 meter Options

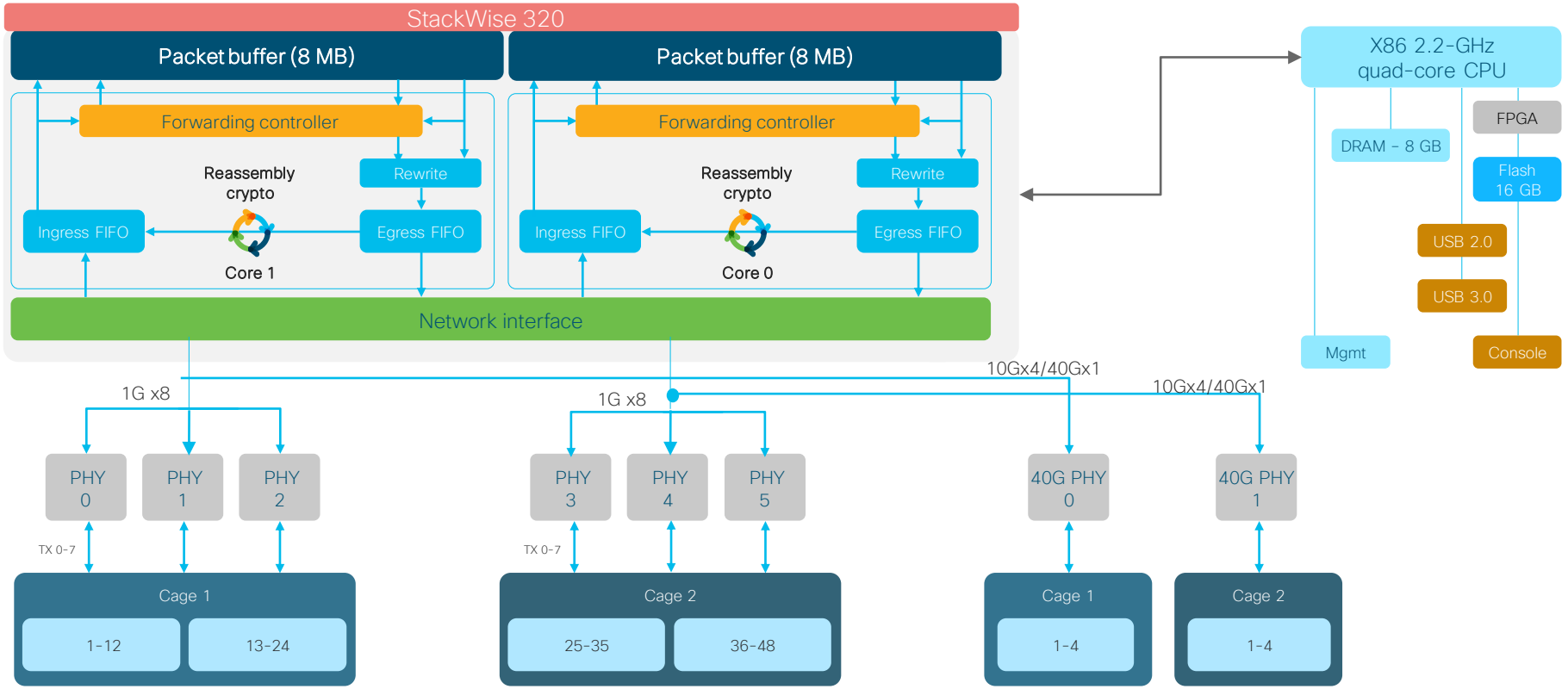
C9300-48 Block Diagram



C9300 Multigigabit-24 Block Diagram

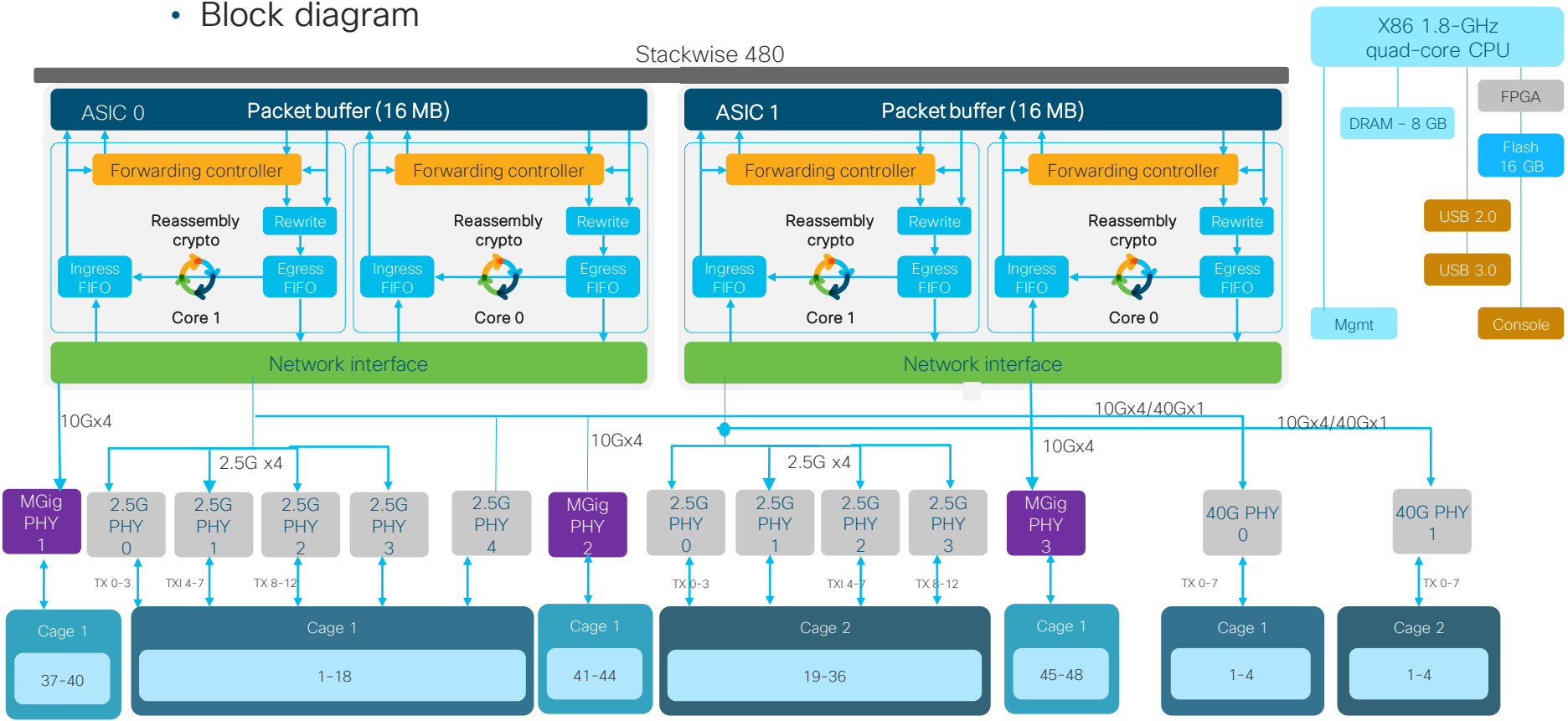


C9300L-48 Block Diagram



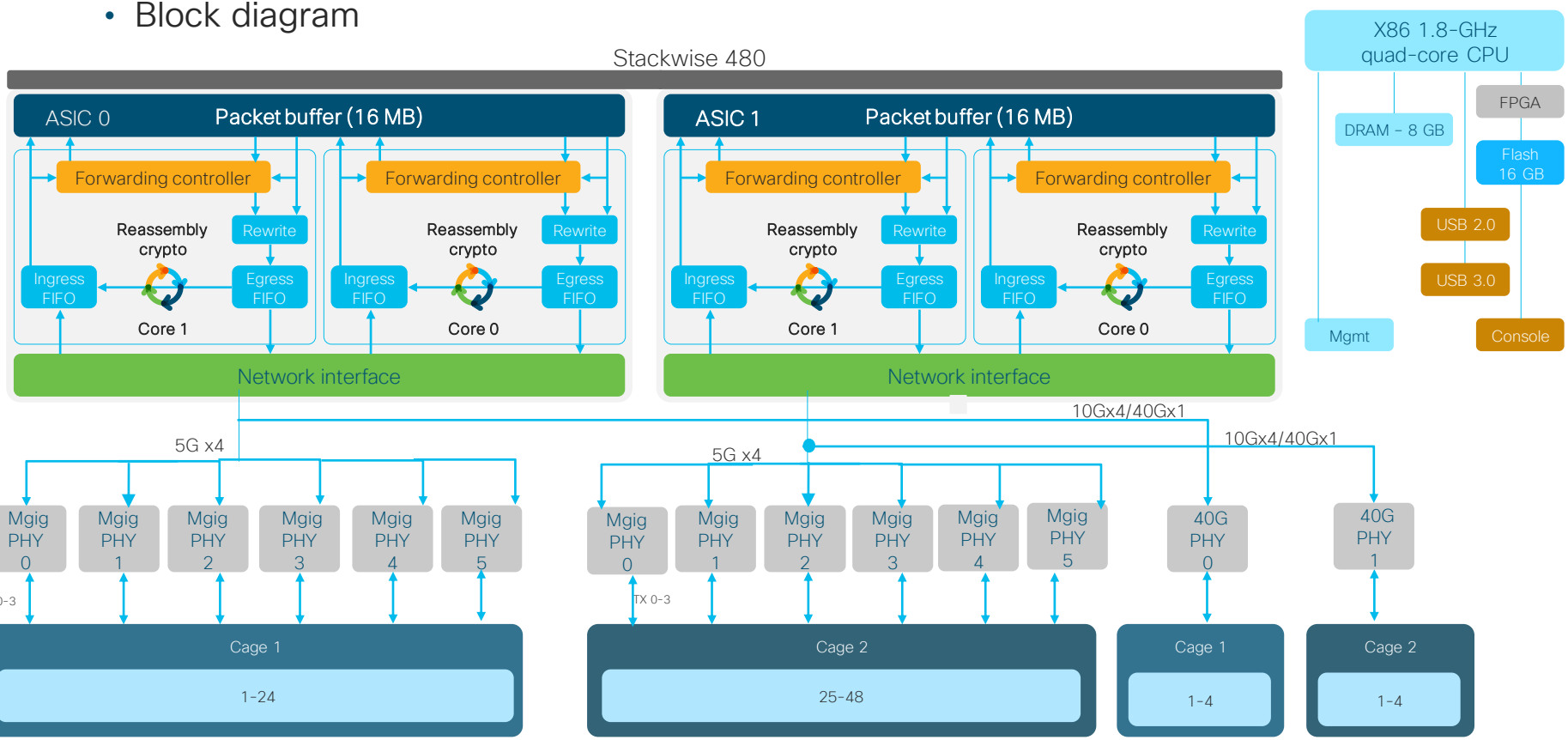
Cisco Catalyst 9300 Multigigabit-48UXM

- Block diagram

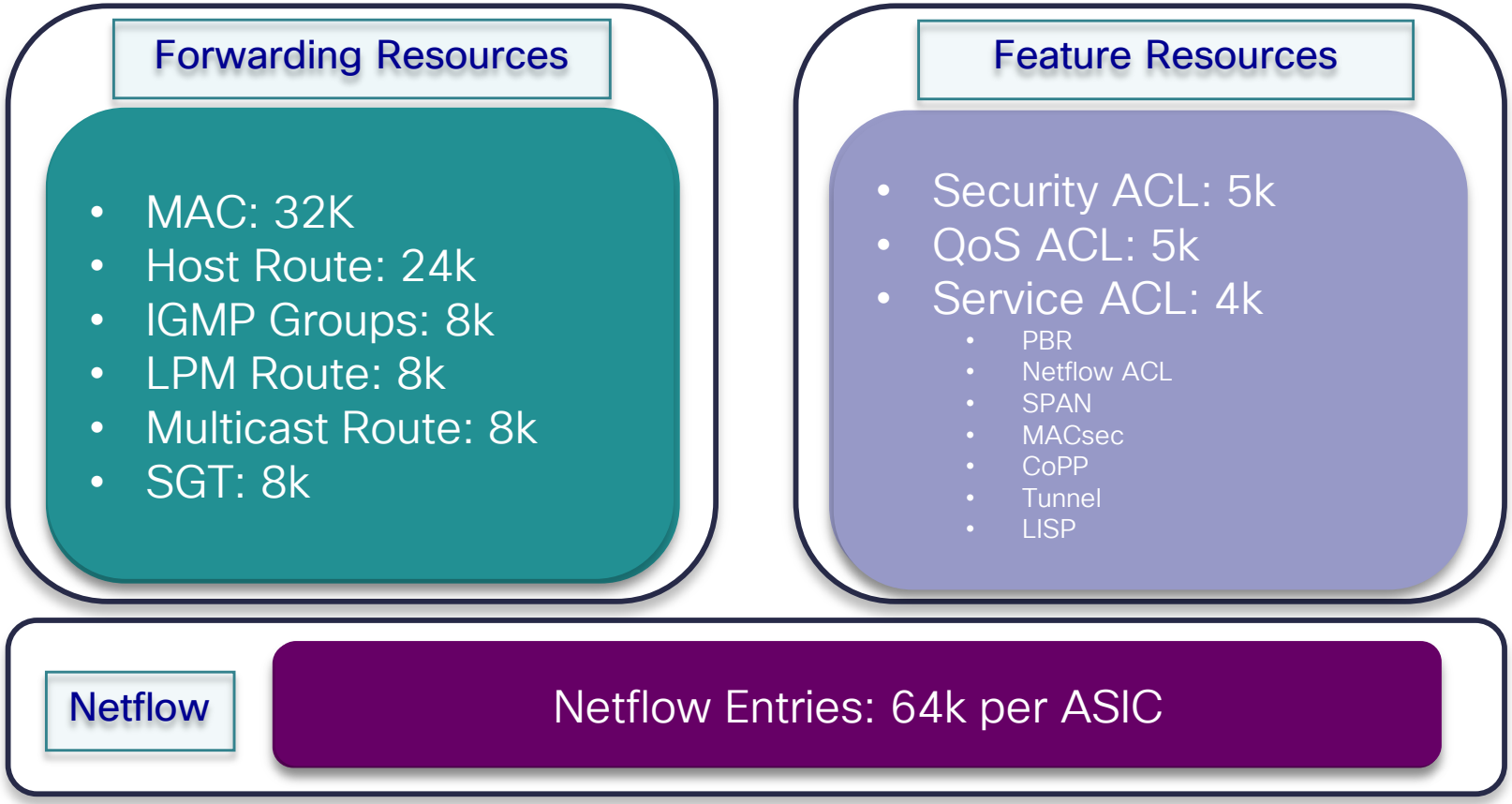


Cisco Catalyst 9300 Multigigabit-48UN

- Block diagram



Higher Scale with 9300



Stackwise-480 & Stack Power

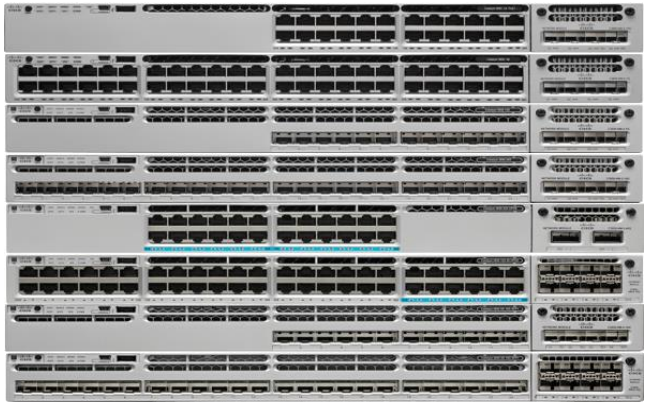
You make security **possible**

Cisco live!

How many can I stack together?

Modular uplink models

C9300 SKUs



8 switches

Stacking supported among **C9300** SKUs only

Fixed uplink models

C9300L SKUs

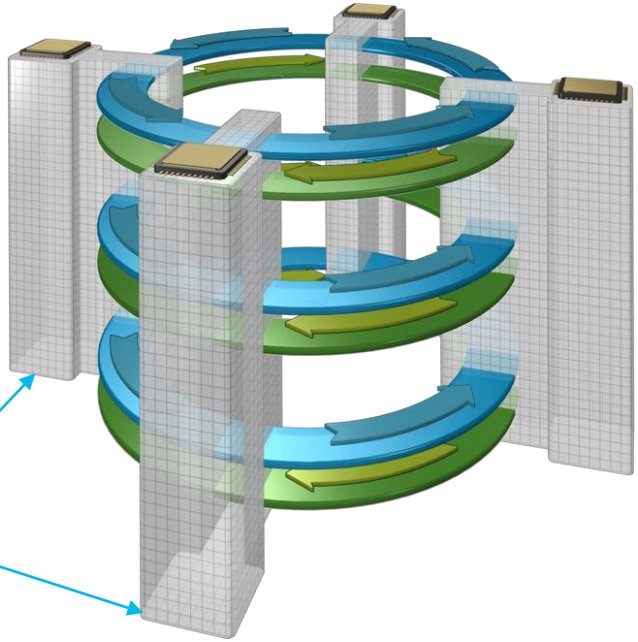
8 switches

Stacking supported among **C9300L** SKUs only

Mixed stacking is not supported between C9300 and C9300L SKUs

Cisco Catalyst 9300 Series Switches

The stack ring – StackWise-480 on C9300 SKUs

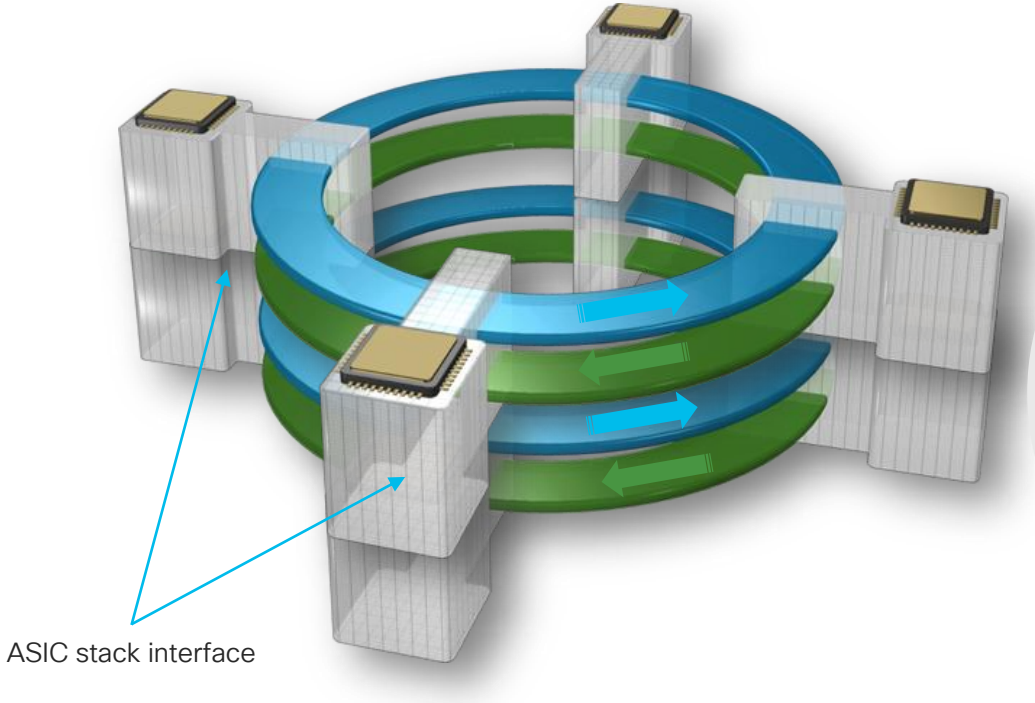


- 6 rings in total
- 3 rings go east
- 3 rings go west
- Each ring is 40 Gbps
- 240 Gbps unidirectional
- Spatial reuse = 480 Gbps

Assuming 4x 24-port Cisco® Catalyst® 9300 Series modular uplink models

Cisco Catalyst 9300 Series Switches

The stack ring – StackWise-320 on C9300L SKUs

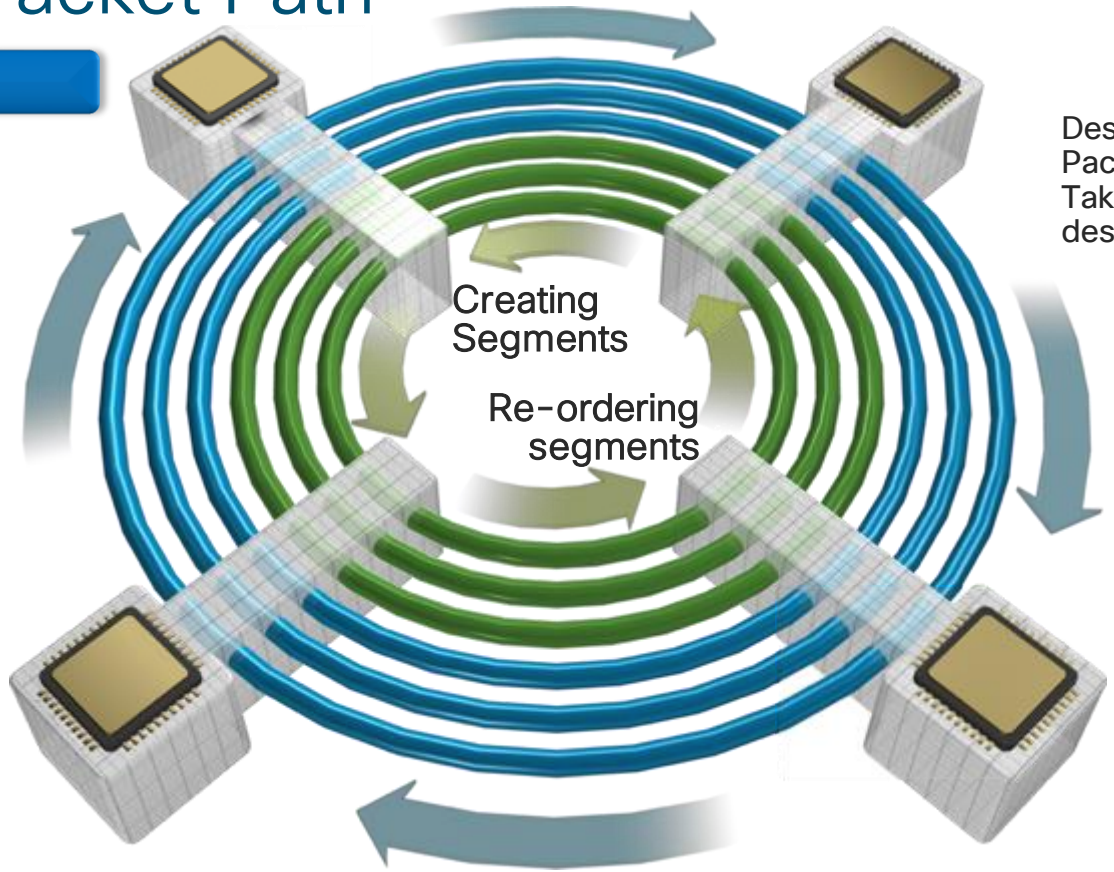


- 4 rings in total
- 2 rings go east
- 2 rings go west
- Each ring is 40 Gbps
- 160 Gbps bidirectional
- Spatial reuse = 320 Gbps

Assuming 4x 24-port Cisco® Catalyst® 9300 Series fixed uplink models

Unicast Packet Path

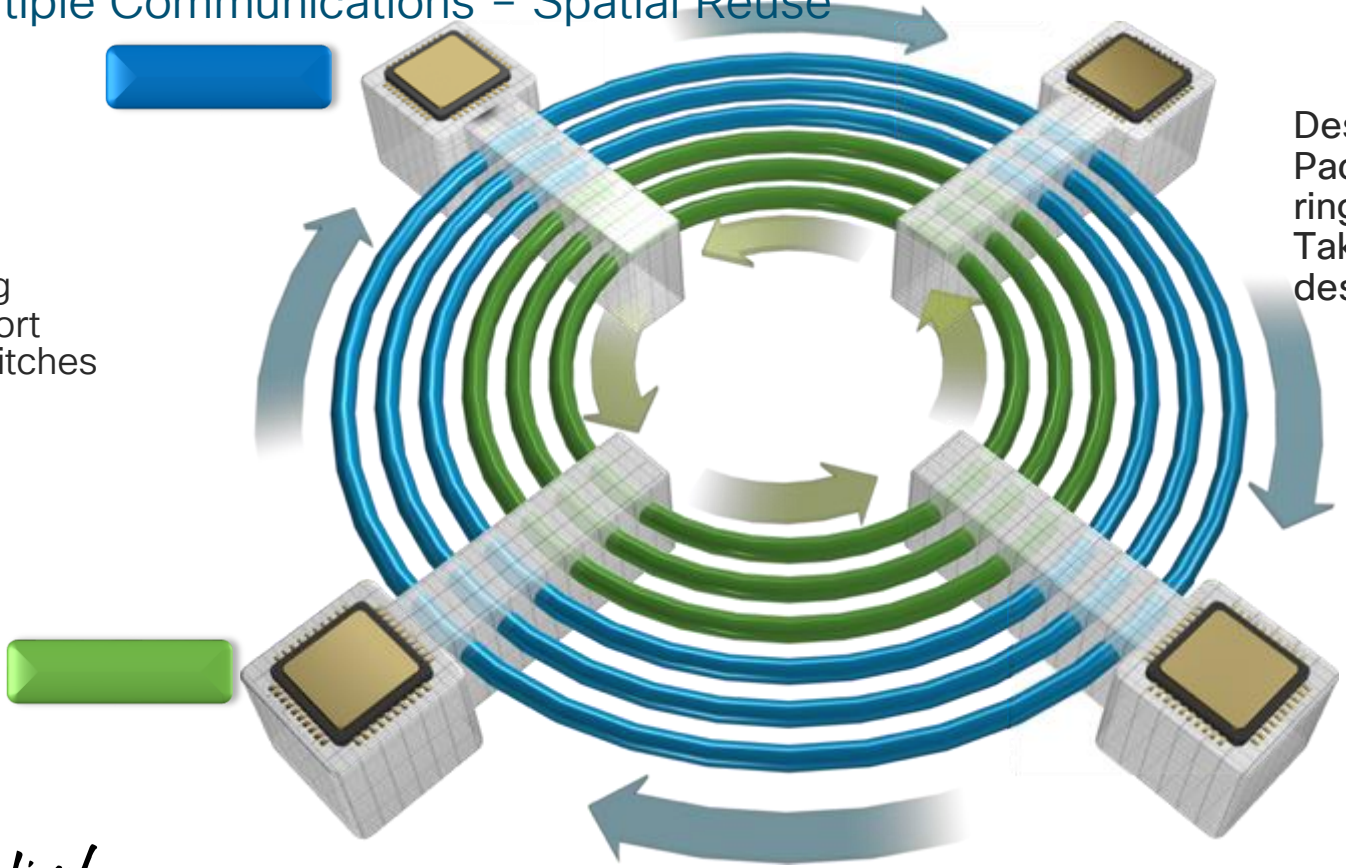
Assuming
4 x 24-port
9300 Switches



Destination Stripping
Packet travels ½ the rings
Taken out of stack by destination

Unicast Packet Path on the Stack Ring

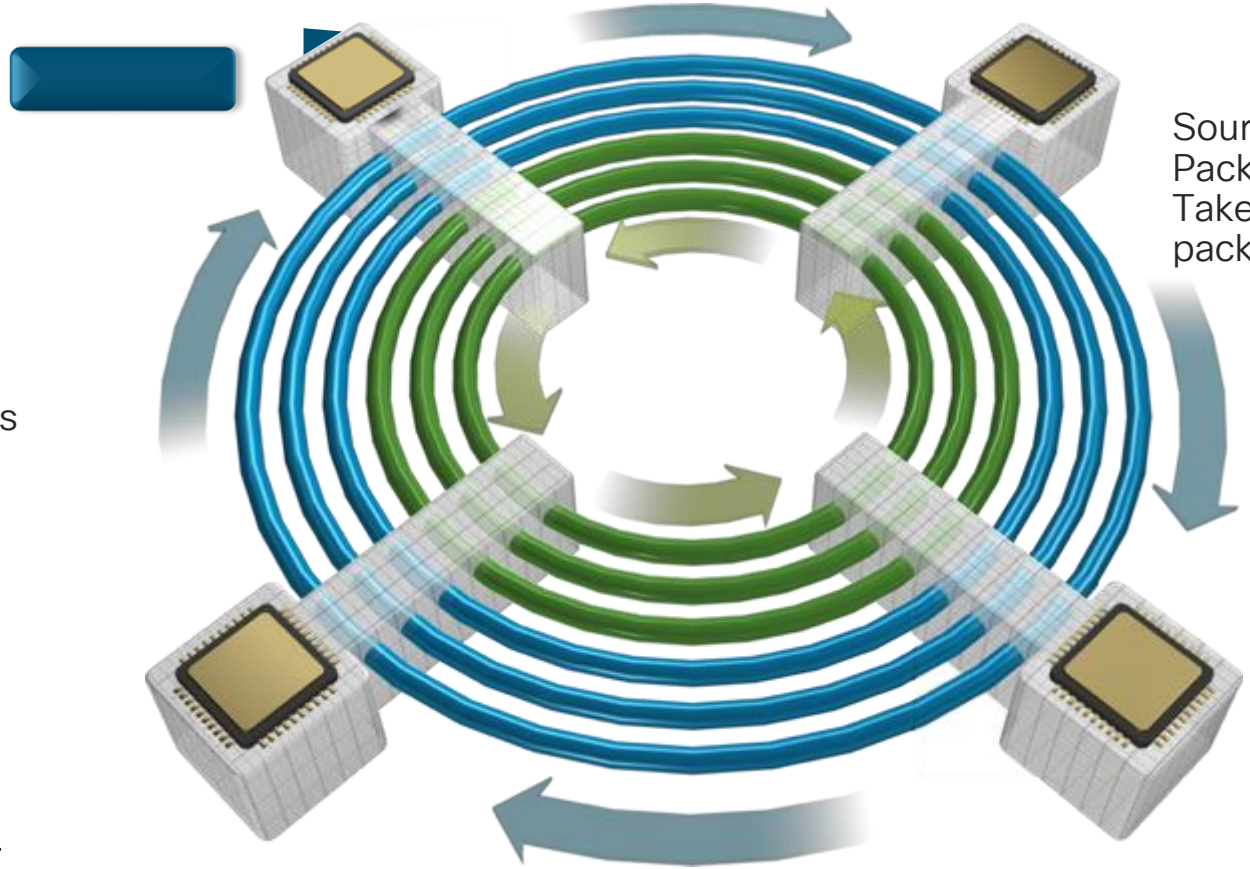
Multiple Communications – Spatial Reuse



Assuming
4 x 24-port
9300 Switches

Destination Stripping
Packet travels ½ the rings
Taken out of stack by destination

Multicast Packet Path on the Stack Ring



Source Stripping
Packet travels the full rings
Taken out by source, when packet reach back

Assuming
4 x 24-port
9300 Switches

StackPower – overview

“Zero-footprint” redundant power system (RPS) deployment

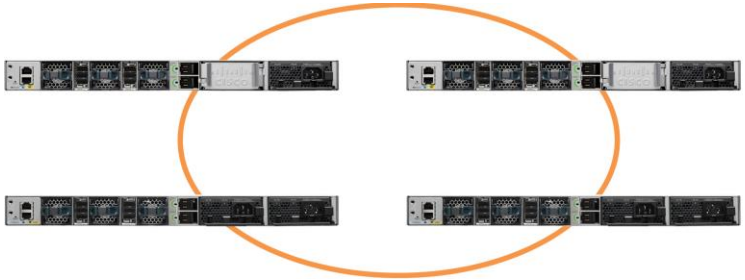
- Provides RPS functionality with zero RPS footprint
- Pay-as-you-grow architecture – similar to the data stack
- 1+N redundancy with inline power
- Up to 4 switches in a StackPower ring
- Multiple StackPower possible within one data stack
- Up to 8 switches in a star topology with an expandable power system (XPS)

StackPower is not supported on C9300L SKUs

Power Redundancy Options

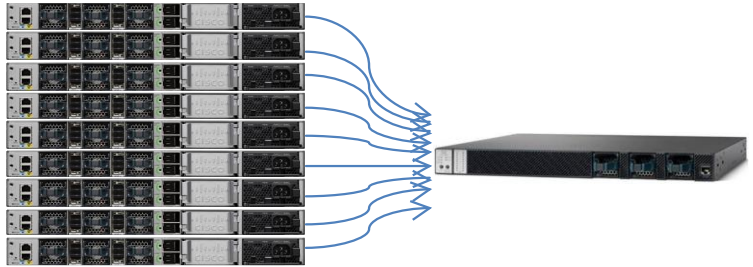
Zero Footprint RPS OR XPS

Day 1



StackPower – Zero Footprint RPS

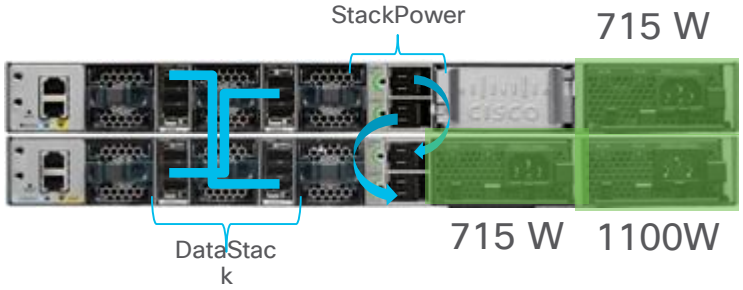
Stack of 4 switches

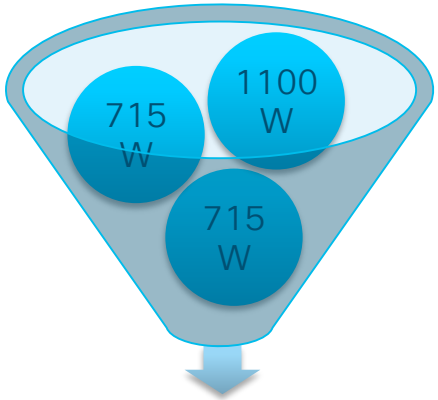


eXpandable Power System (XPS)

Stack of 8 switches

How StackPower Works?

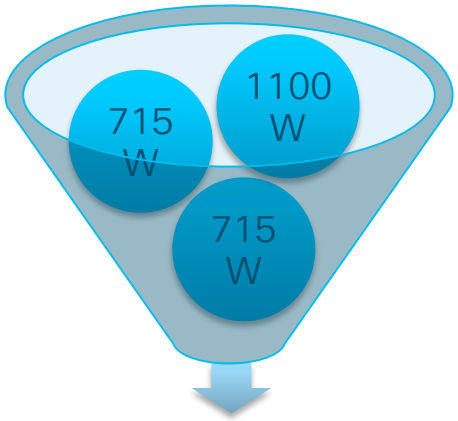




Total Input Power 2530W

- Pools Power from All PS
- All Switches in StackPower share the available Power in Pool
- Each Switch is given their Minimum Power Budget

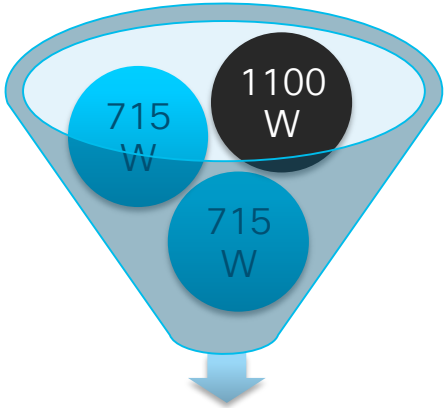
Power Budget Modes



2530W – 30W

Power Sharing Mode

- The Default Mode
- Sum of All PS – 30~60W



1430W – 30W

Redundant Mode

- User Configurable
- Sum of All PS – Largest PS – 30~60W

Global StackPower Reserve = 30W

Power Priority

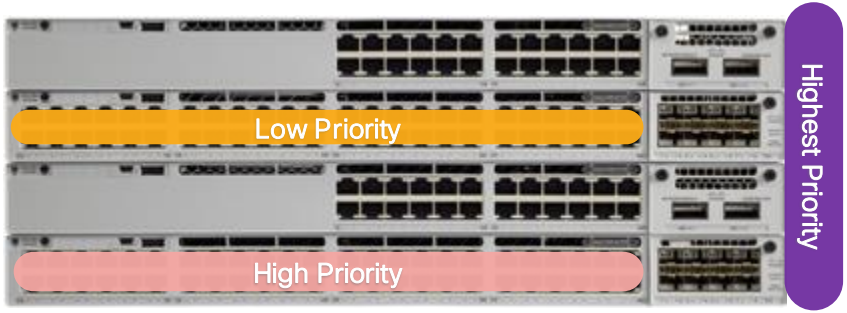
Load Shedding

- Standalone Mode

Load Shedding Based on configured priority

1. Low Priority Ports
2. High Priority Ports

- Stack Mode



Load Shedding Based on configured priority

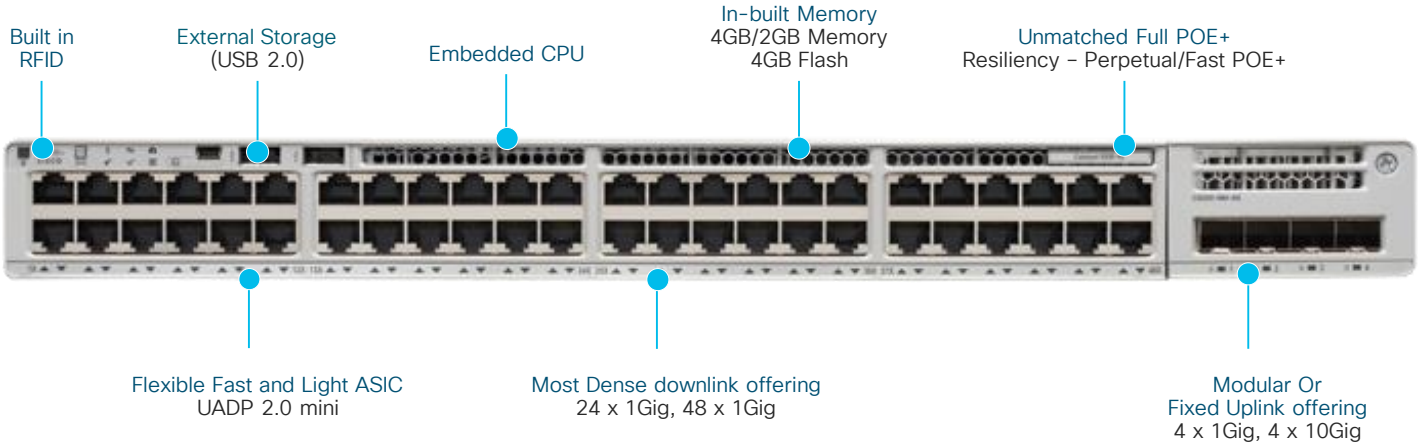
1. Low Priority Ports
2. High Priority Ports
3. Switch Priority – Highest Priority

Catalyst 9200

You make customer experience **possible**

Cisco live!

Catalyst 9200 Series

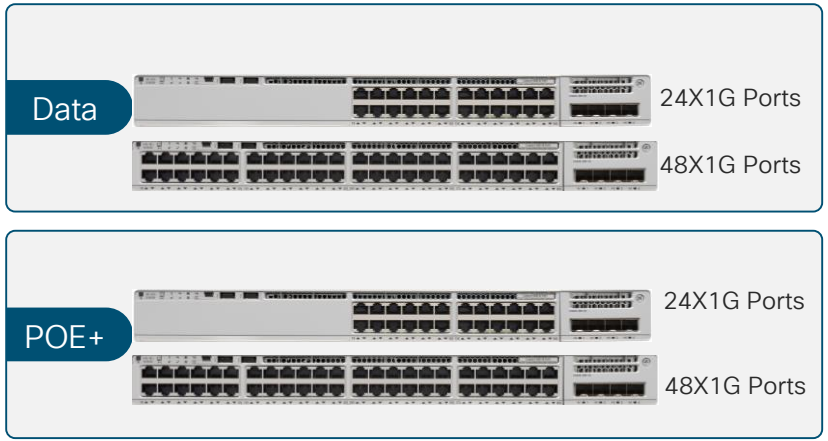


Right Sized Switching for simple Branch Deployments

Catalyst 9200 Series switching 1G Model SKUs

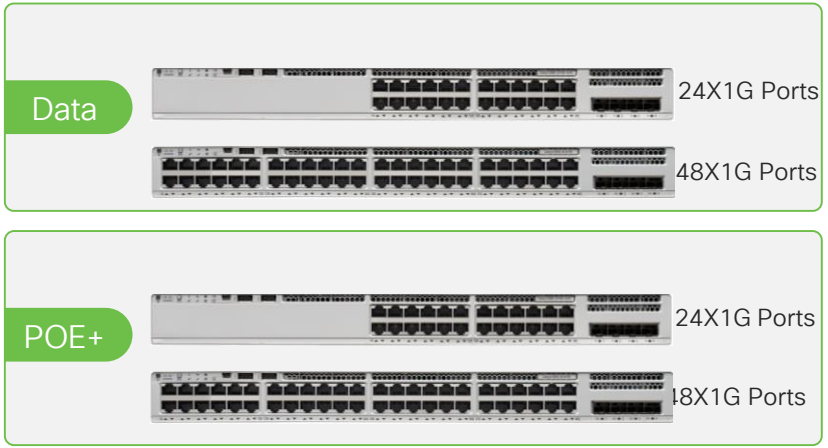
Catalyst 9200 Series switching SKUs

9200 (Modular Uplinks and Fans)



4 x 1G and 4 x 10G Uplinks

9200L (Fixed Uplinks and Fans)



4 x 1G and 4 x 10G Uplinks

Modular Power Supplies available on all the SKUs

Modular uplink options on Catalyst 9200 Series switches

- 4 x 1 Gig
- SFP Transceivers
- **Supported on all modular SKUs**

- 4 x 10 Gig
- SFP/SFP + Transceivers
- **Supported on all modular SKUs***

Modular uplinks supported on Catalyst 9200 Series modular SKUs

Resilient power supplies

Silver Rated (80% efficiency)

125WAC

Supported only on 1G Data SKUs

Platinum Rated (90% efficiency)

600WAC

Supported only on 24 Port POE+ SKUs

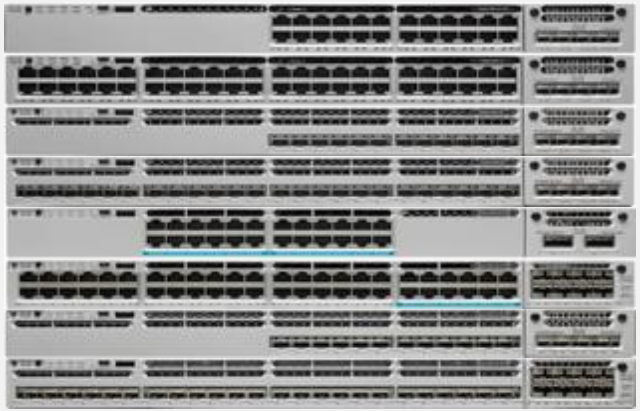
1000WAC

Supported only on 48 Port POE+ SKUs

Load sharing (1+1) mode supported for PoE+ SKUs

Power Supplies are Field Replaceable Units
Redundant Power Supply should be identical

StackWise-160/80 with SSO



Up to 8
member stack

- StackWise-160 supported on all modular Catalyst 9200 Series switching models
- StackWise-80 supported on all fixed Catalyst 9200 Series switching models
- Same Cisco IOS XE and license required on all members

Stacking Kit →

Stack Adapters

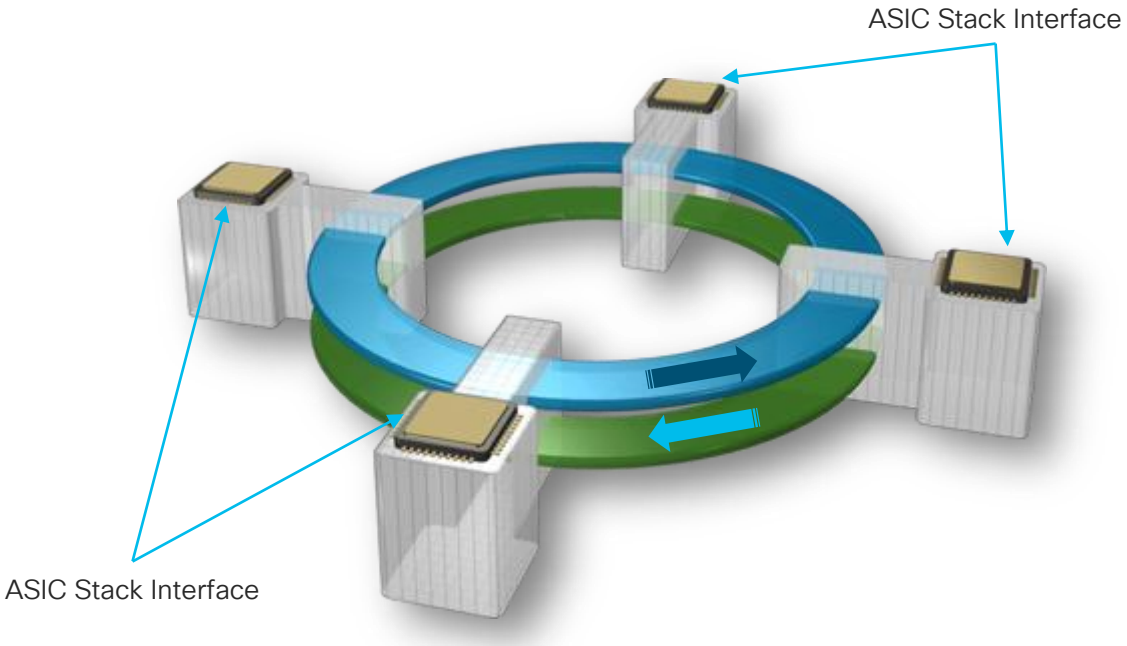
Stacking Cable

Ordered Separately

Stacking cable comes with three options: 50cm, 1m, 3m

*Mix stacking not supported between StackWise-160 and StackWise-80

The stack ring – StackWise 160/80



- 2 rings in total
- 1 ring goes East
- 1 ring goes West
- Each ring is 40/20 Gbps
- 80/40 Gbps bi-direction
- Spatial Reuse= 160/80 Gbps

Assuming 4 x 24-port Catalyst 9200 Series modular switches

Lookup tables

Forwarding Resources

	Modular SKUs	Fixed SKUs
MAC	32k	16k
Host Route	10k	8k
IGMP Groups	1k	1k
Indirect Route	4k	3k
Multicast Route	1k	1k
SGT	2k	2k

Feature Resources

	Modular SKUs	Fixed SKUs
Security ACL • PACL • VACL • RACL	1k	1k
QoS ACL	1k	1k
Netflow ACEs	128	128

Netflow

Netflow Entries: 16k per ASIC

Fixed Access Positioning

L2
Small Scale
1/10G
POE+
Stackwise-160/80
Cold Patching

Catalyst 9200

EVPN
BGP
GRE
MPLS
Stackwise-480
1/10G /40G
ETA
UADP 2.0
L2 + L3
Stack-Power
Guest Shell
X86 CPU
Higher Scale and Buffer
Hot Patching
App-Hosting
POE+/ UPOE
GIR
Multigig abit

Catalyst 9300

Branch Office and Small Campus

Small to Large Campus

Modular Platform – Catalyst 9400

You make networking **possible**

Cisco live!

Catalyst 9400

4-Slot

7-Slot

10-Slot

Chassis

	4 – Slot	7 – Slot	10 – Slot
Supervisor	2 (Redundant)		
Line Cards	2	5	8
Ports	96x 10/100/1000 48 mGig; 56 SFP/SFP+ 2x QSFP+	240x 10/100/1000 120 mGig; 128 SFP/SFP+ 2x QSFP+	384x 10/100/1000 192 mGig; 200 SFP/SFP+ 2x QSFP+
Dimension	W:17.5”; D:16.25”; H:6RU	W:17.5”; D:16.25”; H:10RU	W: 17.5”; D:16.25”; H: 13RU
BW per LC Slot	480G	480G	480G
BW between Sup Slots	720G		
Power Supply	4 PS (N+1 and N+N)	8 PS (N+1 and N+N)	8 PS (N+1 and N+N)
PoE per slot	4,800W		
Cooling	Side to Side (Front-to-Back for PS)		

High Density 10G Ports, 100G Uplinks

Ready for future higher power PoE devices

Sup-1 - Overview

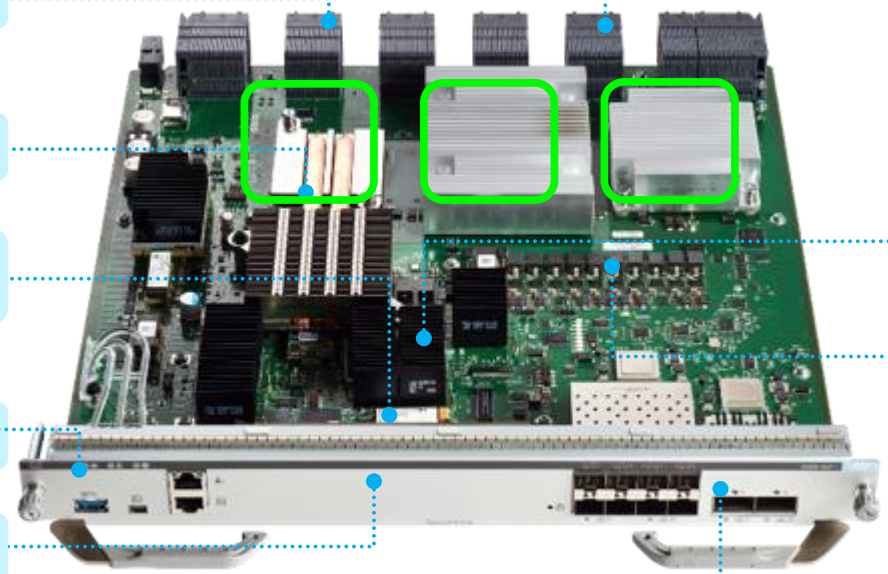
720G LCs/Uplinks

UADP 2.0 XL ASICs

M.2 SATA SSD
(Optional: Upto 1TB)

USB 2.0/3.0

MACSec256



Line Card Slot BW:
7 Slot: 80G
10 Slot: 80G (> 150Byte)

2.4Ghz Quad Core x86
CPU

16G DRAM and 16G Flash

Uplinks:
8x 10G / 2x 40G

C9400-SUP-1XL - Overview

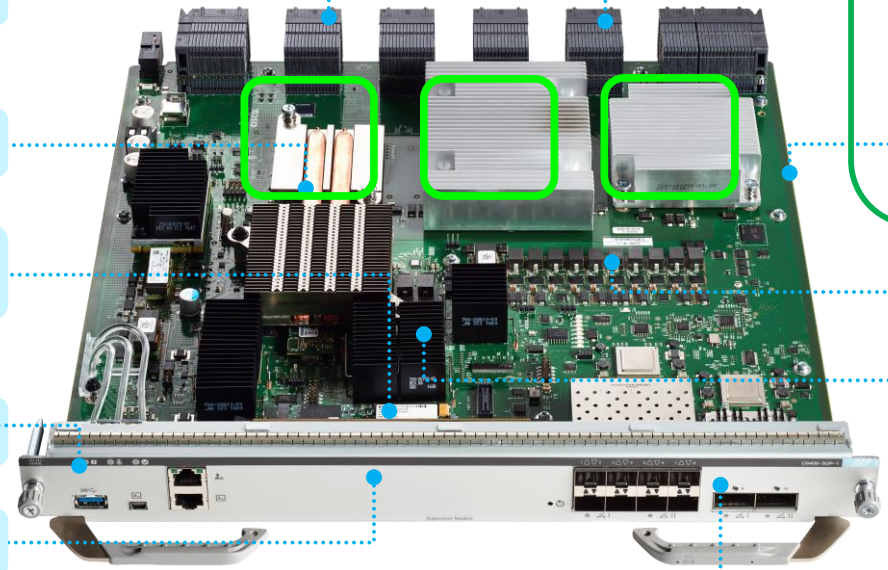
720G LCs/Uplinks

UADP 2.0 XL ASICs

M.2 SATA SSD
(Optional: Upto 1TB)

USB 2.0/3.0

MACSec256



Line Card Slot BW:
4 Slot: **240G** (>150Byte)
7 Slot: **120G** (>150Byte)
10 Slot: 80G (> 150Byte)

Templates: Distribution, Core, SD Boarder, NAT

16G DRAM and 16G Flash

2.4Ghz Quad Core x86 CPU

Uplinks:
8x 10G / 2x 40G

Optimized for Distribution/Core deployment

C9400-SUP-1XL-Y - Overview

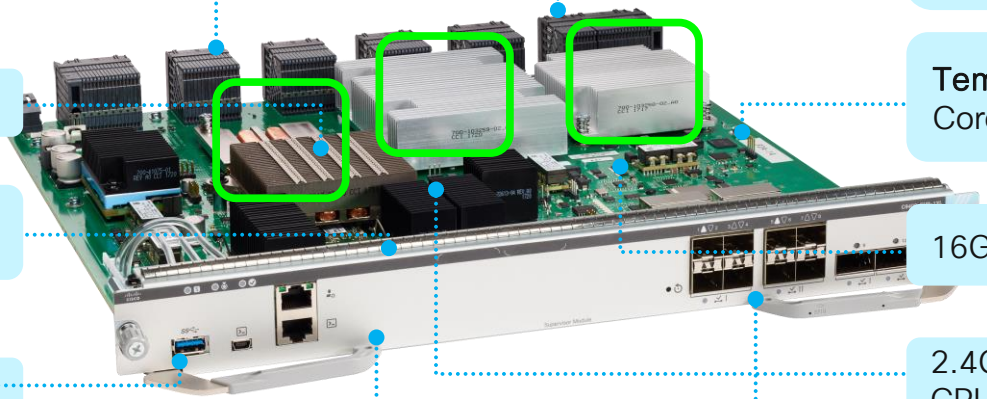
720G LCs/Uplinks

UADP 2.0 XL ASICs

M.2 SATA SSD
(Optional: Upto 1TB)

USB 2.0/3.0

MACSec256



Line Card Slot BW:
4 Slot: **240G** (>150Byte)
7 Slot: **120G** (>150Byte)
10 Slot: 80G (> 150Byte)

Templates: Distribution, Core, SD Boarder, NAT

16G DRAM and 16G Flash

2.4Ghz Quad Core x86 CPU

Uplinks:
2x 25G / 8x 10G / 2x 40G

Optimized for Core deployment

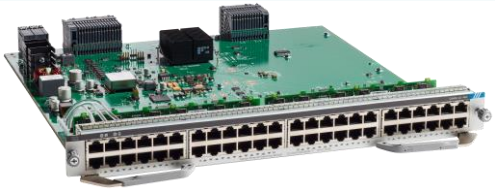
Supervisors

		Line Card Slot BW:	Template:	Uplinks:
C9400-SUP-1		4 Slot: 80G 7 Slot: 80G 10 Slot: 80G	Access	1G 10G 40G
C9400-SUP-1XL		4 Slot: **240G** 7 Slot: **120G** 10 Slot: **80G**	Access, **Core,** **SD Boarder,** **NAT**	
C9400-SUP-1XL-Y				1G 10G **25G** 40G

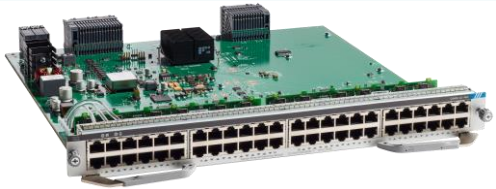
Line Cards - Copper

C9400-LC-48T

RJ45 (Data)
48x 10/100/1000
TrustSec and MACSec(256)

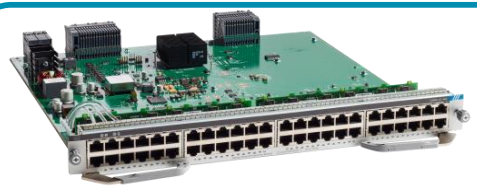


C9400-LC-48P



C9400-LC-48U

RJ45 (UPoE)
48x 10/100/1000
PoE/PoE+; PoE/PoE+/UPoE
TrustSec and MACSec(256)



C9400-LC-48UX

RJ45 (mGig)
24x 10/100/1000 + 24x
100/1G/2.5G/5G/10G
PoE/PoE+/UPoE
TrustSec and MACSec(256)

Line Cards - Fiber

C9400-LC-24S

C9400-LC-48S

SFP (1G)
24x or 48x 100/1000
TrustSec and MACSec(256)

C9400-LC-24XS

Fiber (1G/10G)
24x 1G/10G
TrustSec and MACsec(256)

Power Supplies

- Modular Design: 4 PS for 4 slot chassis; 8 PS for 7 and 10 slot chassis
- Shared: Power for both Data and Inline Power
- Platinum PS: 90%+ efficiency
- PS:
  - 3200W AC PS With 240V input. (1570W with 120V input. 16A input)
  - 2100W AC PS With 240V input. (940W with 120V input. 10.4A input)
  - 3200W DC PS With -40V to -72V input.

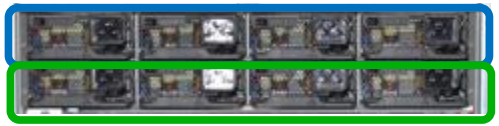
Power

	Normal	PS failure
Combined (Default)	 Load sharing on all PSs	 Load sharing on functional PSs
Redundant	 Load sharing on active PSs Standby PS in output disabled	 Standby PS becomes active System enters alarm state

Failed PS | ACTIVE | STANDBY

Power Redundancy: N+N and N+1

- Default active is PS1-4 and standby is PS5-8 (C9404R: Active: PS1-2; Standby PS3-4)
- Standby power slots are configurable



```
SW(config)#power redundancy-mode redundant ?
  N+N   Redundant N+N (N is active, N is standby)
  N+1   Redundant N+N (N is active, 1 is standby)
SW(config)#power redundancy-mode redundant N+1 ?
  <1-8>  standby slot in N+N mode
SWR(config)#
```

- Default active is PS1-7 and standby is PS8 (C9404R: Active: PS1-3; Standby PS4)
- Standby power slot is configurable

```
SW(config)#power redundancy-mode redundant ?
  N+N   Redundant N+N (N is active, N is standby)
  N+1   Redundant N+N (N is active, 1 is standby)
SW(config)#power redundancy-mode redundant N+1 ?
  <1-8>  standby slot in N+1 mode
SWR(config)#
```

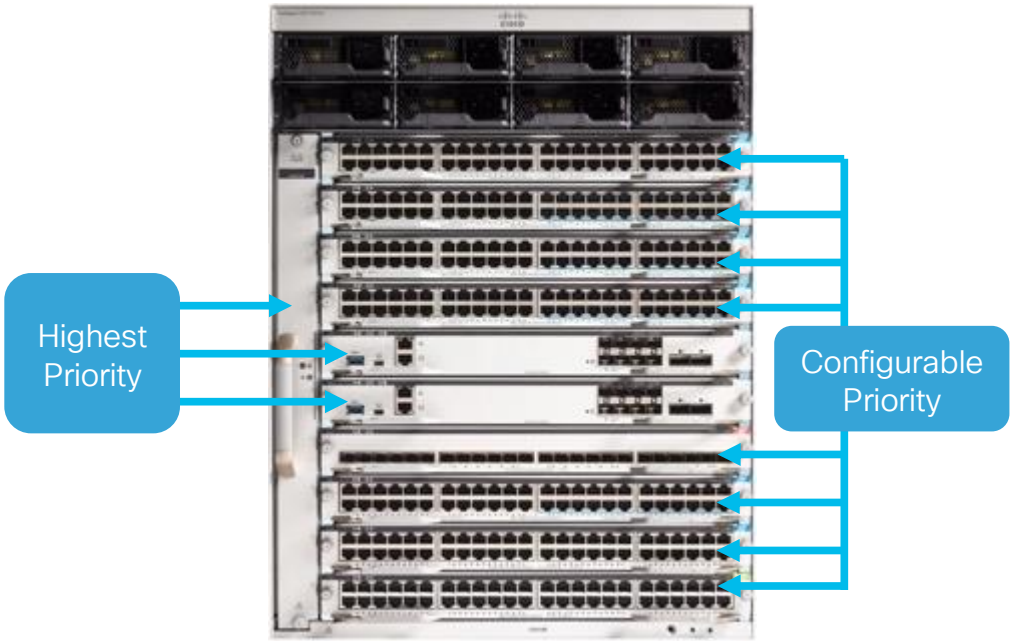
ACTIVE

STANDBY

Power Priority

- All components in the system are assigned with power priority level
- Supervisors and Fan Tray has the same highest priority level
- Lower slot# has the higher power priority level by default if "`power supply autoLC shutdown`" is configured
- Configurable power priority for line card slots

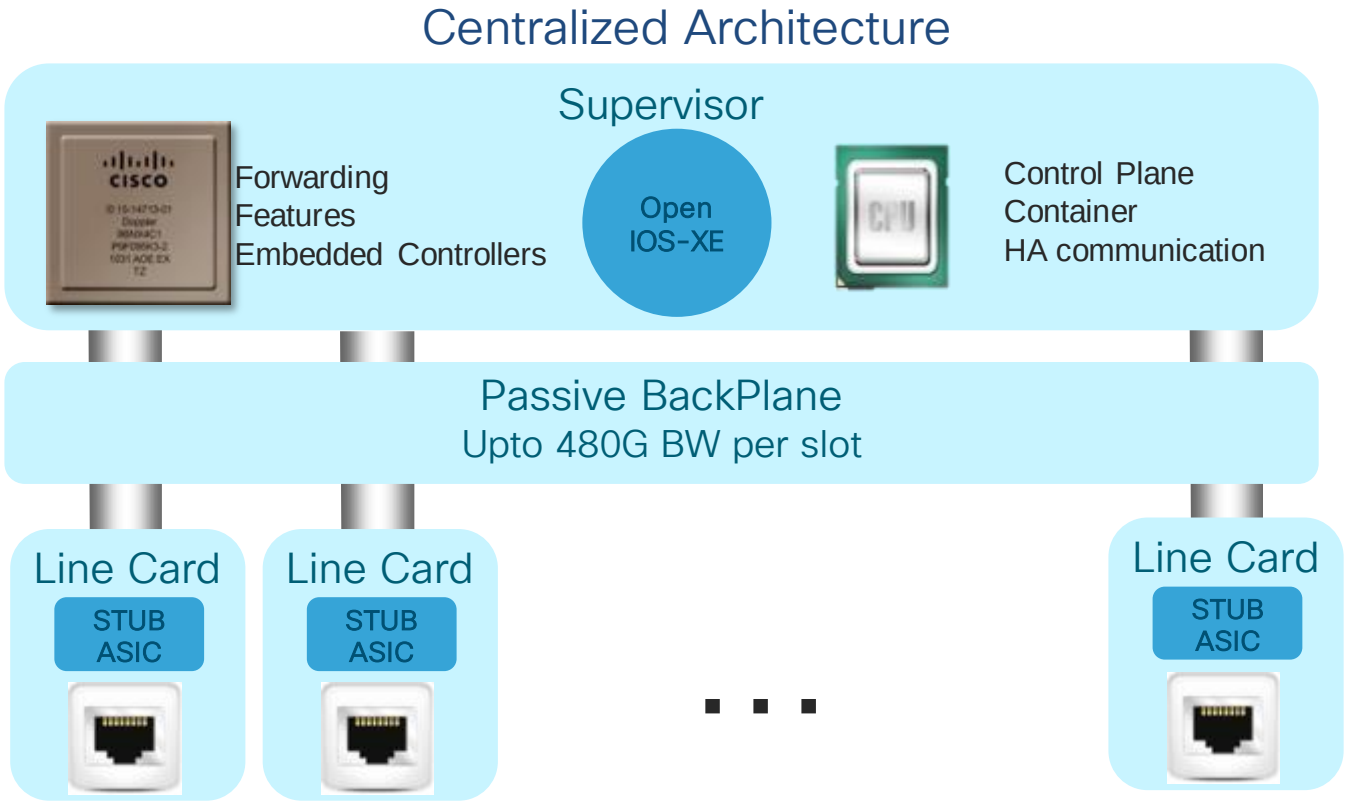
```
C94(config)#power supply autoLC priority ?
  <1-7>  Physical slot number
  <cr>
C94(config)
```



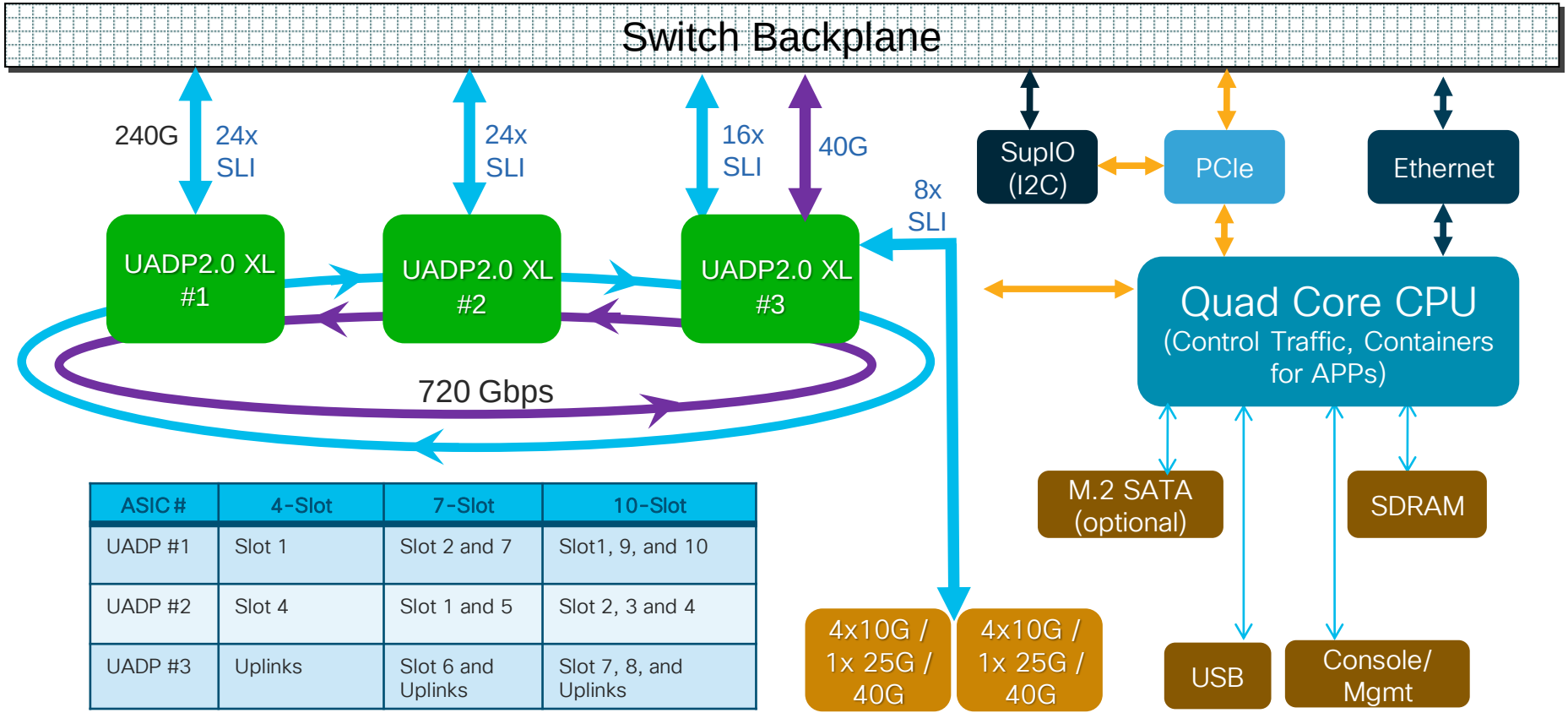
Fan Tray

- Redundant – N+1 fan
- Flexible Service – fan tray can be replaced from the portside or the back
- Efficient – Variable speed per fan depends on the load, temperature and altitudes (=>lower noise).
- Air flow – Side to side air flow

Architecture



Sup-1/Sup-1XL/Sup-1XL-Y Block Diagram



ASIC #	4-Slot	7-Slot	10-Slot
UADP #1	Slot 1	Slot 2 and 7	Slot1, 9, and 10
UADP #2	Slot 4	Slot 1 and 5	Slot 2, 3 and 4
UADP #3	Uplinks	Slot 6 and Uplinks	Slot 7, 8, and Uplinks

SLI – Switch Link Interfaces

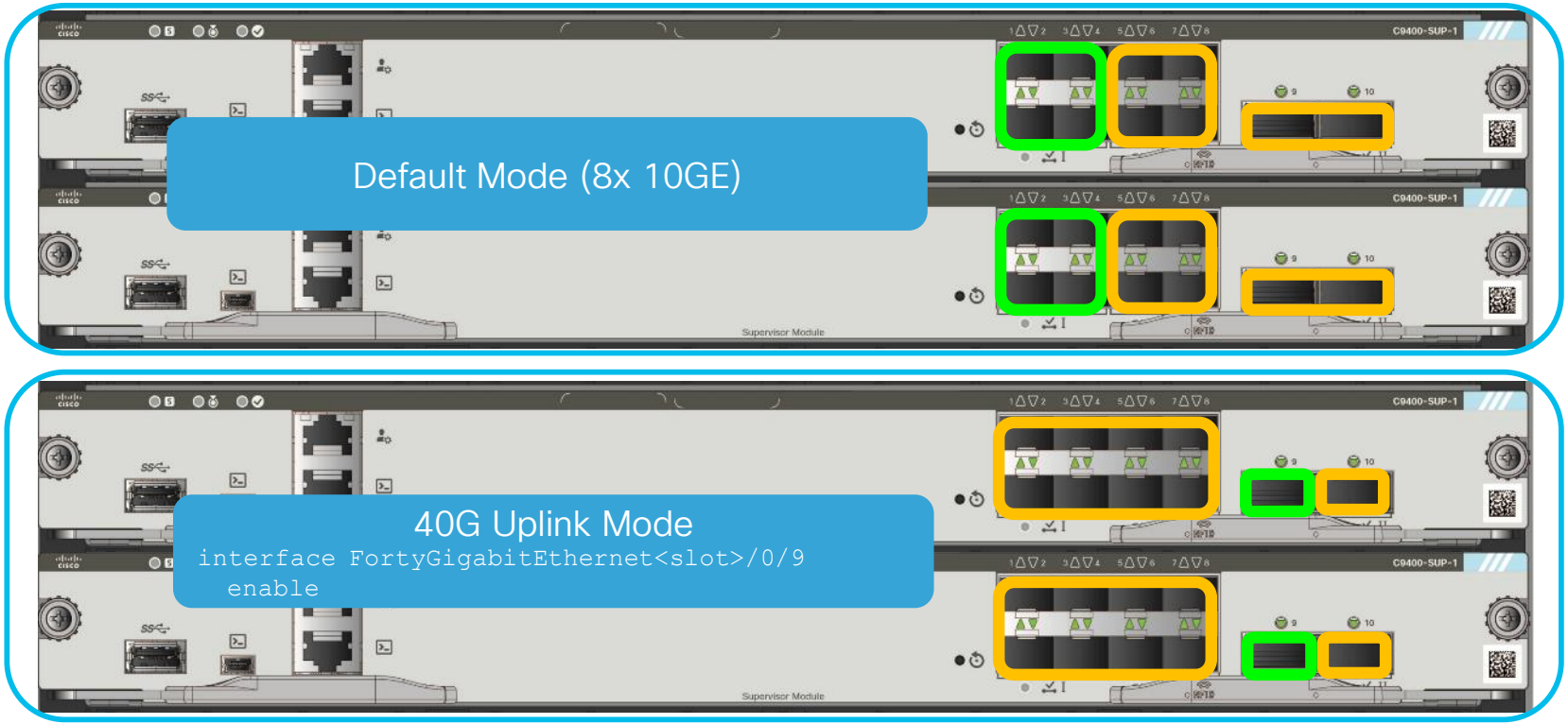
Port to ASIC Mapping

FYI

```
switch#show platform software fed active ifm mappings
Interface                IF_ID     Inst  Asic  Core  Port  SubPort  Mac   Cntx  LPN   GPN   Type  Active
GigabitEthernet1/0/1     0x7         2     1     0     0       0      4     4     1     101   NIF   Y
GigabitEthernet1/0/2     0x8         2     1     0     1       1      4     4     2     102   NIF   Y
GigabitEthernet1/0/3     0xf5        2     1     0     2       2      4     4     3     103   NIF   Y
GigabitEthernet1/0/4     0xa         2     1     0     3       3      4     4     4     104   NIF   Y
GigabitEthernet1/0/5     0xb         2     1     0     4       4      4     4     5     105   NIF   Y
GigabitEthernet1/0/6     0xc         2     1     0     5       5      4     4     6     106   NIF   Y
GigabitEthernet1/0/7     0xd         2     1     0     6       6      4     4     7     107   NIF   Y
GigabitEthernet1/0/8     0xe         2     1     0     7       7      4     4     8     108   NIF   Y
GigabitEthernet1/0/9     0xf         2     1     0     8       0      0     0     9     109   NIF   Y
GigabitEthernet1/0/10    0x10        2     1     0     9       1      0     0     10    110   NIF   Y
GigabitEthernet1/0/11    0x11        2     1     0     10      2      0     0     11    111   NIF   Y
GigabitEthernet1/0/12    0x12        2     1     0     11      3      0     0     12    112   NIF   Y
GigabitEthernet1/0/13    0x13        2     1     0     12      4      0     0     13    113   NIF   Y
GigabitEthernet1/0/14    0x14        2     1     0     13      5      0     0     14    114   NIF   Y
GigabitEthernet1/0/15    0x15        2     1     0     14      6      0     0     15    115   NIF   Y
GigabitEthernet1/0/16    0x16        2     1     0     15      7      0     0     16    116   NIF   Y
GigabitEthernet1/0/17    0x17        2     1     0     16      0      5     5     17    117   NIF   Y
GigabitEthernet1/0/18    0x18        2     1     0     17      1      5     5     18    118   NIF   Y
GigabitEthernet1/0/19    0x19        2     1     0     18      2      5     5     19    119   NIF   Y
GigabitEthernet1/0/20    0x1a        2     1     0     19      3      5     5     20    120   NIF   Y
GigabitEthernet1/0/21    0x1b        2     1     0     20      4      5     5     21    121   NIF   Y
GigabitEthernet1/0/22    0x1c        2     1     0     21      5      5     5     22    122   NIF   Y
GigabitEthernet1/0/23    0x1d        2     1     0     22      6      5     5     23    123   NIF   Y
GigabitEthernet1/0/24    0x1e        2     1     0     23      7      5     5     24    124   NIF   Y
GigabitEthernet1/0/25    0x1f        2     1     0     24      0      1     1     25    125   NIF   Y
<SNIP>

switch#
```

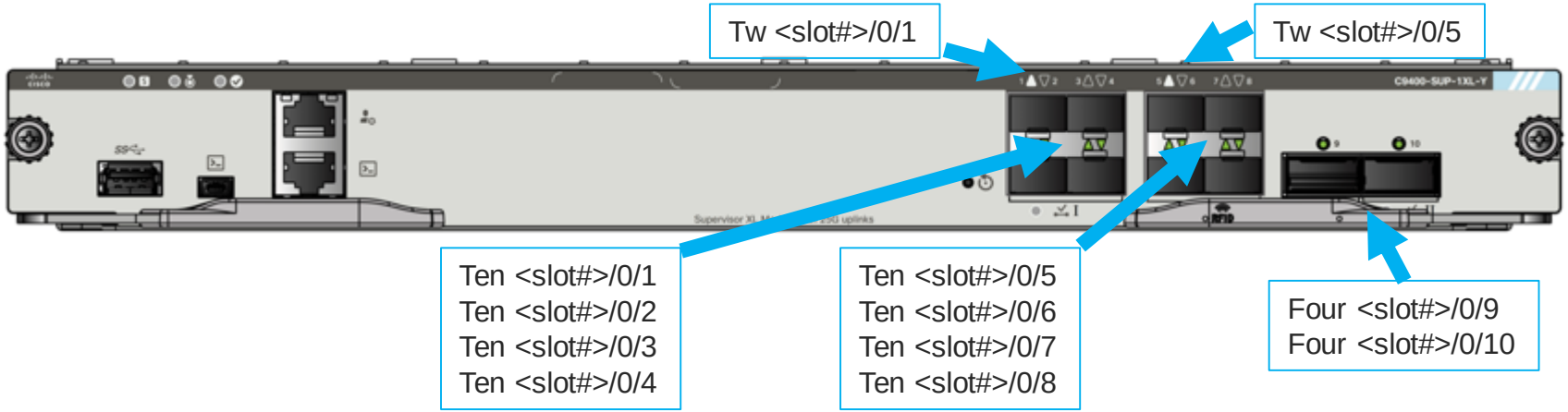
Sup-1/Sup-1XL Uplink - Single Sup

Sup-1/Sup-1XL Dual Sups - Uplink Redundancy



Sup-1/Sup-1XL Dual Sups - Mix Uplink Mode

C9400-Sup-1XL-Y (25G Uplinks)

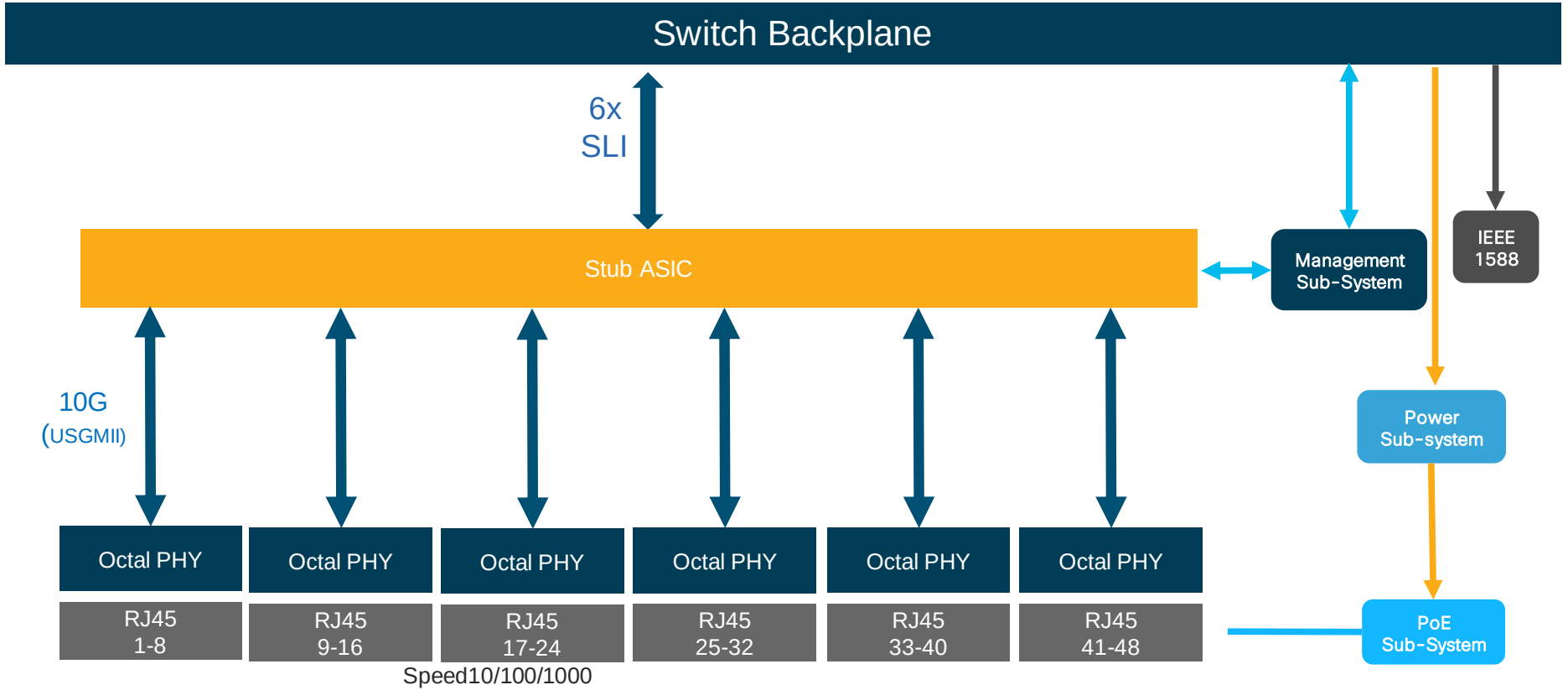


If port 9 (and/or 10) is enabled, port 1-4 (and/or 5-8) are disabled.
=> 40G ports are enabled.

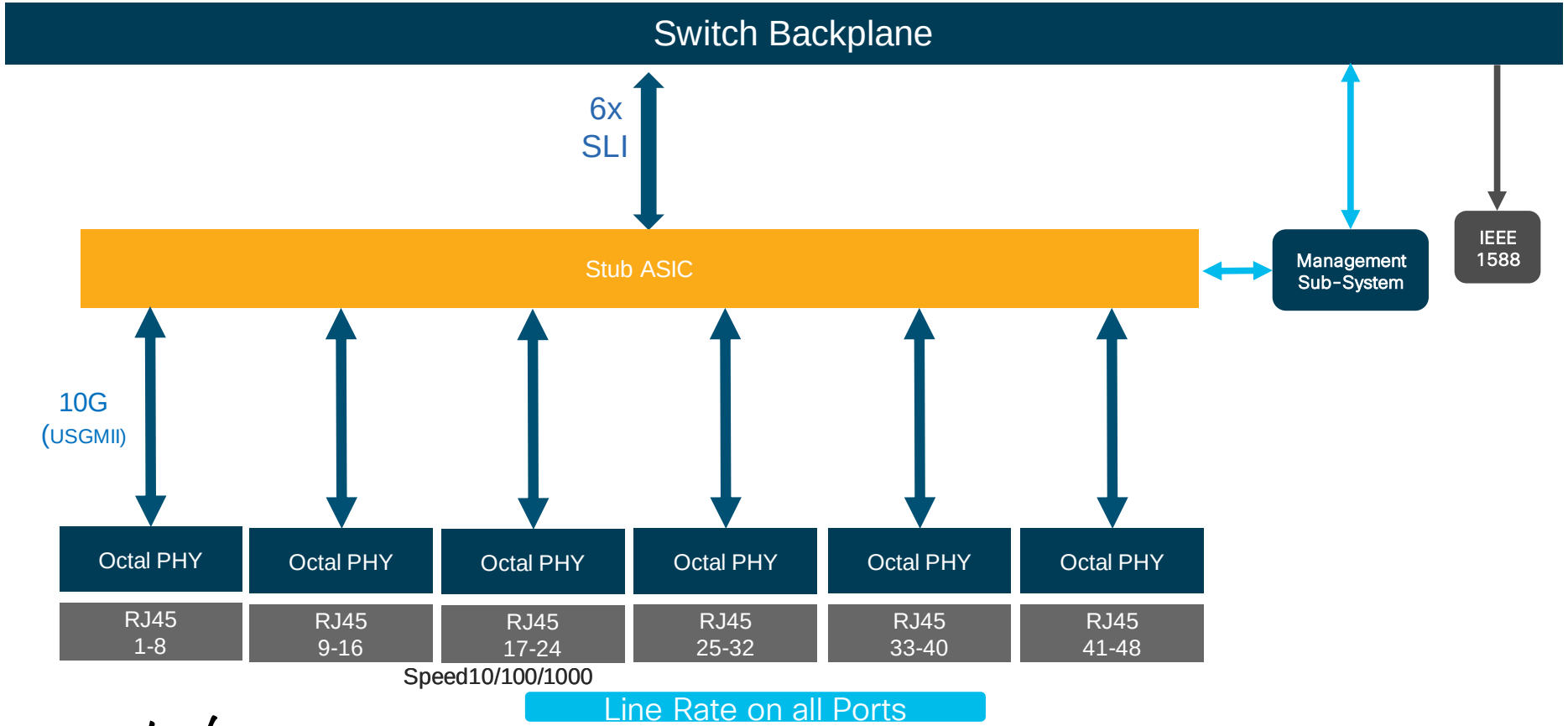
If port 9 (and/or 10) is disabled (which is default)
If Tw <slot#>/0/1(and/or 5) is enabled, Ten <slot#>/0/1 – 4 (and/or 5-8) are disabled.
If Tw <slot#>/0/1(and/or 5) is disabled, Ten <slot#>/0/1 – 4 (and/or 5-8) are enabled. (which is default)

Note:
1. TW ports are not auto-sense with speed for 10G/1G, manual speed configuration is needed. (same for dual-rate SFP28)

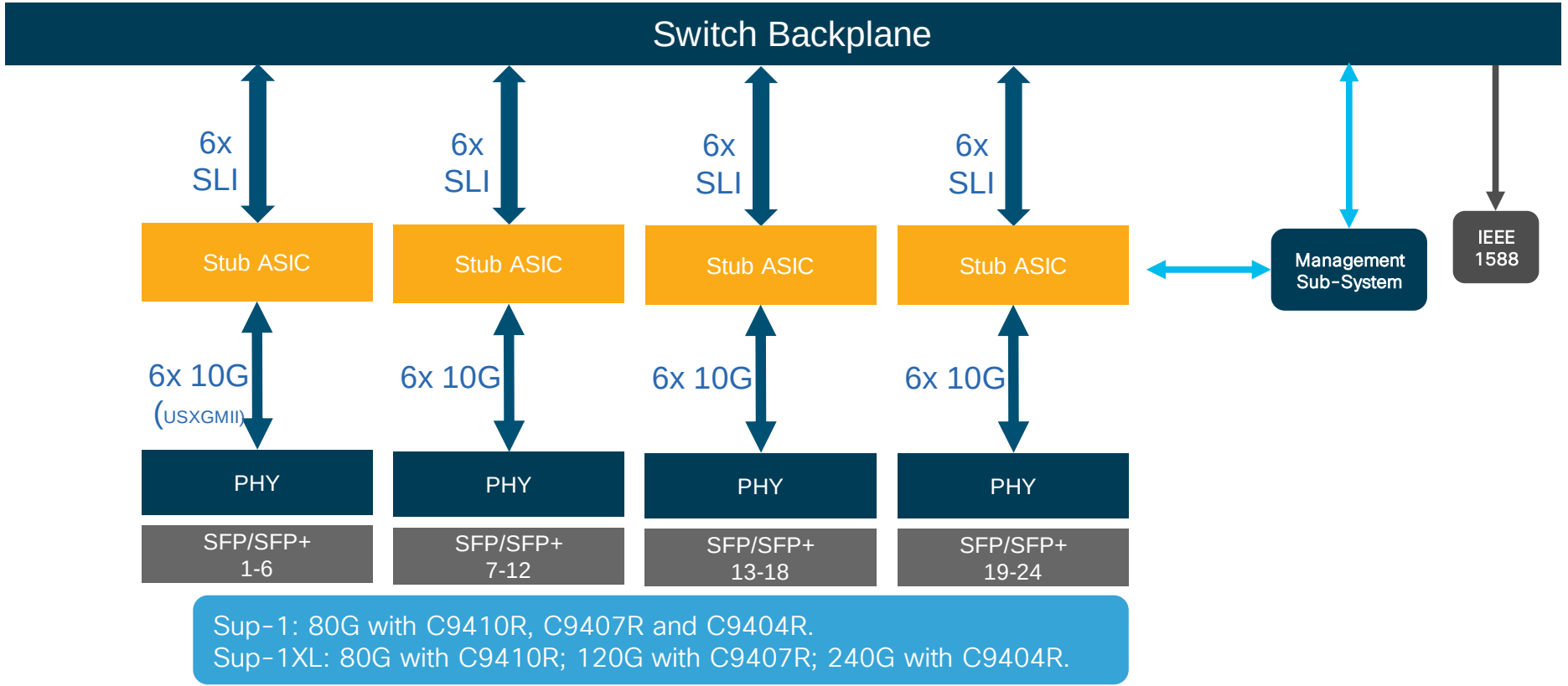
48x1G RJ45 Line Card (PoE+/UPoE)



48x1G Line Card (RJ45 Data or SFP)



24x 1/10G SFP/SFP+ Line Card

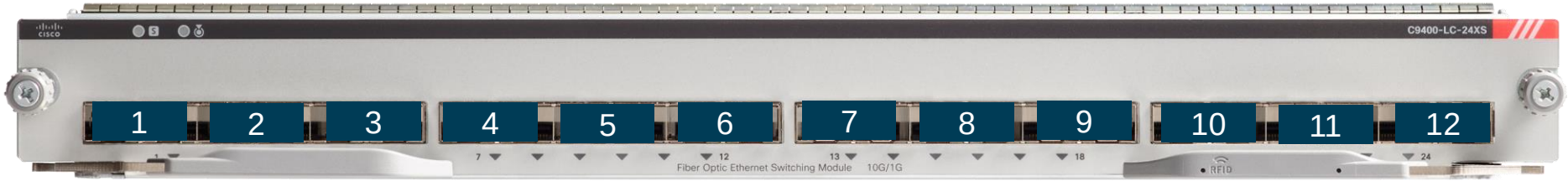


Sup-1: 80G with C9410R, C9407R and C9404R.
Sup-1XL: 80G with C9410R; 120G with C9407R; 240G with C9404R.

C9400-LC-24XS Port-Group
With XL Supervisors

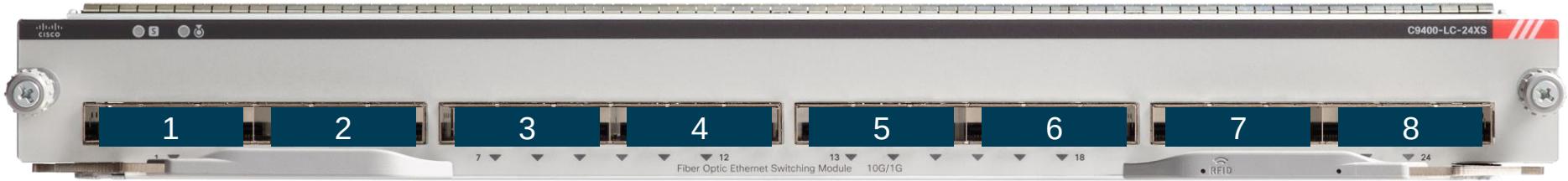
7 Slot Chassis: 12 Port-Group

2 Ports in a port-group



10 Slot Chassis: 8 Port-Group

3 Ports in a port-group



FYI

C9400-LC-24XS Port-Group – 7 Slot Chassis

- Bandwidth shared within port-group
- 12 port-group in the 7 slot chassis
- Modes: dynamic, performance and static
- For 10G line rate performance:
  - Configure: "`hw-module subslot <slot#/0> mode performance`"
  - 8 Port @ line-rate, other ports are disabled

```
R4-C94-2041#show platform hardware iomd 5/0 portgroups
Port  Interface                    Status     Interface  Group
Max
Group                                         Bandwith   Bandwidth

1     TenGigabitEthernet5/0/1      up          10G
1     TenGigabitEthernet5/0/2      down        10G        10G

2     TenGigabitEthernet5/0/3      up          10G
2     TenGigabitEthernet5/0/4      down        10G        10G

3     TenGigabitEthernet5/0/5      up          10G
3     TenGigabitEthernet5/0/6      down        10G        10G

4     TenGigabitEthernet5/0/7      up          10G
4     TenGigabitEthernet5/0/8      down        10G        10G
<SNIP>
11    TenGigabitEthernet5/0/21     up          10G
11    TenGigabitEthernet5/0/22     down        10G        10G


12    TenGigabitEthernet5/0/23     up          10G
12    TenGigabitEthernet5/0/24     down        10G        10G

R4-C94-2041#show
```

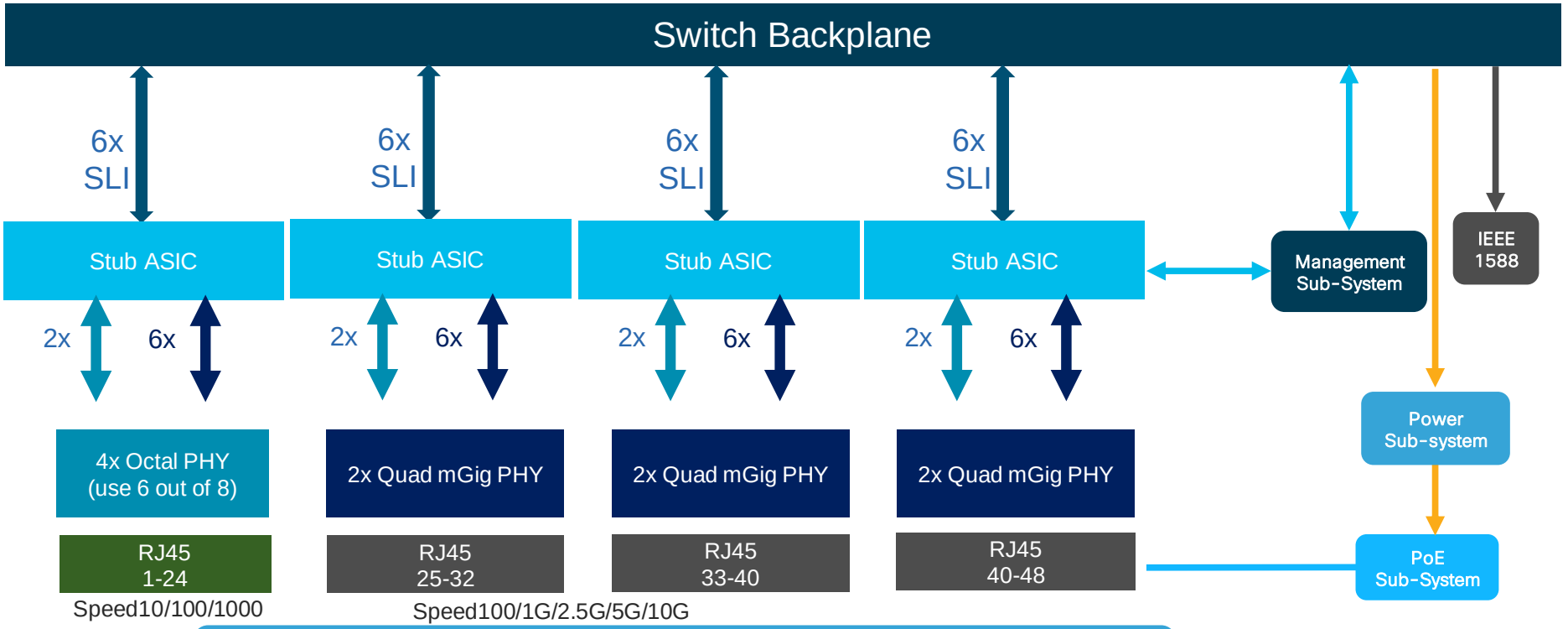
C9400-LC-24XS Port-Group – 10 Slot Chassis

FYI

- Bandwidth shared within port-group
- 8 port-group in the 10 slot chassis
- Modes: dynamic, performance and static
- For 10Gline rate performance:
  - Configure: "`hw-module subslot <slot#/0> mode performance`"
  - 5 Port @ line-rate, other ports are disabled

```
mac1#show platform hardware iomd 10/0 portgroups
Port  Interface                        Status     Interface  Group Max
Group                                             Bandwith   Bandwidth

1     TenGigabitEthernet10/0/1         admindown  10G
1     TenGigabitEthernet10/0/2         admindown  10G
1     TenGigabitEthernet10/0/3         admindown  10G        10G

2     TenGigabitEthernet10/0/4         admindown  10G
2     TenGigabitEthernet10/0/5         admindown  10G
2     TenGigabitEthernet10/0/6         admindown  10G        10G

3     TenGigabitEthernet10/0/7         admindown  10G
3     TenGigabitEthernet10/0/8         admindown  10G
3     TenGigabitEthernet10/0/9         admindown  10G        10G
<SNIP>
7     TenGigabitEthernet10/0/19        admindown  10G
7     TenGigabitEthernet10/0/20        admindown  10G
7     TenGigabitEthernet10/0/21        admindown  10G        10G

8     TenGigabitEthernet10/0/22        admindown  10G
8     TenGigabitEthernet10/0/23        down       10G
8     TenGigabitEthernet10/0/24        admindown  10G        10G


mac1#
```

mGig RJ45 Line Card

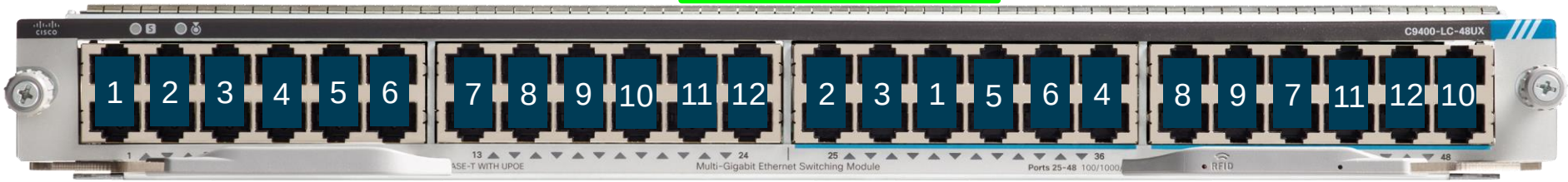


Sup-1: 80G with C9410R, C9407R, and C9404R
Sup-1XL/1XL-Y: 80G with C9410R; 120G with C9407R; 240G with C9404R

C9400-LC-48UX Port-Group
With XL Supervisors

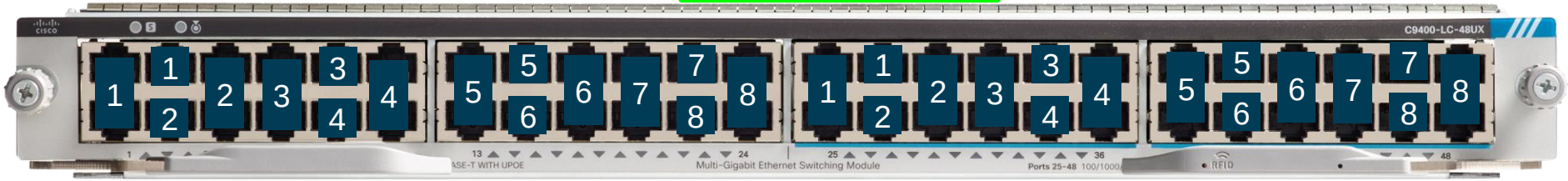
7 Slot Chassis: 12 Port-Group

4 Ports in a port-group



10 Slot Chassis: 8 Port-Group

6 Ports in a port-group



C9400-LC-48UX Port-Group – 7 Slot Chassis

FYI

- Bandwidth shared within port-group
- 12 port-group in the 7 slot chassis
- Modes: dynamic, performance and static
- For 10G line rate performance:
  - Configure: "`hw-module subslot <slot#/0> mode performance`"
  - 8 Port @ line-rate, other ports are disabled

```
R4-C94-2041#show platform hardware iomd 6/0 portgroups
Port  Interface                      Status     Interface  Group
Max
Group                                          Bandwith   Bandwidth

1     GigabitEthernet6/0/1           up          1G
1     GigabitEthernet6/0/2           up          1G
1     TenGigabitEthernet6/0/29       up          10G
1     TenGigabitEthernet6/0/30       up          10G        10G

2     GigabitEthernet6/0/3           up          1G
2     GigabitEthernet6/0/4           up          1G
2     TenGigabitEthernet6/0/25       up          10G
2     TenGigabitEthernet6/0/26       up          10G        10G
<SNIP>
11    GigabitEthernet6/0/21          down        1G
11    GigabitEthernet6/0/22          down        1G
11    TenGigabitEthernet6/0/43       up          10G
11    TenGigabitEthernet6/0/44       up          10G        10G

12    GigabitEthernet6/0/23          down        1G
12    GigabitEthernet6/0/24          down        1G
12    TenGigabitEthernet6/0/45       up          10G
12    TenGigabitEthernet6/0/46       up          10G        10G

R4-C94-2041#
```

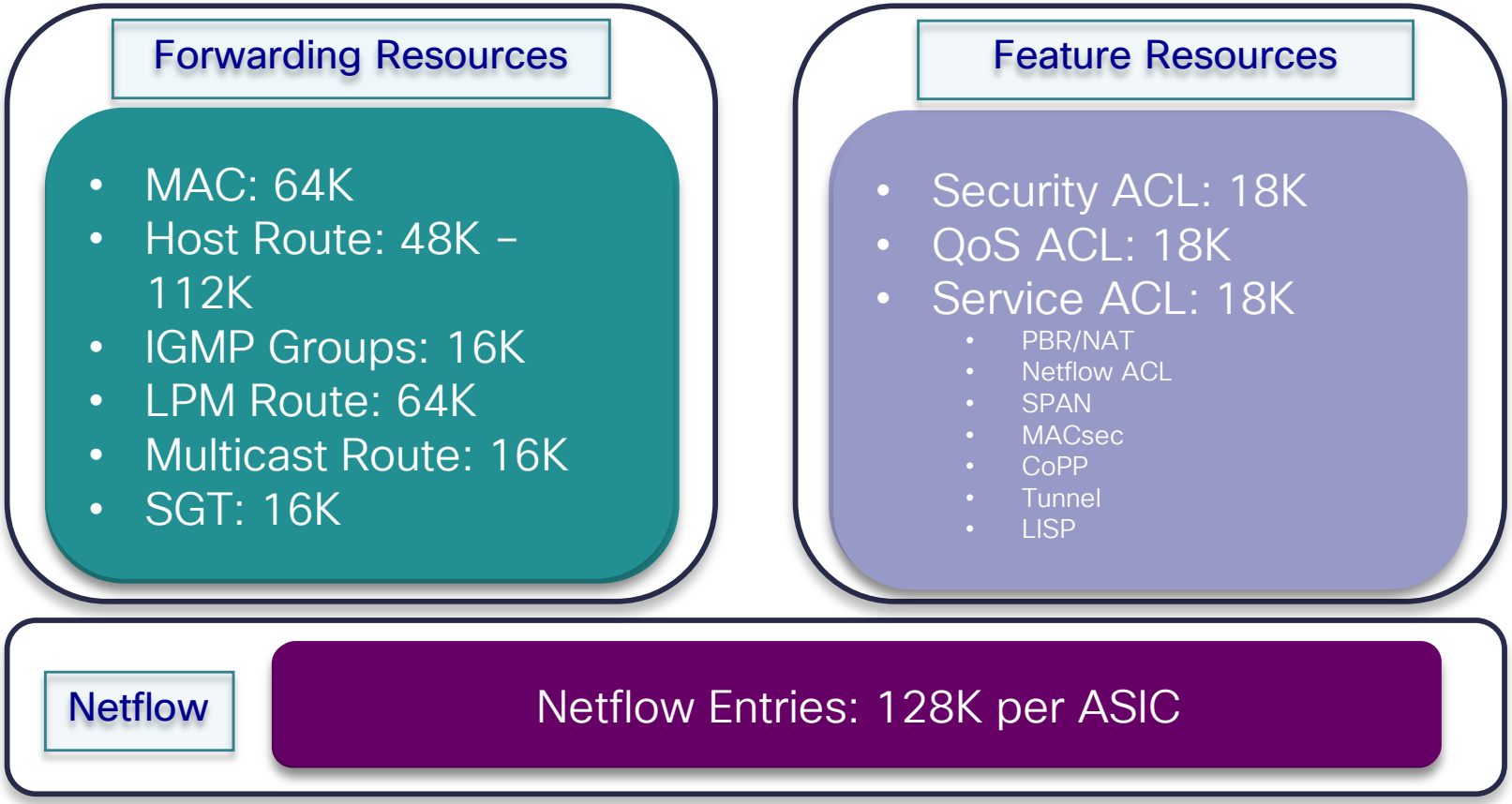
C9400-LC-48UX Port-Group – 10 Slot Chassis

FYI

- Bandwidth shared within port-group
- 8 port-group in the 10 slot chassis
- Modes: dynamic, performance and static
- For 10Gline rate performance:
  - Configure: "`hw-module subslot <slot#/0> mode performance`"
  - 5 Port @ line-rate, other ports are disabled

```
mac1#show platform hardware iomd 9/0 portgroups
Port  Interface                      Status     Interface  Group Max
Group                                          Bandwith   Bandwidth

1     GigabitEthernet9/0/1           admindown  1G
1     GigabitEthernet9/0/2           admindown  1G
1     GigabitEthernet9/0/3           admindown  1G
1     TenGigabitEthernet9/0/25       admindown  10G
1     TenGigabitEthernet9/0/26       admindown  10G
1     TenGigabitEthernet9/0/27       admindown  10G        10G

2     GigabitEthernet9/0/4           admindown  1G
2     GigabitEthernet9/0/5           admindown  1G
2     GigabitEthernet9/0/6           admindown  1G
2     TenGigabitEthernet9/0/28       admindown  10G
2     TenGigabitEthernet9/0/29       admindown  10G
2     TenGigabitEthernet9/0/30       admindown  10G        10G
<SNIP>
8     GigabitEthernet9/0/22          admindown  1G
8     GigabitEthernet9/0/23          admindown  1G
8     GigabitEthernet9/0/24          admindown  1G
8     TenGigabitEthernet9/0/46       admindown  10G
8     TenGigabitEthernet9/0/47       admindown  10G
8     TenGigabitEthernet9/0/48       admindown  10G        10G

mac1#
```

Flex Tables



Catalyst 9400 Templates (For Sup-1XL/1XL-Y)

	16.6 – 16.8	16.9 and beyond			
	Access	Access	Core	SDA	NAT
LPM	64K	64K	64K	64K	64K
Host	48K	48K	32K	80K	48K
Layer2 Multicast	16K	16K	16K	16K	16K
Layer3 Multicast	16K	16K	32K	16K	32K
MAC Address	64K	64K	16K	16K	16K
SGT	8K	8K	8K	8K	8K
Flexible Netflow	128K/ASIC	128K/ASIC	128K/ASIC	128K/ASIC	128K/ASIC
Security ACL	18K	18K	18K	18K	18K
QoS ACL	18K	18K	18K	18K	3K
PBR/NAT	2K	2K	2K	2K	16K
Tunnel	1K	1K	1K	1K	1K
LISP	1K	1K	1K	1K	1K
MPLS L3VPN VRF	256	256	256	N/A	256
MPLS Label	8K	16K	24K		16K
MPLS L3VPN Routes VRF	16K	32K	32K		32K
MPLS L3VPN Routes Prefix	4K	4K	4K		4K
MVPN MDT Tunnels	256	1K	1K		1K
L2VPN EOMPLS Attachment	256	1K	1K		1K


bpafree
APPROX VOLUME
900 ml
800
700
600
500
400
300
200
32 fl oz
28
24
20
16
12
8
nalgene
MADE IN USA

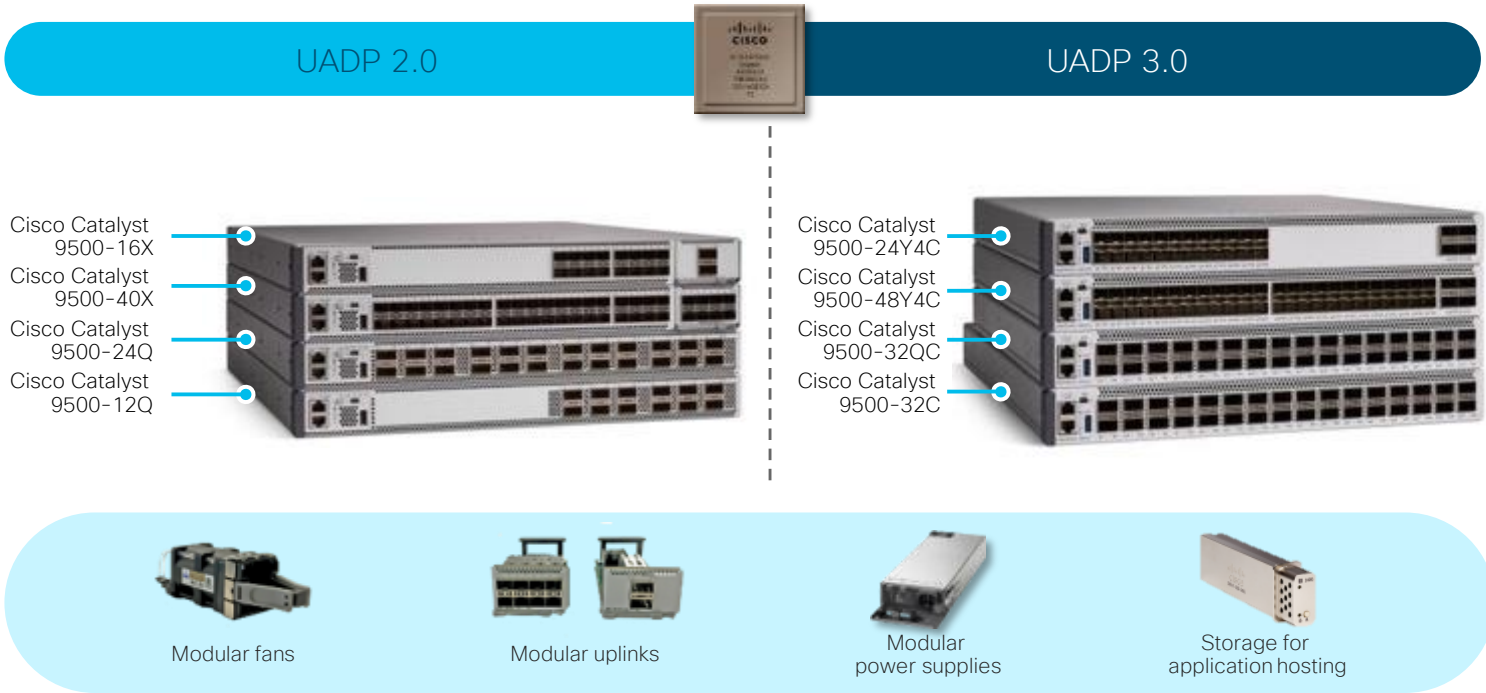
Catalyst 9500

You make networking **possible**

Cisco live!

Cisco Catalyst 9500 Series

New generation of purpose-built fixed core/aggregation



Cisco Catalyst 9500 Series

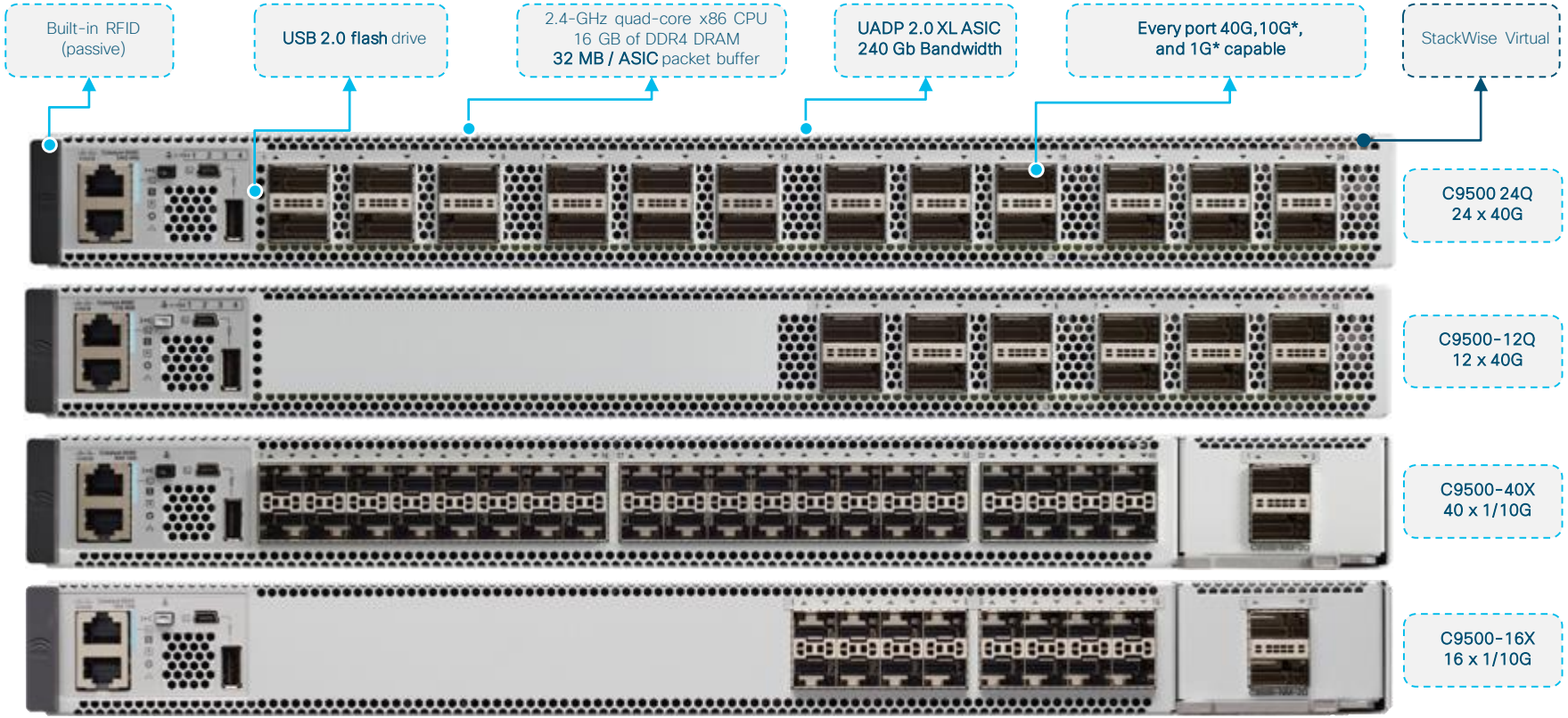
New generation of purpose-built fixed mid-range core/aggregation

UADP 2.0 XL

Industry's first 40G enterprise switch

Cisco Catalyst 9500

High-level overview



* With QSA Adaptor

Cisco Catalyst 9500
Network Modules

C9500-NM-2Q

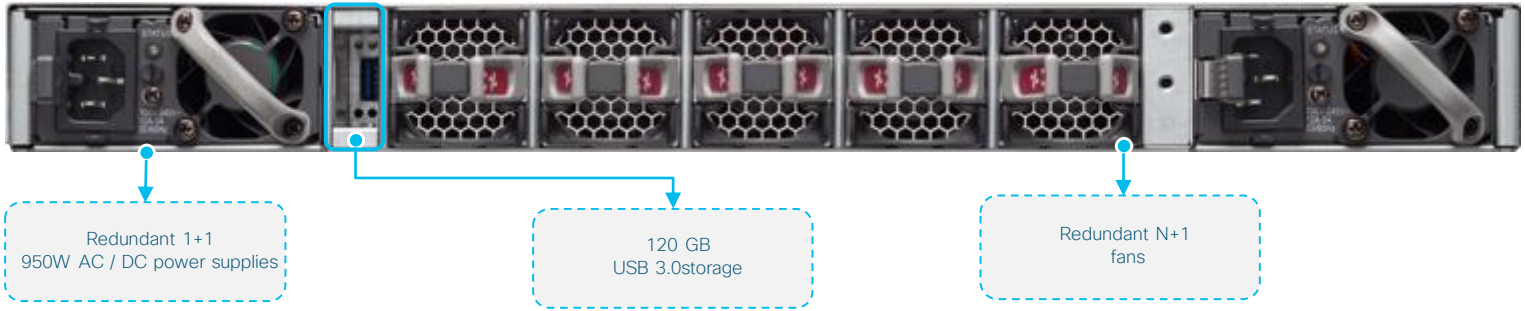
Cisco Catalyst 9500 Series Network Module
2-port 40 Gigabit Ethernet with QSFP+

C9500-NM-8X

Cisco Catalyst 9500 Series Network Module
8-port 1/10 Gigabit Ethernet with SFP/SFP+

- Uplink Modules supported on C9500-40X and C9500-16X
- OIR Supported on all Uplink Modules
- Breakout support on C9500-NM-2Q

Redundant Power Supplies and Fans



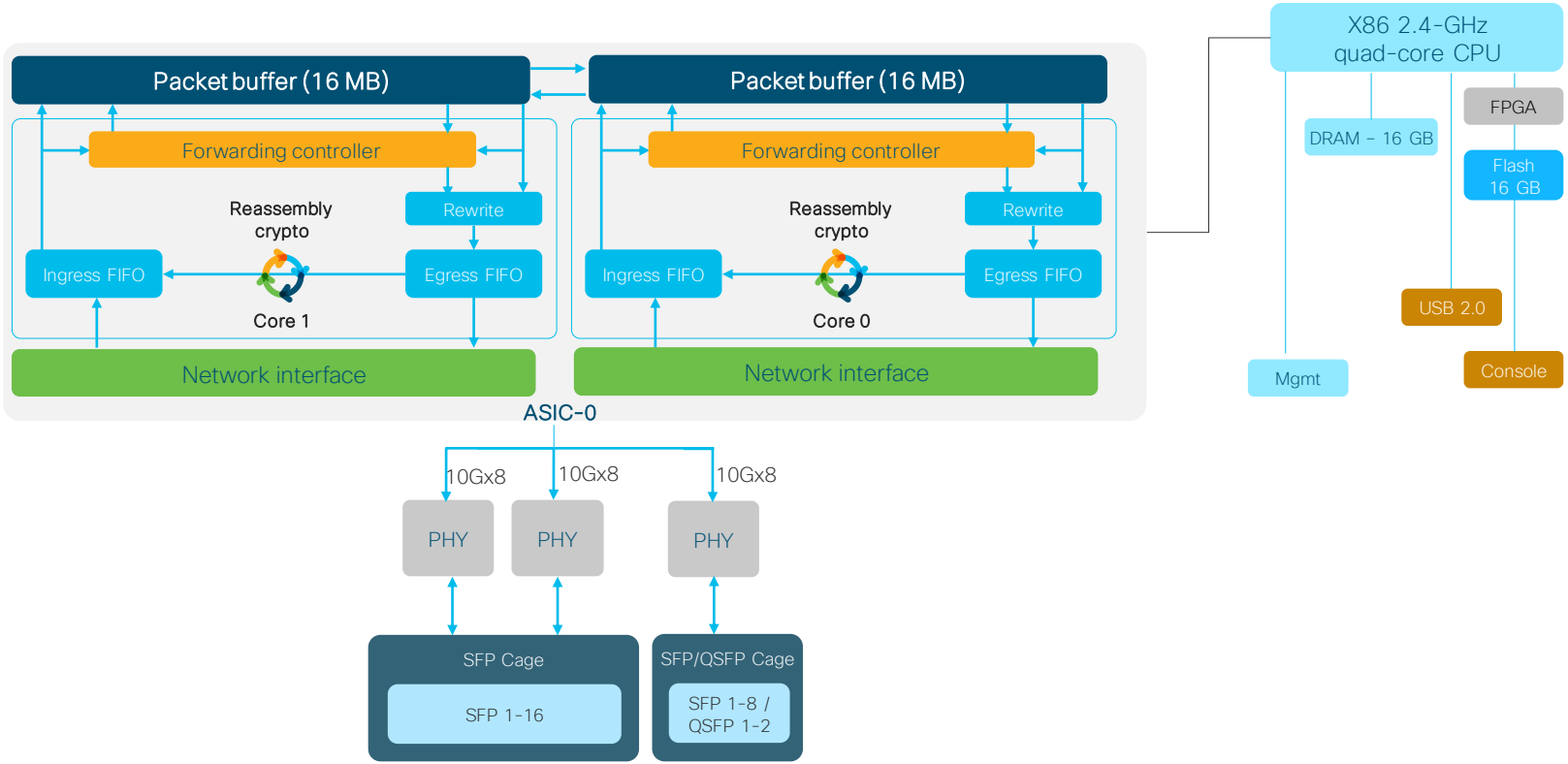
Power supply highlights:

- Hot-swappable
- AC/DC/mixed power supplies supported
- Maximum output 12V/950W at 220V/110V AC input
- More than 90% power efficiency at 50% to 100% of load
- Redundant load sharing (1+1) mode only

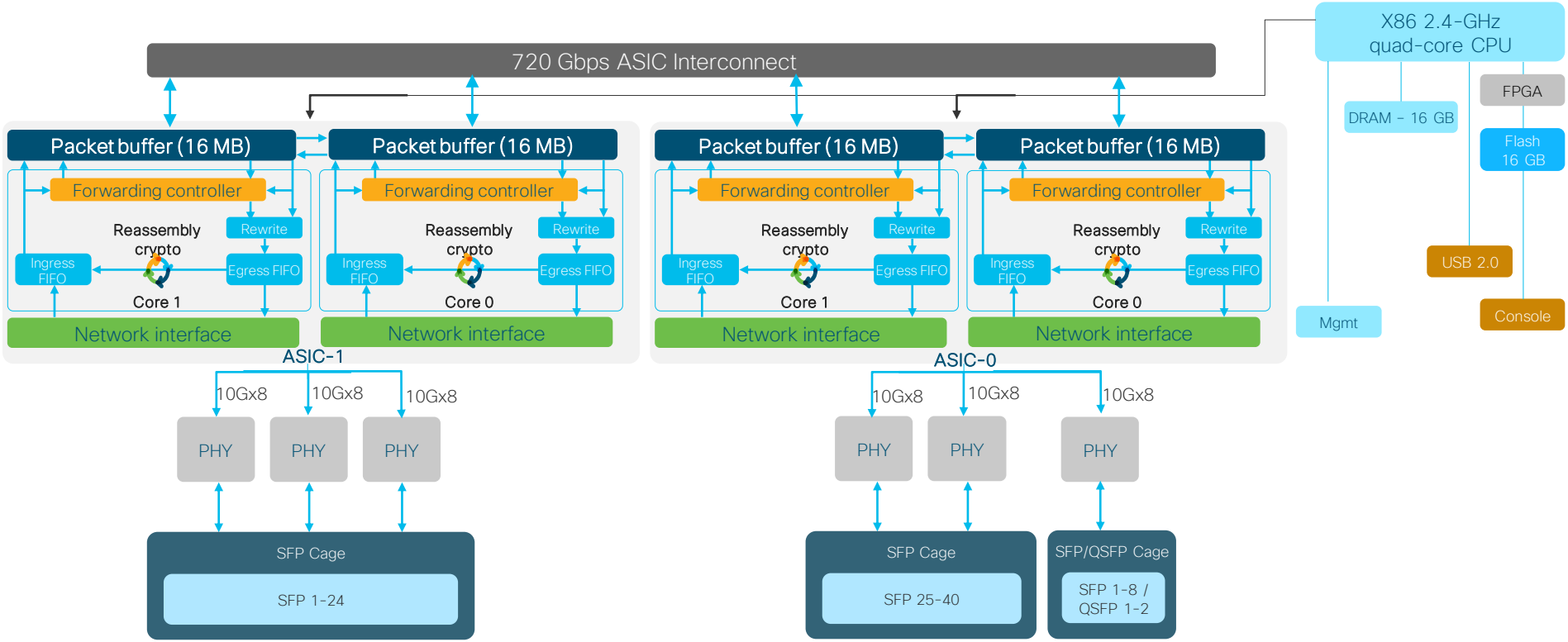
Fan Highlights:

- Variable-speed high-efficiency fans
- Detect ambient temperature and adjust fan speeds
- Individual Fan are OIR capable up to 120 secs
- Front-to-back airflow
- Can still operate with individual fan tray failure

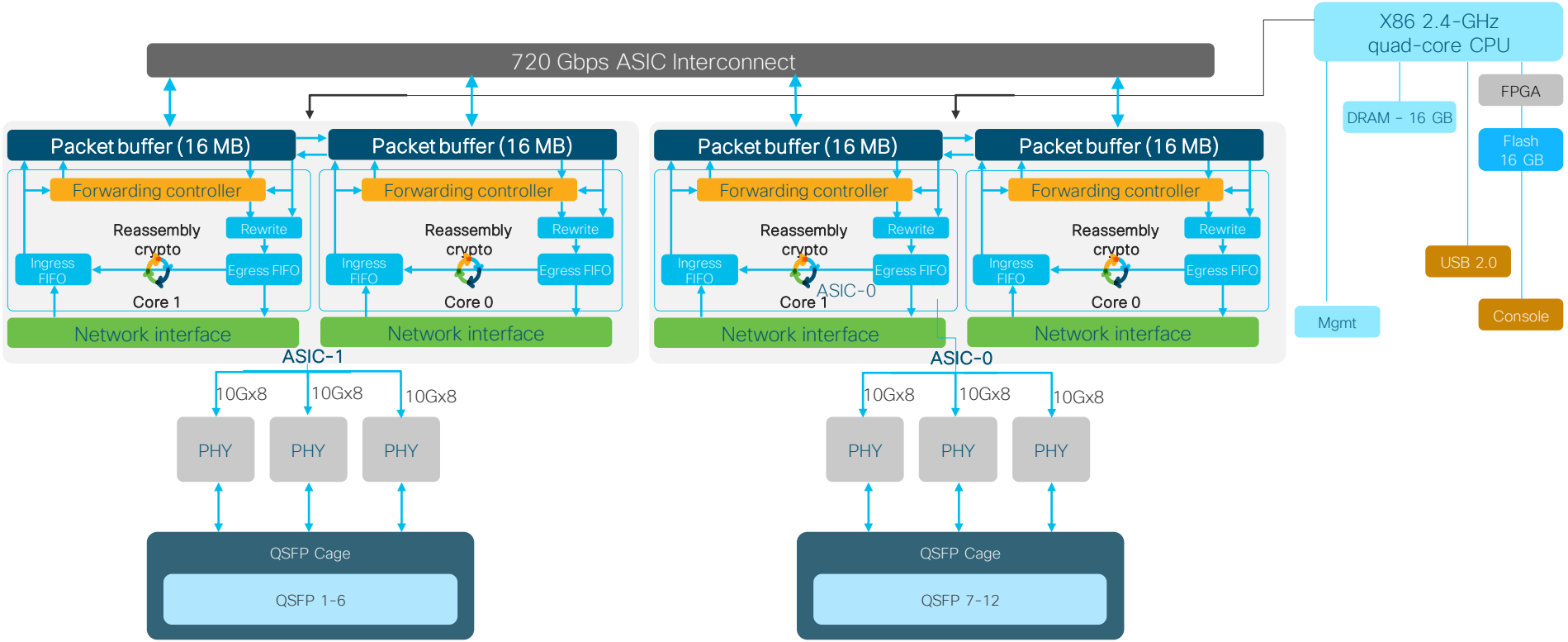
Cisco Catalyst 9500-16X
Block diagram



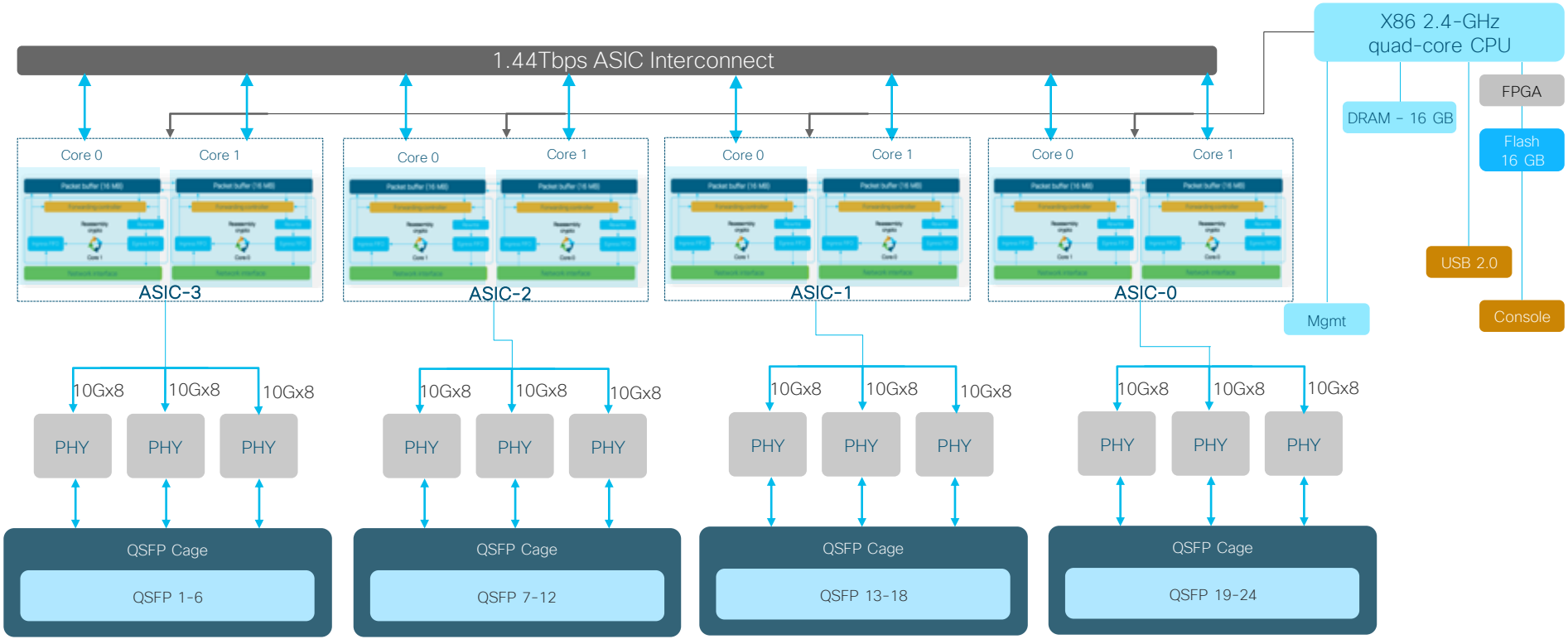
Cisco Catalyst 9500-40X
Block diagram



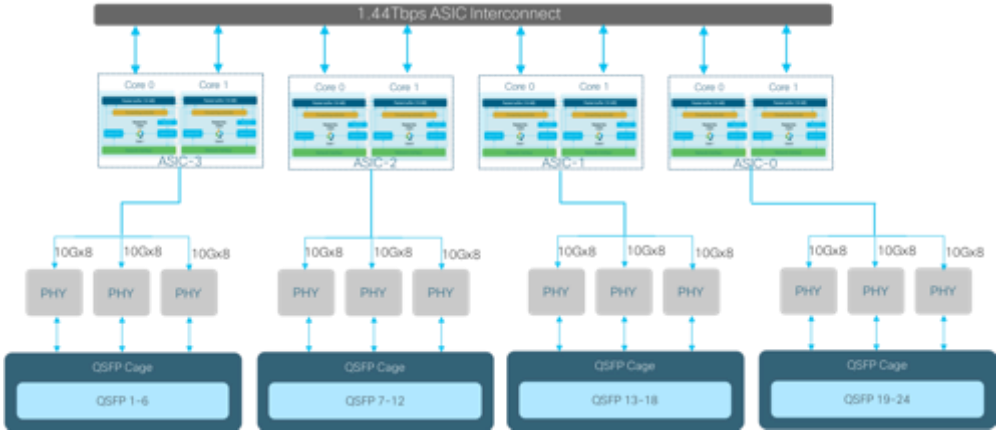
Cisco Catalyst 9500-12Q
Block diagram



Cisco Catalyst 9500-24Q
Block diagram



Cisco Catalyst 9500-24Q/12Q/40X/16X
Port-to-ASIC mapping




```
C9500-24Q#sh platform software fed switch active ifm mappings lpn
Mappings Table

LPN         ASIC  Port  Interface                IF_ID       Active
-----------------------------------------------------------------
1           3     0     FortyGigabitEthernet1/0/1  0x00000007  Y
2           3     1     FortyGigabitEthernet1/0/2  0x00000008  Y
3           3     2     FortyGigabitEthernet1/0/3  0x00000009  Y
4           3     3     FortyGigabitEthernet1/0/4  0x0000000a  Y
5           3     4     FortyGigabitEthernet1/0/5  0x0000000b  Y
6           3     5     FortyGigabitEthernet1/0/6  0x0000000c  Y
7           2     6     FortyGigabitEthernet1/0/7  0x0000000d  Y
8           2     7     FortyGigabitEthernet1/0/8  0x0000000e  Y
9           2     8     FortyGigabitEthernet1/0/9  0x0000000f  Y
10          2     9     FortyGigabitEthernet1/0/10 0x00000010  Y
11          2     10    FortyGigabitEthernet1/0/11 0x00000011  Y
12          2     11    FortyGigabitEthernet1/0/12 0x00000012  Y
13          1     12    FortyGigabitEthernet1/0/13 0x00000013  Y
14          1     13    FortyGigabitEthernet1/0/14 0x00000014  Y
15          1     14    FortyGigabitEthernet1/0/15 0x00000015  Y
16          1     15    FortyGigabitEthernet1/0/16 0x00000016  Y
17          1     16    FortyGigabitEthernet1/0/17 0x00000017  Y
18          1     17    FortyGigabitEthernet1/0/18 0x00000018  Y
19          0     18    FortyGigabitEthernet1/0/19 0x00000019  Y
20          0     19    FortyGigabitEthernet1/0/20 0x0000001a  Y
21          0     20    FortyGigabitEthernet1/0/21 0x0000001b  Y
22          0     21    FortyGigabitEthernet1/0/22 0x0000001c  Y
23          0     22    FortyGigabitEthernet1/0/23 0x0000001d  Y
24          0     23    FortyGigabitEthernet1/0/24 0x0000001e  Y
```

Command to verify the port-to-ASIC mapping:

show platform software fed switch active ifm mappings lpn

Cisco Catalyst 9500 Series

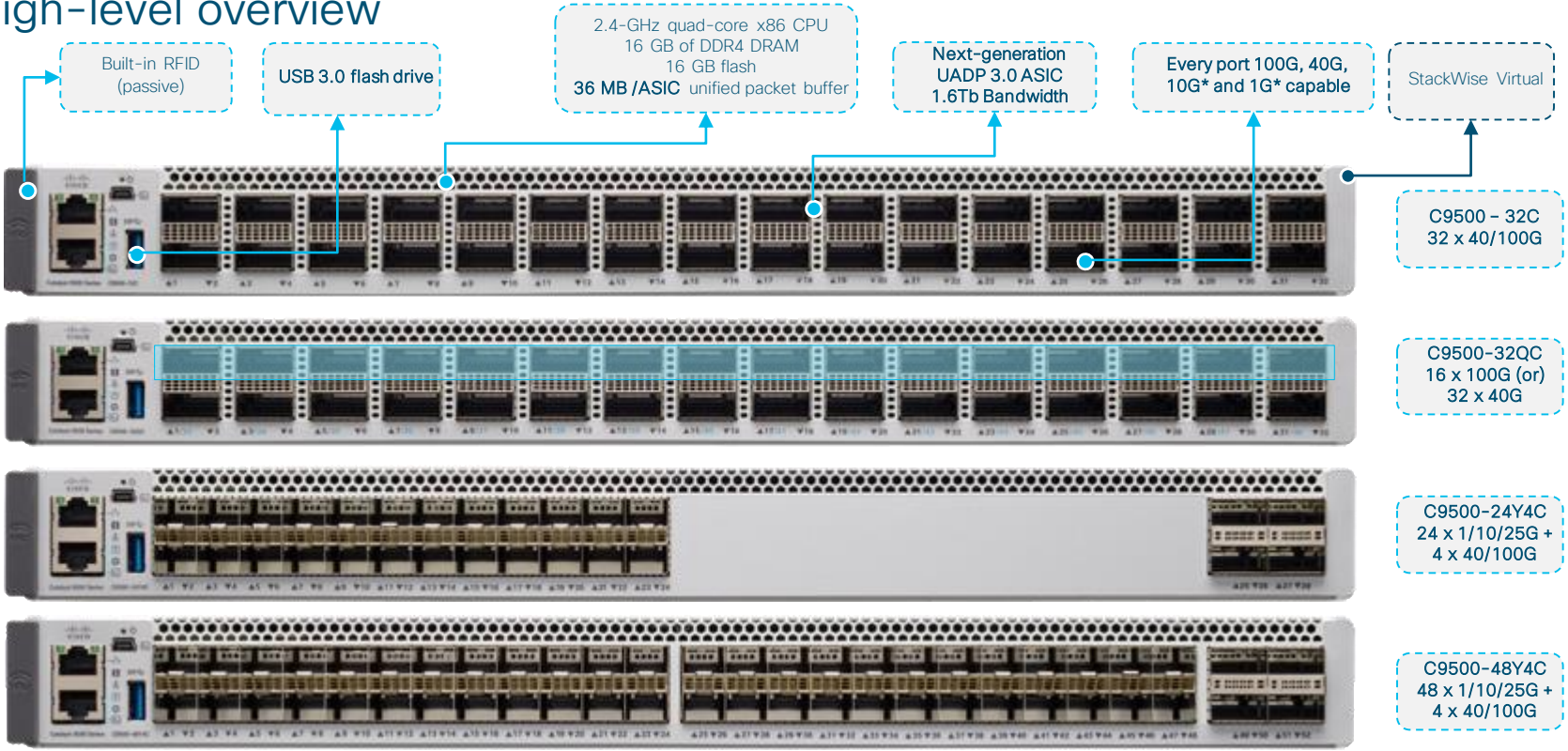
New generation of purpose-built fixed high-end core/aggregation

UADP 3.0

Industry's first 25G/100G enterprise switch

Cisco Catalyst 9500 100G/25G

High-level overview



* With QSA adapter

Redundant Power Supplies and Fans
C9500-32C

Power supply highlights:

- Hot-swappable
- AC/DC/mixed power supplies supported
- Maximum output is **1600W at 220V and 1000W at 110V**
- More than 90% power efficiency at 50% to 100% of load
- Redundant load sharing (1+1) mode only

Fan Highlights:

- 5 variable-speed high-efficiency fans at rear of chassis
- Detect ambient temperature and adjust fan speeds
- Fans are hot-swappable
- **Front-to-back airflow**
- Can still operate with one fan unit failure

Redundant Power Supplies and Fans
C9500-32QC, 24Y4C, 48Y4C

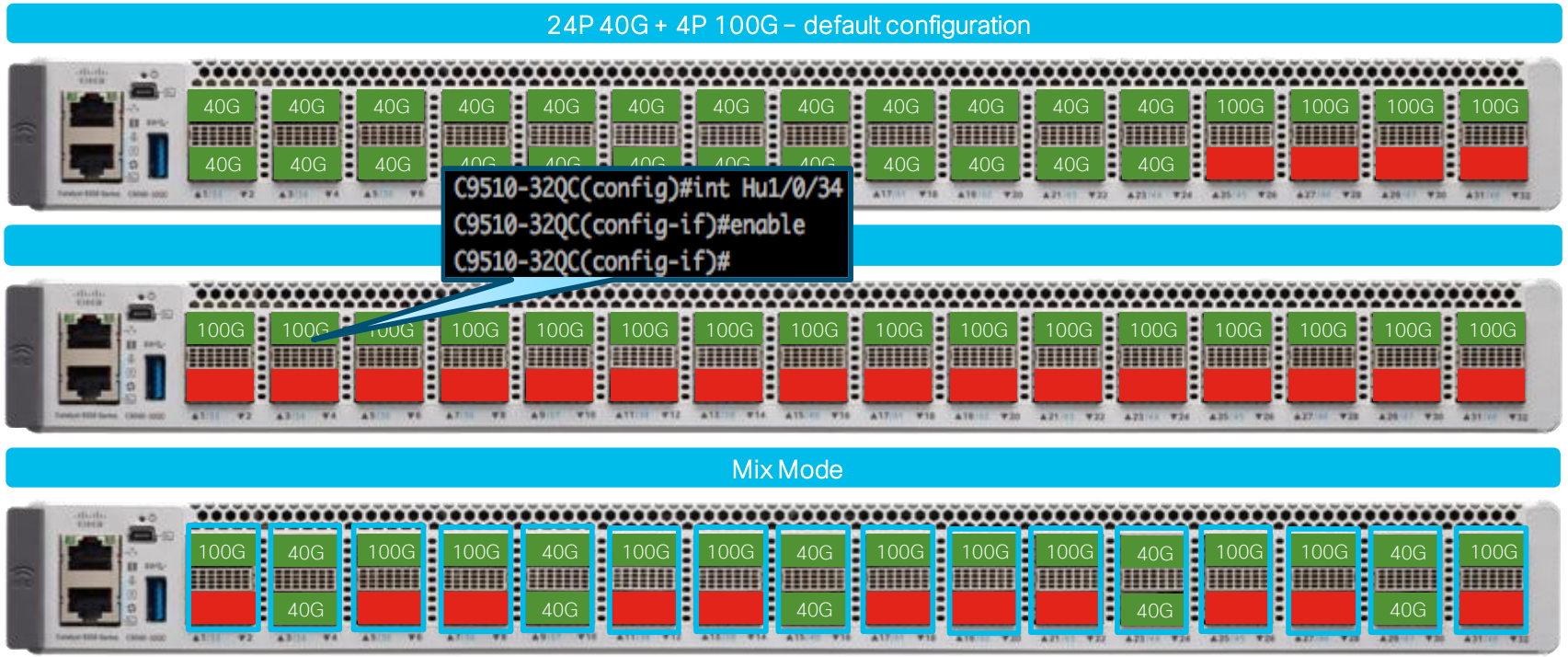
Power supply highlights:

- Hot-swappable
- AC/DC/mixed power supplies supported
- Maximum output **12V/650W at 220V/110V AC Input**
- More than 90% power efficiency at 50% to 100% of load
- Redundant load sharing (1+1) mode only

Fan Highlights:

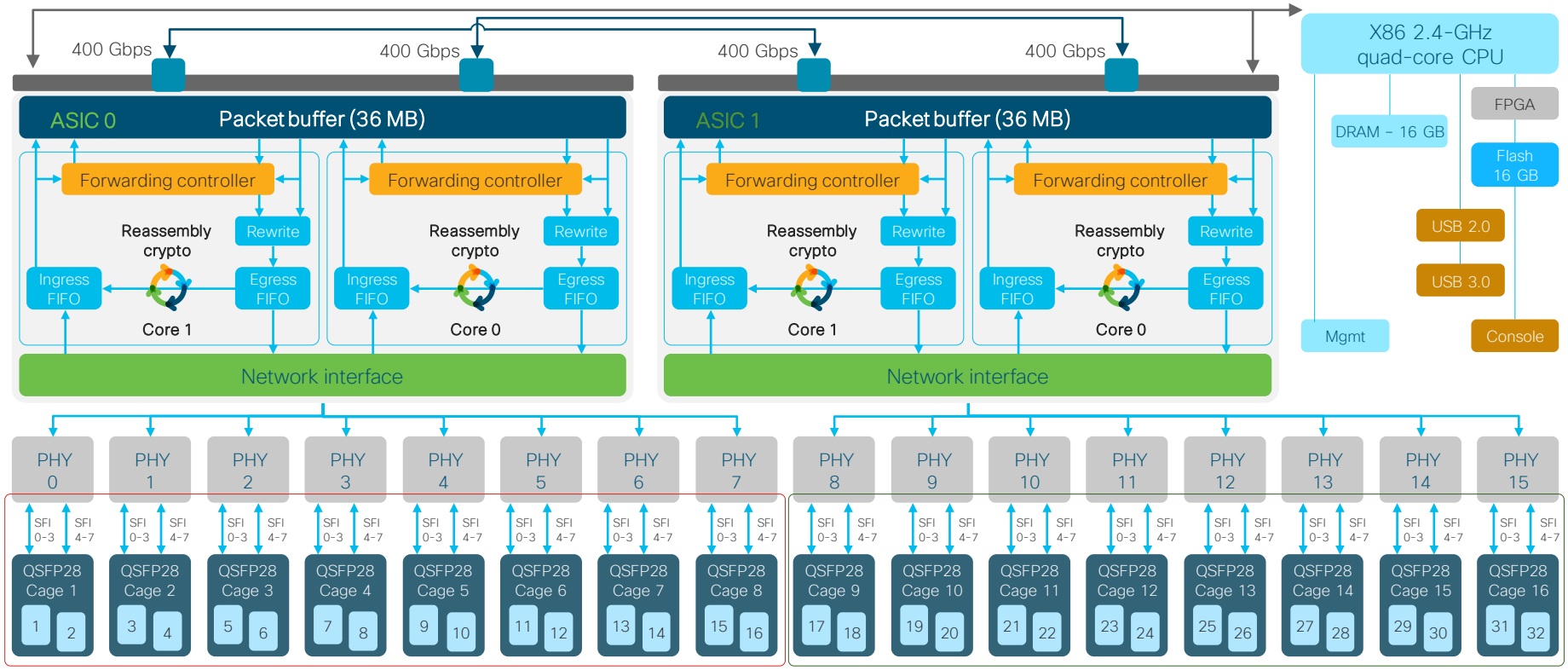
- **Dual variable-speed high-efficiency fan trays**
- Thermal sensor to detect ambient temperature and adjust fan speeds
- Fan trays are hot-swappable
- **Front-to-back airflow**
- Can still operate with individual fan tray failure

Cisco Catalyst 9500-32QC
Configuration modes

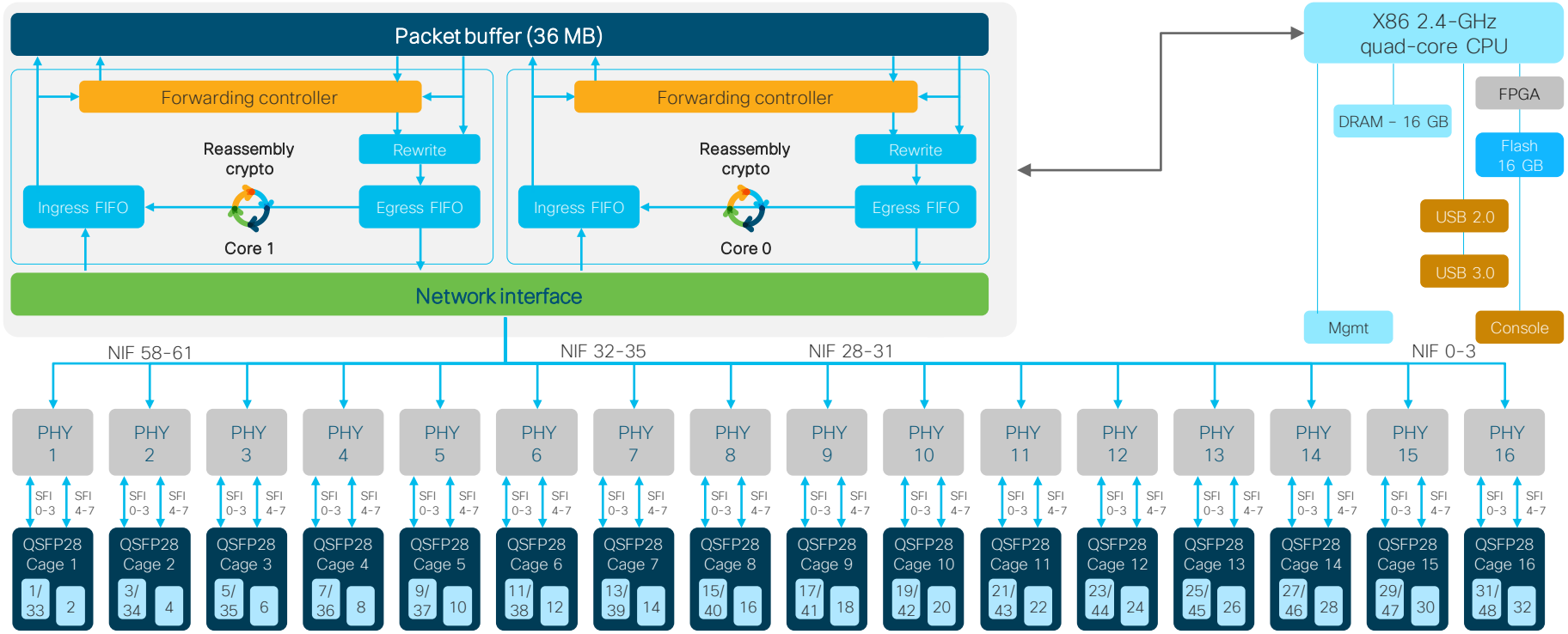


Note: Other configuration options are supported, including mix and match of speeds

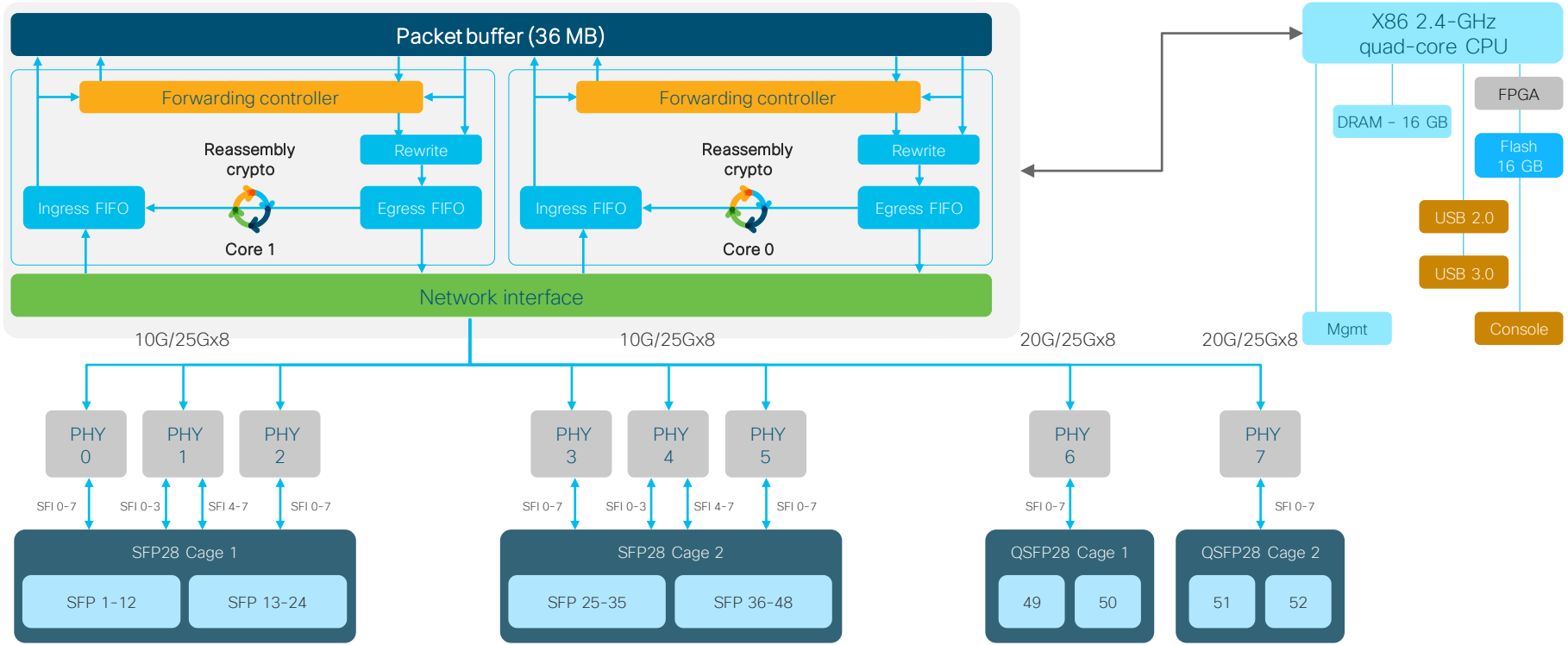
Cisco Catalyst 9500-32C
Block diagram



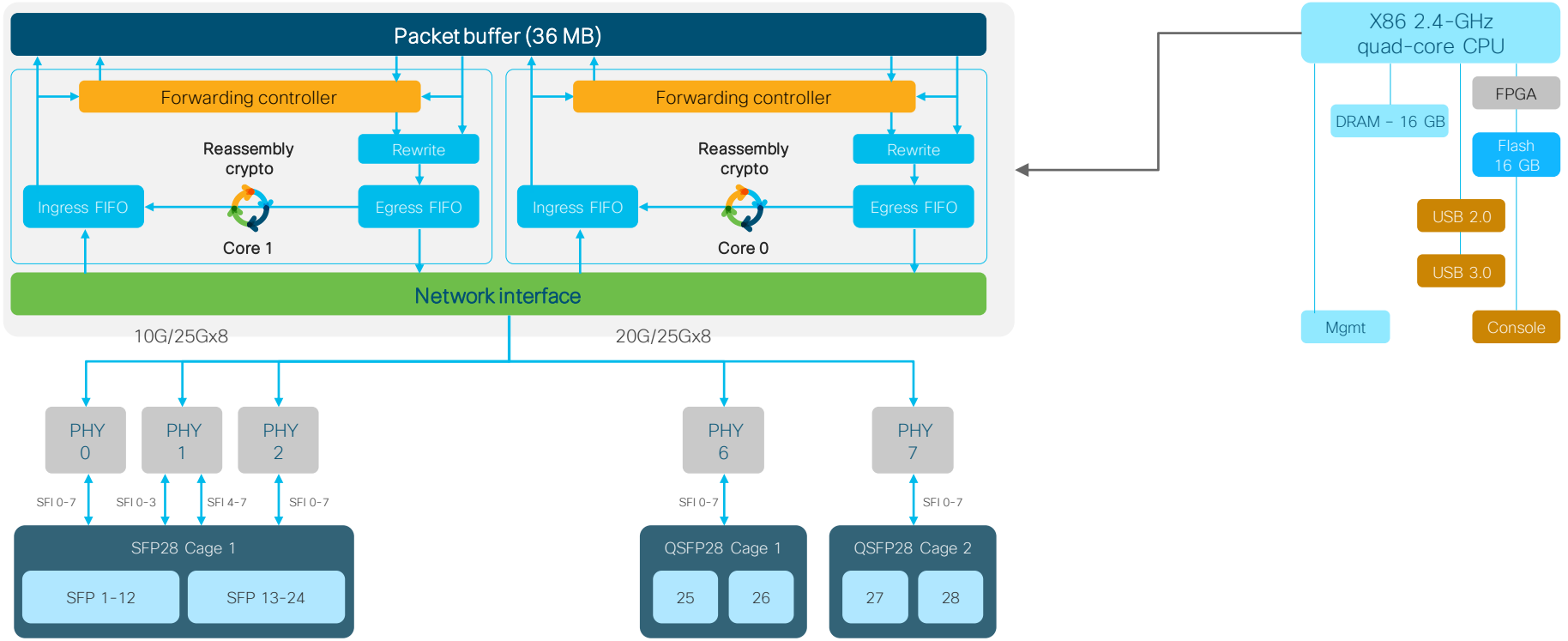
Cisco Catalyst 9500-32QC
Block diagram



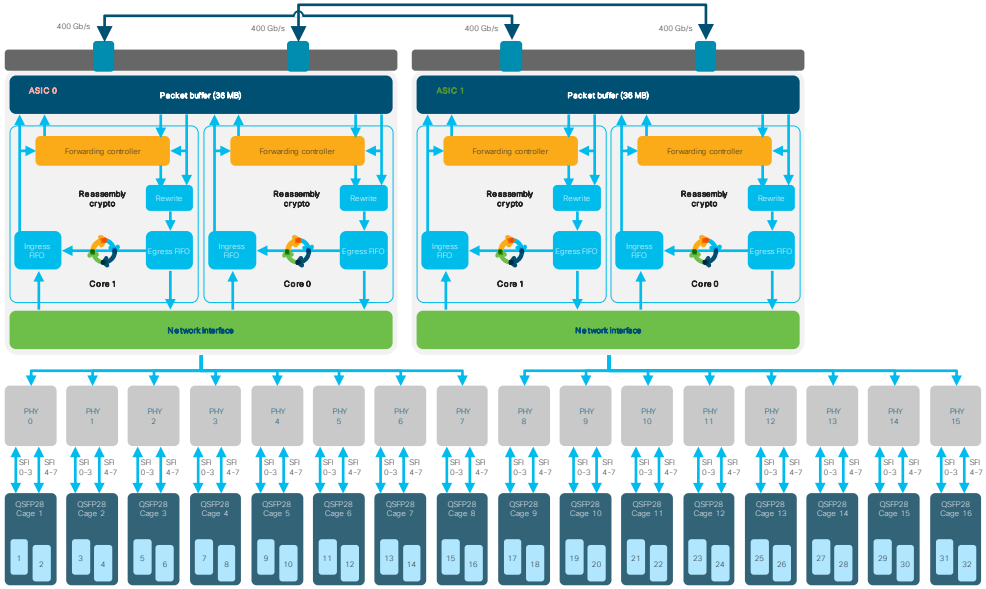
Cisco Catalyst 9500-48Y4C
Block diagram



Cisco Catalyst 9500-24Y4C
Block diagram



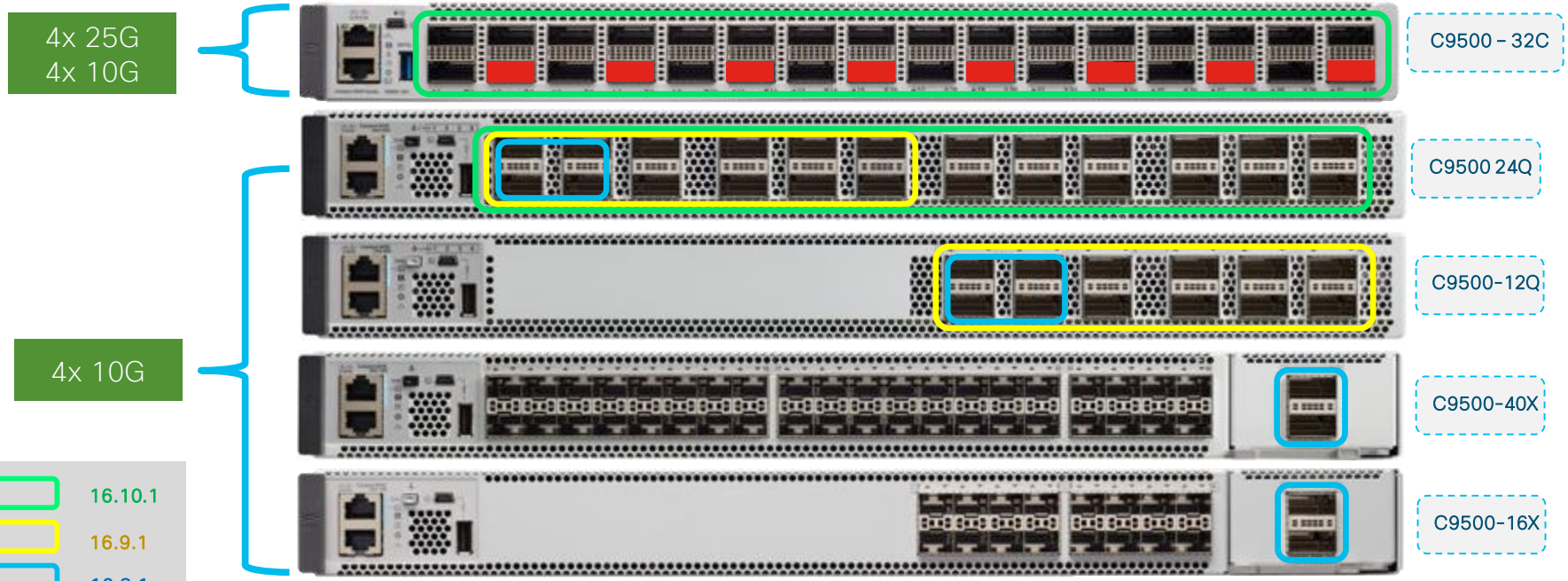
Cisco Catalyst 9500-32C/32QC/24Y4C/48Y4C
Port-to-ASIC mapping




```
C9500H-32C#show platform software fed active ifm mapping
Interface                IF_ID     Inst Asic Core Port SubPort Mac  Cntx LPN  GPN  Type Activ
HundredGigE1/0/1         0x6       1    0    1    16   0       16   2    1    101  NIF  Y
HundredGigE1/0/2         0x7       1    0    1    17   0       20   6    2    102  NIF  Y
HundredGigE1/0/3         0x8       1    0    1    18   0       24   10   3    103  NIF  Y
HundredGigE1/0/4         0x9       1    0    1    19   0       28   14   4    104  NIF  Y
HundredGigE1/0/5         0xa       1    0    1    0    0       0    2    5    105  NIF  Y
HundredGigE1/0/6         0xb       1    0    1    1    0       4    6    6    106  NIF  Y
HundredGigE1/0/7         0xc       1    0    1    2    0       8    10   7    107  NIF  Y
HundredGigE1/0/8         0xd       1    0    1    3    0       12   14   8    108  NIF  Y
HundredGigE1/0/9         0xe       0    0    0    16   0       28   2    9    109  NIF  Y
HundredGigE1/0/10        0xf       0    0    0    17   0       24   6    10   110  NIF  Y
HundredGigE1/0/11        0x10      0    0    0    18   0       20   10   11   111  NIF  Y
HundredGigE1/0/12        0x11      0    0    0    19   0       16   14   12   112  NIF  Y
HundredGigE1/0/13        0x12      0    0    0    0    0       12   2    13   113  NIF  Y
HundredGigE1/0/14        0x13      0    0    0    1    0       8    6    14   114  NIF  Y
HundredGigE1/0/15        0x14      0    0    0    2    0       4    10   15   115  NIF  Y
HundredGigE1/0/16        0x15      0    0    0    3    0       0    14   16   116  NIF  Y
HundredGigE1/0/17        0x16      3    1    1    16   0       16   2    17   117  NIF  Y
HundredGigE1/0/18        0x17      3    1    1    17   0       20   6    18   118  NIF  Y
HundredGigE1/0/19        0x18      3    1    1    18   0       24   10   19   119  NIF  Y
HundredGigE1/0/20        0x19      3    1    1    19   0       28   14   20   120  NIF  Y
HundredGigE1/0/21        0x1a      3    1    1    0    0       0    2    21   121  NIF  Y
HundredGigE1/0/22        0x1b      3    1    1    1    0       4    6    22   122  NIF  Y
HundredGigE1/0/23        0x1c      3    1    1    2    0       8    10   23   123  NIF  Y
HundredGigE1/0/24        0x1d      3    1    1    3    0       12   14   24   124  NIF  Y
HundredGigE1/0/25        0x1e      2    1    0    16   0       28   2    25   125  NIF  Y
HundredGigE1/0/26        0x1f      2    1    0    17   0       24   6    26   126  NIF  Y
HundredGigE1/0/27        0x20      2    1    0    18   0       20   10   27   127  NIF  Y
HundredGigE1/0/28        0x21      2    1    0    19   0       16   14   28   128  NIF  Y
HundredGigE1/0/29        0x22      2    1    0    0    0       12   2    29   129  NIF  Y
HundredGigE1/0/30        0x23      2    1    0    1    0       8    6    30   130  NIF  Y
HundredGigE1/0/31        0x24      2    1    0    2    0       4    10   31   131  NIF  Y
HundredGigE1/0/32        0x25      2    1    0    3    0       0    14   32   132  NIF  Y
```

Command to verify the port-to-ASIC mapping:
show platform software fed active ifm mappings

Cisco Catalyst 9500 Breakout Options



In Stackwise Virtual System, Breakout cables are not supported as SVL/DAD links.

Cisco Catalyst 9500 Breakout Interface

C9500-32C

```
Device# configure terminal
Device (config)# hw-module breakout <port-num>
```

Hu1/0/1 --- > Hu1/0/1/1, Hu1/0/1/2, Hu1/0/1/3, Hu1/0/1/4

C9500-12/24Q/16X/40X

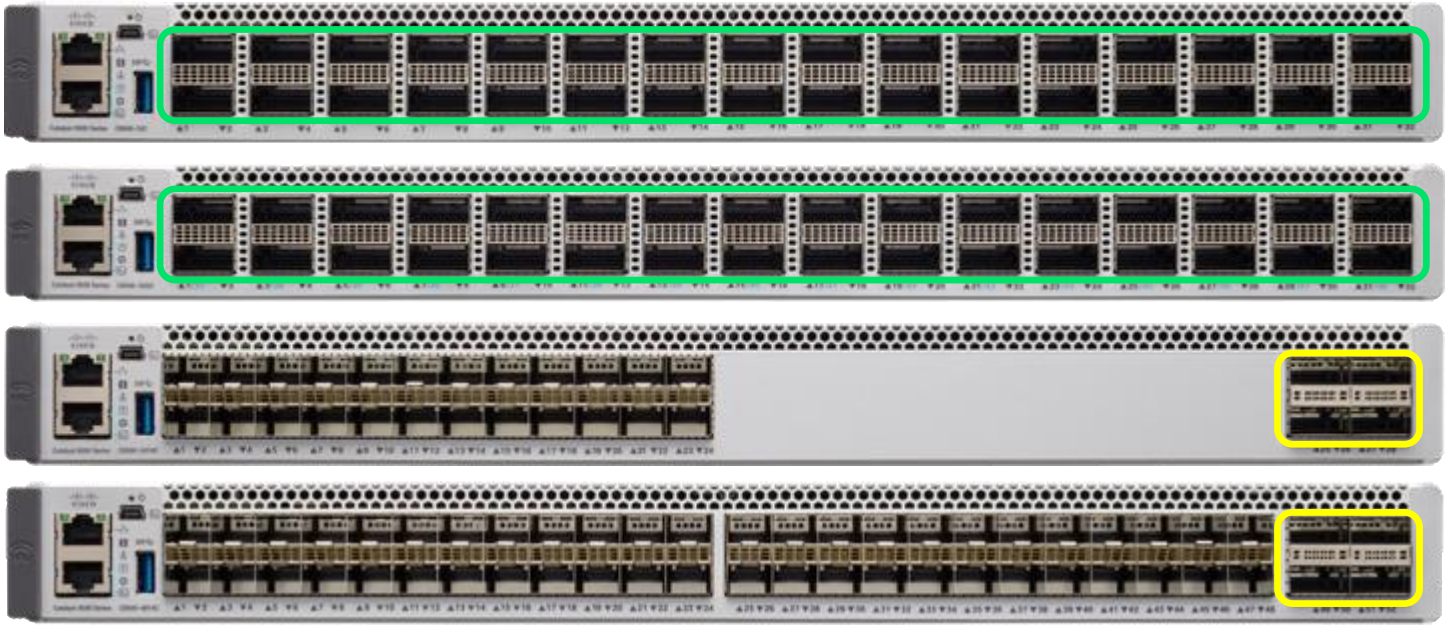
```
Device# configure terminal
Device (config)# hw-mod breakout module 1 port <port-num> switch <switch_num>
```

Fo 1/0/1 --- > Te 1/0/1, Te 1/0/2, Te 1/0/3, Te 1/0/4
Fo 1/0/2 --- > Te 1/0/5, Te 1/0/6, Te 1/0/7, Te 1/0/8
..
Fo 1/0/24 -- > Te 1/0/93, Te 1/0/94, Te 1/0/95, Te 1/0/96

Fo 1/1/1 --- > Te 1/1/1, Te 1/1/2, Te 1/1/3, Te 1/1/4

Conversion process do not require system reload to make configuration effective

Cisco Catalyst 9500 QSA Options



C9500 – 32C

C9500-32QC

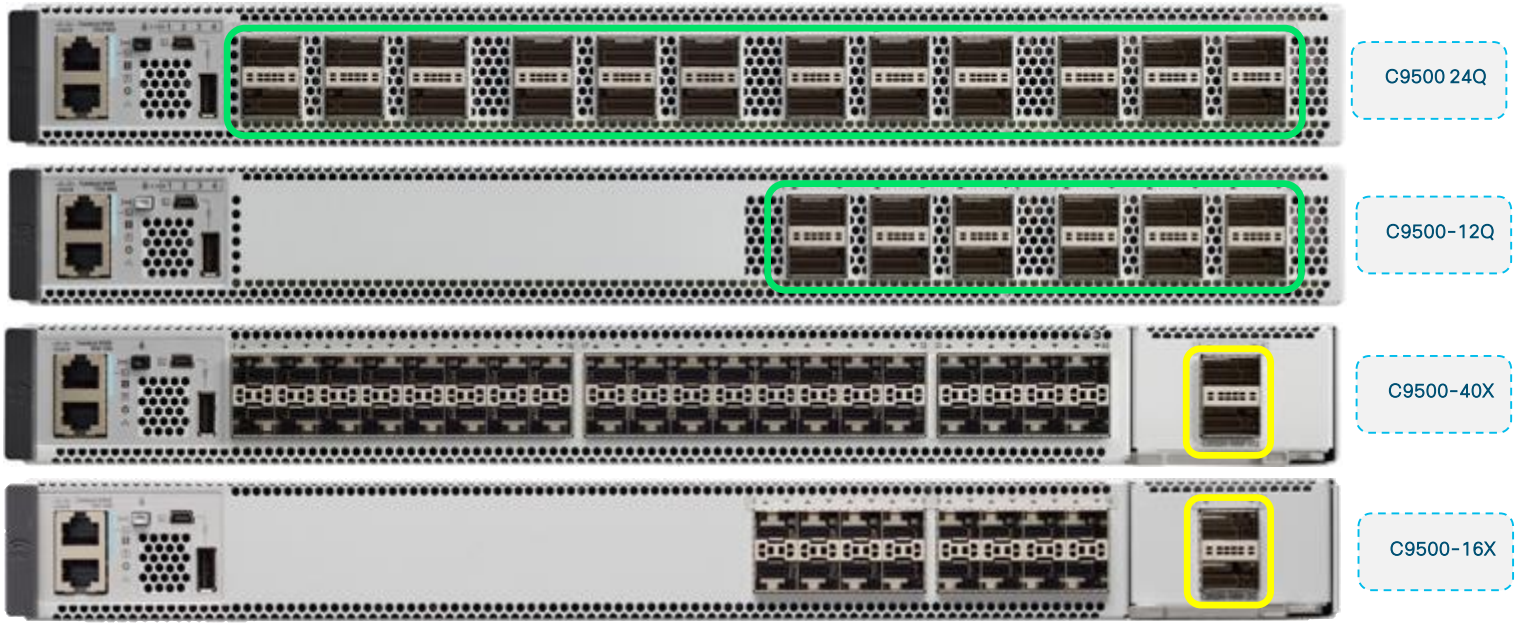
C9500-24Y4C

C9500-48Y4C

1G/10G supported

Only 10G supported

Cisco Catalyst 9500 QSA Options



QSA Limitation

1G Optics with QSA		10G Optics with QSA		
C9500-24Q C9500-12Q (16.8.1)	C9500-32C C9500-32QC (16.10.1)	C9500-24Q (16.5.1a) C9500-12Q (16.6.1) C9500-NM-2Q (16.6.1) C9300-NM-2Q (16.6.1)	C9500-32C (16.8.1) C9500-32QC (16.8.1) C9500-48Y4C (16.9.1) C9500-24Y4C (16.9.1)	C9600 (16.11.1)
GLC-SX-MMD, GLC-LH-MMD, GLC-ZX-SMD GLC-TE GLC-T GLC-BX-D/U SFP-GE-S/L/T/Z	GLC-SX-MMD GLC-LH-SMD GLC-TE GLC-T	SFP-10G-SR/SR-S SFP-10G-LR/LR-S SFP-10G-ER/ER-S SFP-10G-ZR/ZR-S	SFP-10G-SR/SR-S SFP-10G-LR/LR-S SFP-10G-ER/ER-S SFP-10G-ZR/ZR-S SFP-H10GB-CU1M= SFP-H10GB-CU3M= SFP-H10GB-CU5M=	SFP-10G-SR/SR-S SFP-10G-LR/LR-S SFP-10G-ER/ER-S SFP-10G-ZR/ZR-S SFP-H10GB-CU1M= SFP-H10GB-CU3M= SFP-H10GB-CU5M= CWDM-SFP10G-xxxx

QSA is supported as data ports for Stackwise Virtual and Standalone deployment.

Cisco Catalyst 9500 Series

Switch Database Management (SDM) template

Core template
Maximizes system resources for unicast and multicast routing and security
(Default: C9500 100G/25G)

User-customizable template
Allows customizable* ACL TCAM resources

Cisco® Catalyst® 9500 Series

Distribution template
Maximizes system resources for MAC and security
(Default: C9500 Switches)

SD-Access template
Maximizes system resources for security to support fabric deployment

NAT template
Maximizes the NAT configurations on the switch

* Cisco Catalyst 9500 High Performance Switch Security ACL TCAM only

Cisco Catalyst 9500 40G/10G

SDM templates and scale numbers

Feature		Distribution template (default)	Core template	SDA template	NAT template
Indirect/LPM Routes (IPv4/IPv6)		64K / 32K	64K / 32K	64K / 32K	64K / 32K
Direct/Host Routes (IPv4/IPv6)		48K / 24K	32K / 16K	80K / 16K	48K / 24K
Multicast routes (IPv4/IPv6)		16K / 8K	32K / 16K	16K / 8K	32K / 16K
MAC address table		64K	16K	16K	16K
Flexible netflow		128K/ASIC	128K/ASIC	128K/ASIC	128K/ASIC
SGT label		8K	8K	8K	8K
Security ACL	Ingress	18K			18K
	Egress				
QOS ACL	Ingress	18K			3K
	Egress				
Netflow ACL	Ingress	1K			1K
	Egress	2K			2K
SPAN	Ingress	1K			1K
	Egress				
PBR/NAT		2K			16K
CPP		1K			1K
Tunnel termination and MACSEC		1K			1K
LISP		1K			1K

Cisco Catalyst 9500 100G/25G

SDM templates and scale numbers

Feature		Distribution template	Core template (default)	SDA template	NAT template
Routes (IPv4/IPv6)		114K / 114K	212K / 212K	212K / 212K	212K / 212K
Multicast routes (IPv4/IPv6)		16K / 16K	32K / 32K	32K / 32K	32K / 32K
MAC address table		82K	32K	32K	32K
Flexible netflow		98K	64K	64K	64K
SGT label		32K	32K	32K	32K
Security ACL	Ingress	12K		8K	12K
	Egress	15K		19K	8K
QOS ACL	Ingress	8K		8K	4K
	Egress	8K		8K	4K
Netflow ACL	Ingress	1K		1K	1K
	Egress	1K		1K	1K
SPAN	Ingress	0.5K		0.5K	0.5K
	Egress	0.5K		0.5K	0.5K
PBR/NAT		3K		2K	15.5K
CPP		1K		1K	1K
Tunnel termination and MACSEC		3K		3K	2K
LISP		1K		2K	1K

Customizable ACL TCAM resources

Cisco Catalyst 9500 Series
SDM template – CLI

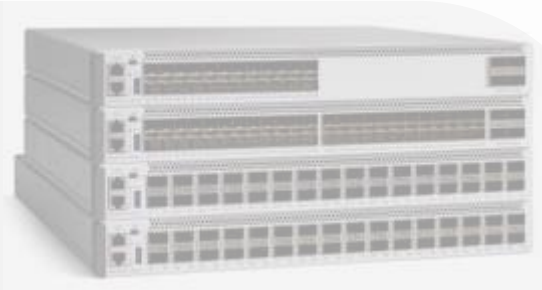
	Command	Purpose
Step 1	Show sdm prefer	Display the template in use
Step 2	Configure terminal	Enter Global Configuration mode
Step 3	Sdm prefer {core|distribution|nat|sda|template -modification*}	Specify the SDM template to be used on the switch
Step 4	End	Return to Privilege exec mode
Step 5	Reload	Reload the operating system
Step 6	Show sdm prefer	Display the template in use

```
C9500H-32QC#sh sdm prefer
Showing SDM Template Info

This is the Distribution template.
  Security Ingress IPv4 Access Control Entries*:      6656  (current) - 6656  (proposed)
  Security Ingress Non-IPv4 Access Control Entries*:  5632  (current) - 5632  (proposed)
  Security Egress IPv4 Access Control Entries*:       6656  (current) - 6656  (proposed)
  Security Egress Non-IPv4 Access Control Entries*:   8704  (current) - 8704  (proposed)
  QoS Ingress IPv4 Access Control Entries*:           4608  (current) - 4608  (proposed)
  QoS Ingress Non-IPv4 Access Control Entries*:       3584  (current) - 3584  (proposed)
  QoS Egress IPv4 Access Control Entries*:            4608  (current) - 4608  (proposed)
  QoS Egress Non-IPv4 Access Control Entries*:        3584  (current) - 3584  (proposed)
  Netflow Input Access Control Entries*:              1024  (current) - 1024  (proposed)
  Netflow Output Access Control Entries*:             1024  (current) - 1024  (proposed)
  Flow SPAN Input Access Control Entries*:            512   (current) - 512   (proposed)
  Flow SPAN Output Access Control Entries*:           512   (current) - 512   (proposed)
  Number of VLANs:                                    4094
  Unicast MAC addresses:                              81920
  Overflow Unicast MAC addresses:                     768
  Overflow L2 Multicast groups:                       2304
  IGMP and Multicast groups:                          16384
  Overflow IGMP and Multicast groups:                 768
  Directly connected routes:                          114688
  Indirect routes:                                    1536
  Policy Based Routing ACEs:                          3072
  Tunnels:                                            2816
  LISP Instance Mapping Entries:                      1024
  Control Plane Entries:                              1024
  Input Netflow flows:                                49152
  Output Netflow flows:                               49152
  SGT/DGT (or) MPLS VPN entries:                      32768
  SGT/DGT (or) MPLS VPN Overflow entries:             768
  Wired clients:                                      2048
  NAT DA Entries:                                     1024
  NAT SA Entries:                                     1024
  MPLS L3 VPN VRF:                                    256
  MPLS Labels:                                        16384
  MPLS L3 VPN Routes VRF Mode:                        16384
  MPLS L3 VPN Routes Prefix Mode:                     4096
  MVPN MDT Tunnels:                                   1024
  L2 VPN EOMPLS Attachment Circuit:                   1024
  MAX VPLS Bridge Domains :                           128
  MAX VPLS Peers Per Bridge Domain:                   32
  MAX VPLS/VPMS Pseudowires :                         4096
These numbers are typical for L2 and IPv4 features.
Some features such as IPv6, use up double the entry size;
so only half as many entries can be created.
* values can be modified by sdm cli.
```

* - Only on Cisco 9500 High Performance SKU's

Cisco Catalyst 9500 Series
SDM Customizable template – CLI

Command to modify ACL TCAM Allocation



```
C9500-32C-2(config)#sdm prefer template-modification ?
  default       Default prefered template
  fspan         Filter Span
  nfl           NFL ACLs
  qos           QOS
  security-acl  Security ACLs
```

```
C9500-32C-2(config)# sdm prefer template-modification security-acl input allowed-range
Total_size : 27648 Suggested split percentage for input : 29 33 37 40 48 49 52 60 63 67 71
```

```
C9500-32C-2(config)#sdm prefer template-modification security-acl input 25 input-ipv4 75 output-ipv4 75
Allocated Security Acl Input (IPv4:4608, Non-IPv4:3584) entries, Output (IPv4:13824, Non-IPv4:5632) entries input=29.63
input_ipv4=56.25, output_ipv4=71.05
```

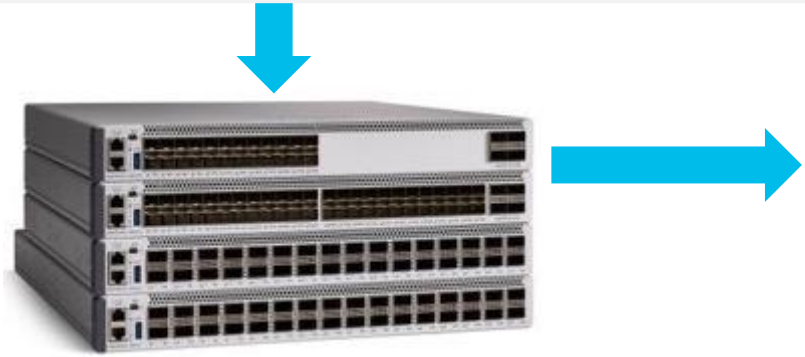
Modifications to preferred template have been stored, but cannot effect until the next reload. Allocations will be an approximation of user specified percentages. Use 'show sdm prefer' to see proposed values.

Cisco Catalyst 9500 Series
SDM Customizable template – CLI

Command to modify ACL TCAM Allocation

*C9500-32C(config)#**sdm prefer template-modification security-acl input 25 input-ipv4 75 output-ipv4 75***
*Allocated Security Acl Input (**IPv4:4608, Non-IPv4:3584**) entries, Output (**IPv4:13824, Non-IPv4:5632**) entries*
input=29.63 input_ipv4=56.25, output_ipv4=71.05

Modifications to preferred template have been stored, but cannot effect until the next reload. Allocations will be
an approximation of user specified percentages. Use 'show sdm prefer' to see proposed values.



Security-ACL Allocation	Input=25% Input V4 – 75% Output v4 – 75%	
27K	8K(Input)	4.5K(v4)
		3.5K(non-v4)
	19K(Output)	13.5K(v4)
		5.5K(non-v4)

Security-ACL Allocation	Input=50% Input V4 – 75% Output v4 – 75%	
27K	13K(Input)	9.5K(v4)
		3.5K(non-v4)
	14K(Output)	10.5K(v4)
		3.5K(non-v4)

Security-ACL Allocation	Input=75% Input V4 – 75% Output v4 – 75%	
27K	19K(Input)	13.5K(v4)
		5.5K(v4)
	8K(Output)	4.5K(v4)
		3.5K(non-v4)

Cisco Catalyst 9500 Series comparison

Capabilities (per ASIC)	Cisco® Catalyst 9500 Series (UADP 2.0)	Cisco Catalyst 9500 100G/25G (UADP 3.0)
Switching and forwarding capacity	**240 Gbps**/360 Mpps	**1.6 Tbps**/1 Bpps
ASIC interconnect bandwidth	2x 360 Gbps	2x 400 Gbps
Buffer capability	**16 MB per Core (32MB /ASIC)**	**36 MB across Cores**
Switch Database Management (SDM) template	**Fixed templates**	**Customizable templates**
NetFlow capabilities	**Dedicated NetFlow table**	**Shared NetFlow table**
v4 FIB scale	Total 228,000*	Total 412,000*
v4 and v6 scale	**v6 reduced by half**	**v4 and v6 same scale**
Storage	120GB USB 3.0	Up to 1TB M2 SATA SSD
StackWise Virtual	Supported	Supported
Spanning-Tree Instances – RPVST+	128	1K
Virtual Routing & Forwarding(VRF) – v4	256	1K

* Maximum ASIC Capability

Catalyst 9600

You make networking **possible**

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Cisco Catalyst 9600 Series Switches

Cisco Catalyst 9600 Series
Chassis

Dual-serviceable fan tray

Built-in RFID

Blue Beacons (system/fan tray, sup, line cards)

Modular power supplies

4 line card slots

2 supervisor slots (dedicated)

6.4 Tbps per slot from each supervisor slot

Dimensions (HxWxD inches) 13.95 x 17.4 x 16.1 (8RU)

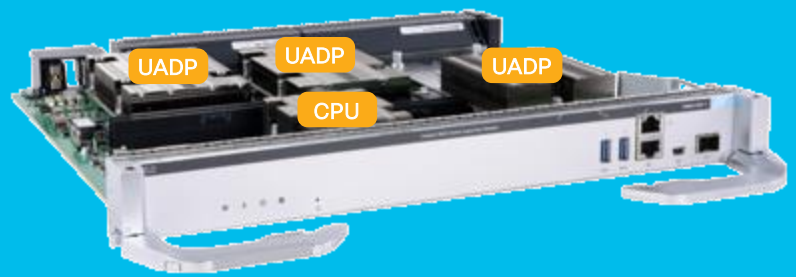
Cisco Catalyst 9600 Series
C9606R chassis port density

Port speed	Density with supervisor 1	Maximum chassis density
100G	48	128
40G	96	128
25G	192	192
10G	192	192
1G*	192	192

Line Rate non-blocking

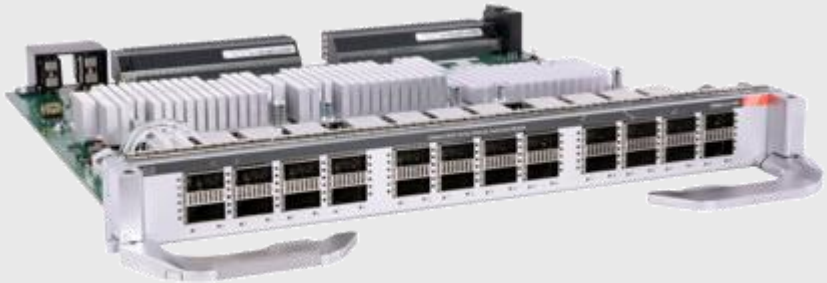
*Roadmap

Cisco Catalyst 9600 Series
Supervisor 1



9.6 Tbps	2.4 Tbps per slot
3x UADP 3.0 ASIC	**8 core** X86 CPU @2.0 Ghz
M.2 SATA SSD (optional: up to 1 TB)	16G DDR4 memory
Built-in RFID	Mgmt ports: copper and **fiber**
Blue Beacon	2x USB3 1x mini-B USB console

Cisco Catalyst 9600 Series
Line cards

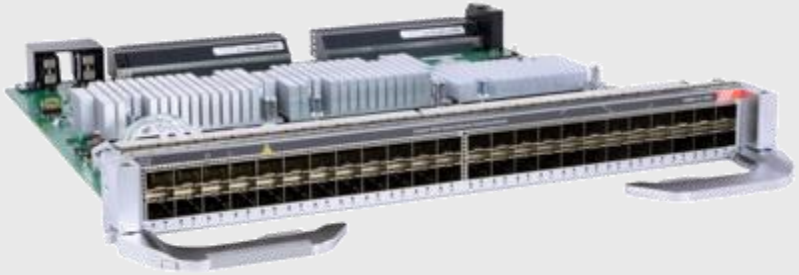


C9600-LC-24C – 100G/40G (fiber)

- 24 ports
- QSFP28/QSFP+
- Supports 100G and 40G

C9600-LC-48YL – 25G/10G/1G* (fiber)

- 48 ports
- SFP28/SFP+/SFP
- Supports 25G, 10G, and 1G



*Roadmap

The Y in the product ID (PID) indicates the hardware capability

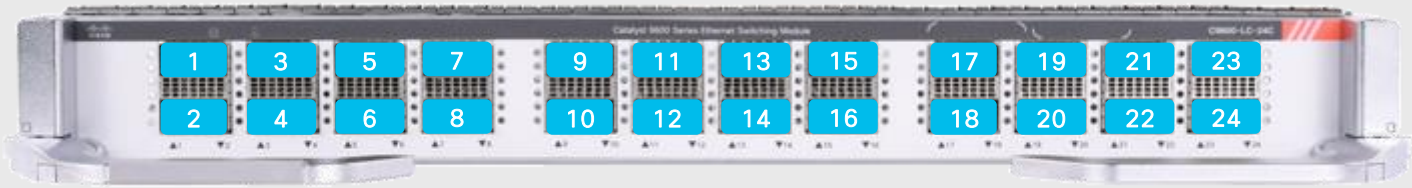
Cisco Catalyst 9600 Series
100G/40G Line card – C9600-LC-24C

- All 24 ports are capable of 100G (QSFP28)/40G (QSFP+)
- Hardware-ready with QSA (for 1G/10G)
- With Supervisor Engine 1
  - 100G: Every 2 ports in a port-group. The odd number of ports can be 100G and the next even number port is disabled. (Maximum of 12x 100G, line rate with 187 byte or higher)
  - 40G – 24x 40G (line rate with 148 byte or higher)

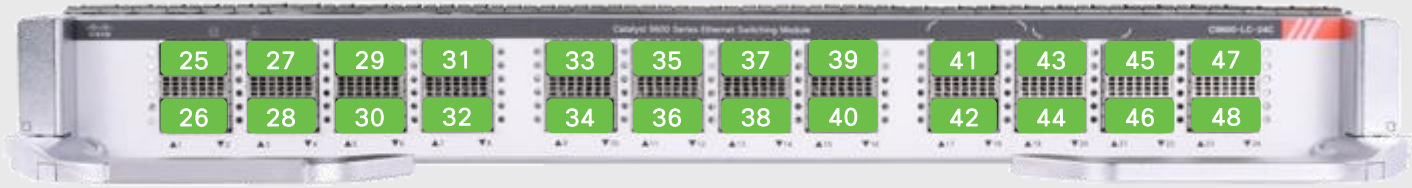
C9600-LC-24C – Port Numbering with Supervisor Engine 1

- 40G numbering from 1 to 24
- 100G number from 25 to 48

40G port numbering



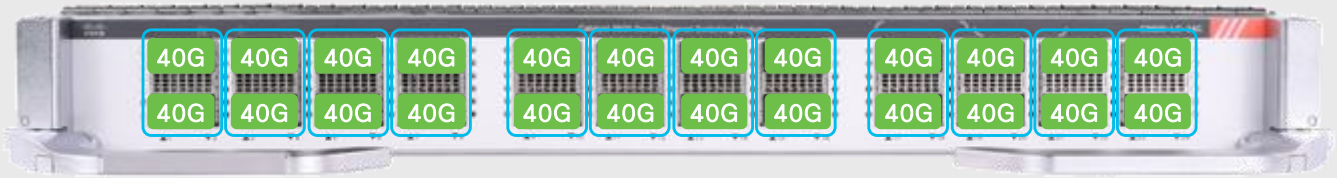
100G port numbering



C9600-LC-24C with supervisor engine 1

- This line card appears in 40G mode by default
- Future supervisors can support 100G speed on all ports at the same time

Default mode
(all ports 40G)



100G
configuration

Fo<slot#>/0/1
Hu <slot#>/0/25

interface HundredGigE1/0/25 enable

- Enable Hu1/0/25 as 100G
- Disabled Fo1/0/1 and 1/0/2

Fo<slot#>/0/23
Hu <slot#>/0/47

Cisco Catalyst 9600 Series
25G/10G/1G Line card – C9600-LC-48YL

- All 48 ports support 25G/10G/1G
- Hardware capable of 10/100M
- Line rate with 25G/10G/1G (at 187 bytes for 25G; any packet size with 10G/1G)
- Any port, any supported speed
- Port reference is always ”TwentyFive<slot#>/0/<port#>” and port speed is auto-detected based on the inserted transceiver

Cisco Catalyst 9600 Series
Fan tray

- N+1 (8+1) fan redundancy
- Flexible service - fan tray can be replaced from the portside or the back
- Efficient - variable speed per fan depends on the load, temperature, and altitudes (=>lower noise)
- Airflow – side-to-side airflow

Fan tray hot-swappable needs to be done within 120 seconds

Cisco Catalyst 9600 Series
Power supplies

- Chassis has 4 slots for power supply
- Individual on/off switch for each power supply
- Supports a mix of AC (@220V) and DC power supplies

AC

- Supports both 110V and 220V input
- 2 KW output with 220V (1050W with 110V)
- Platinum rate power supply
- Redundant mode: Combined and N+1

DC

- Supports input range of -40V to -72V
- 2 KW output
- Platinum rate power supply
- Redundant mode: Combined and N+1

Architecture

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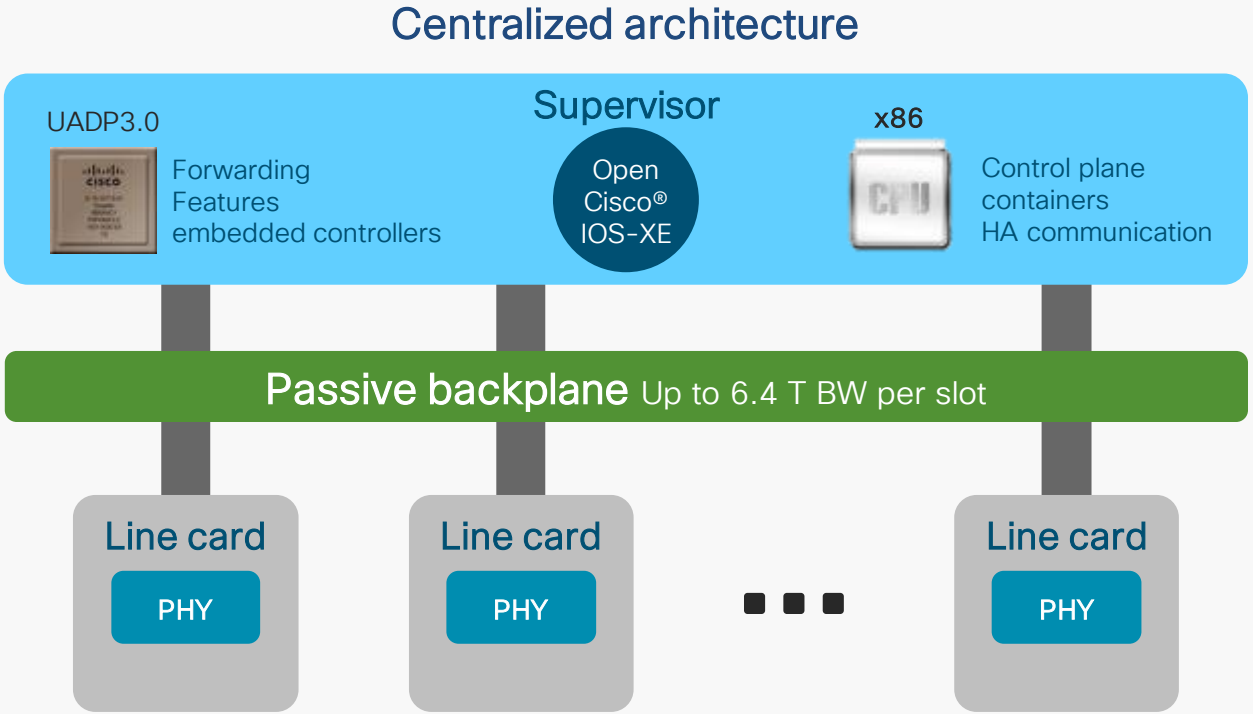
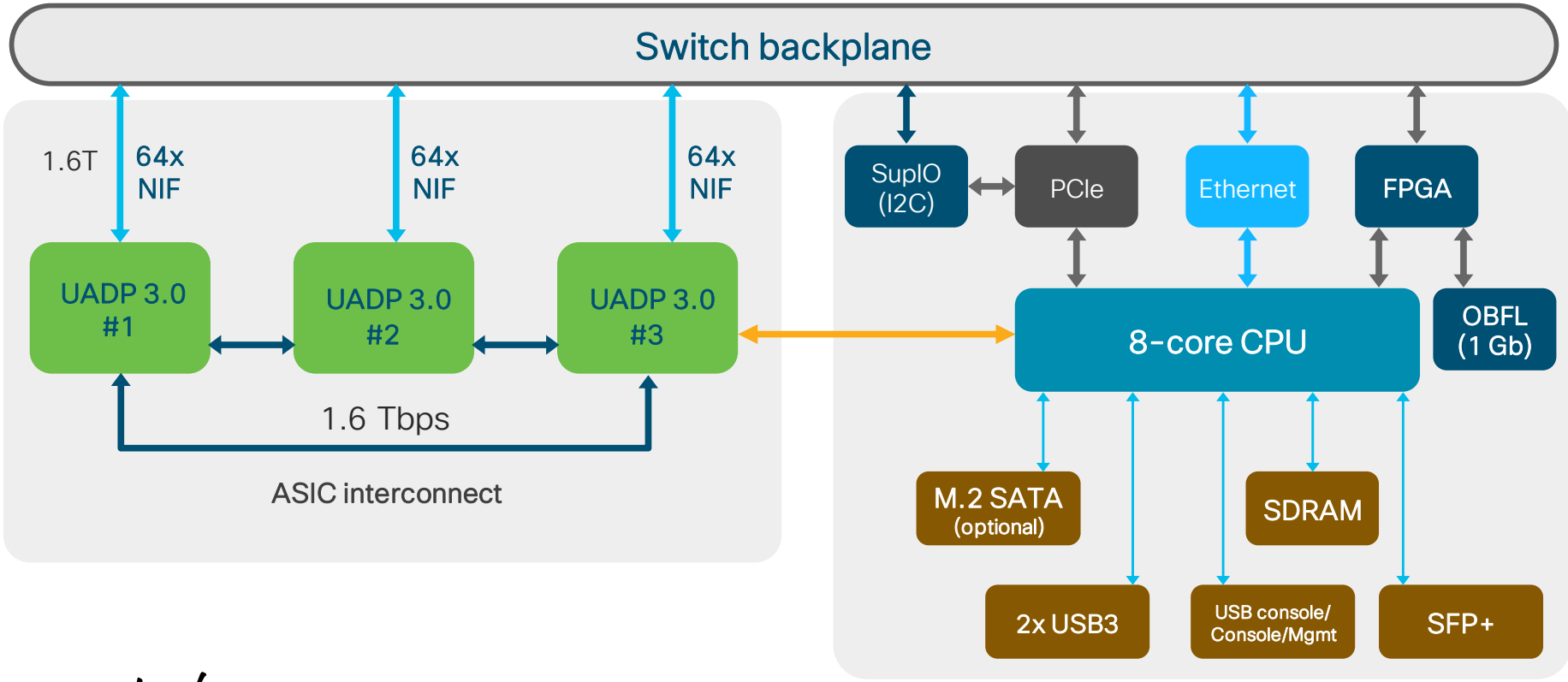
Architecture

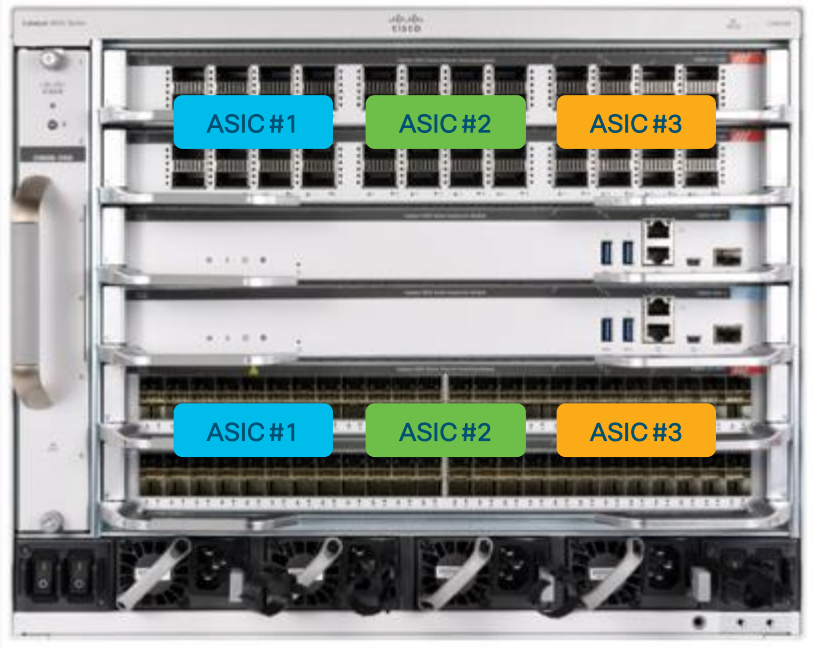


- Centralized architecture => **Uninterrupted supervisor switchover**
- Centralized architecture (Forwarding, queuing, and security are done on the supervisor) => **Unlock new capability** with a supervisor upgrade
- Transparent line cards => **Compatible** with new sup
- Passive backplane => **High MTBF**
- X86 CPU + storage => **App hosting**

Supervisor engine 1 – Block diagram



Supervisor engine 1 – ASICs to LC mapping



- ASIC #1: First third of the ports
  - 48-port module: 1-16
  - 24-port module: 1-8
- ASIC #2: Middle third of the ports
  - 48-port module: 17-32
  - 24-port module: 9-16
- ASIC #3: Last third of the ports
  - 48-port module: 33-48
  - 24-port module: 17-24

Cisco Catalyst 9600 – Supervisor 1
Port-to-ASIC mapping

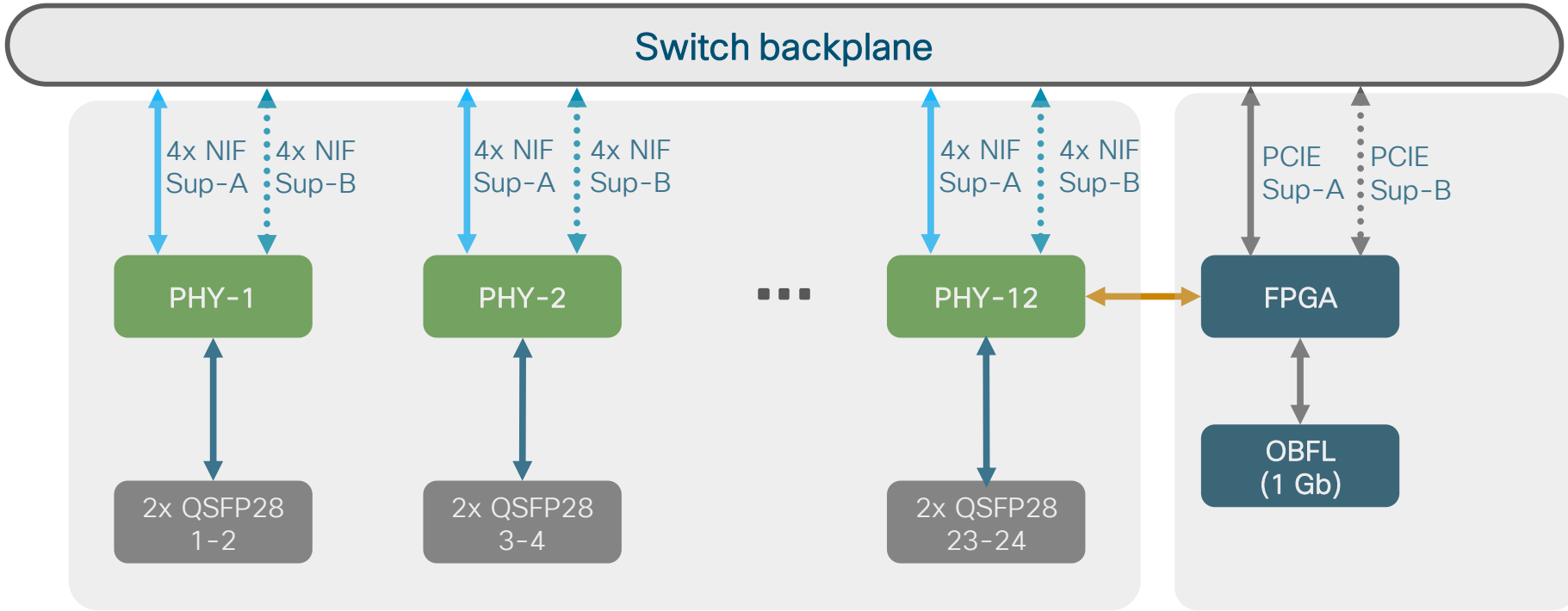
Reference

Command to verify the port-to-ASIC mapping:
show platform software fed active ifm mappings

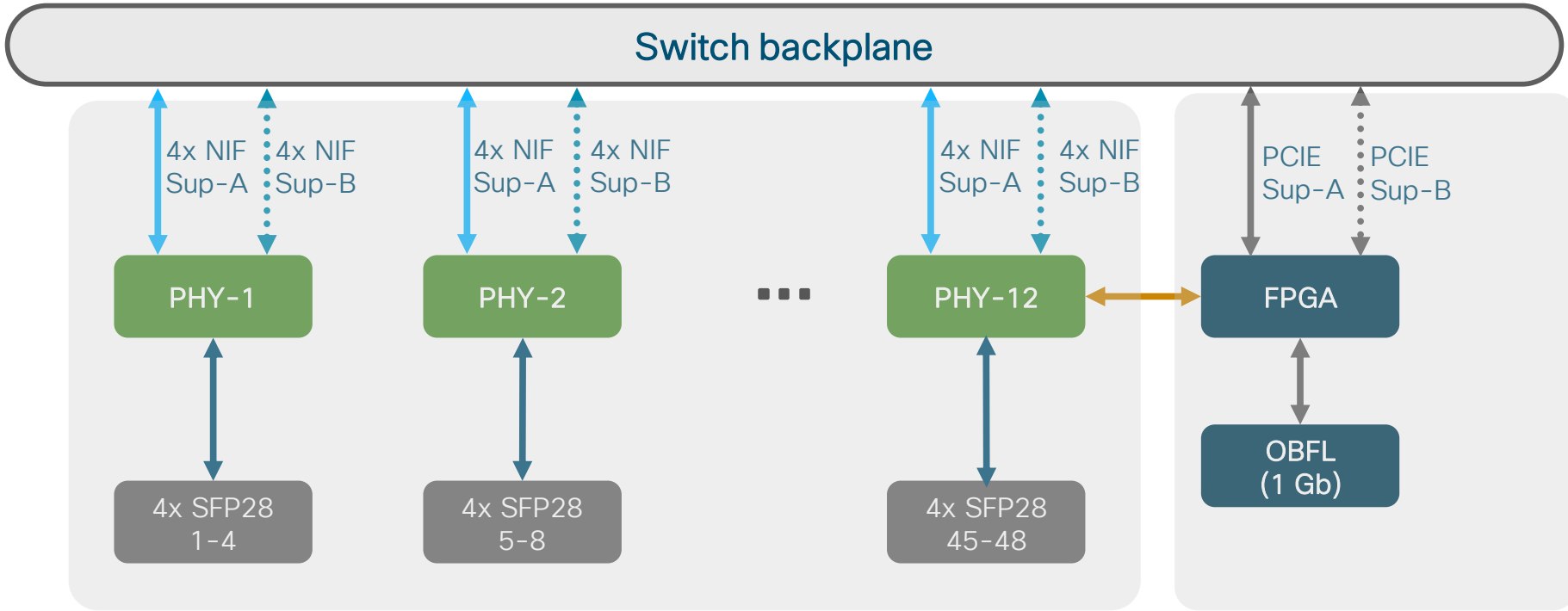
```
C9600-Bottom#show platform software fed active ifm mappings
Interface                IF_ID    Inst Asic Core Port SubPort Mac  Cntx LPN  GPN  Type Active
FortyGigabitEthernet1/0/1 0x7       0    0    0    0      0      0    0    1    101  NIF  N
FortyGigabitEthernet1/0/2 0x8       0    0    0    8      0      2    1    2    102  NIF  N
FortyGigabitEthernet1/0/3 0x9       0    0    0    16     0      16   0    3    103  NIF  N
FortyGigabitEthernet1/0/4 0xa       0    0    0    24     0      18   1    4    104  NIF  N
FortyGigabitEthernet1/0/5 0xb       1    0    1    8      0      14   1    5    105  NIF  Y
FortyGigabitEthernet1/0/6 0xc       1    0    1    0      0      12   0    6    106  NIF  Y
FortyGigabitEthernet1/0/7 0xd       1    0    1    24     0      30   1    7    107  NIF  Y
FortyGigabitEthernet1/0/8 0xe       1    0    1    16     0      28   0    8    108  NIF  Y
FortyGigabitEthernet1/0/9 0xf       2    1    0    0      0      0    0    9    109  NIF  Y
<SNIP>
FortyGigabitEthernet1/0/16 0x16      3    1    1    16     0      28   0    16   116  NIF  Y
FortyGigabitEthernet1/0/17 0x17      4    2    0    0      0      0    0    17   117  NIF  Y
<SNIP>
FortyGigabitEthernet1/0/24 0x1e      5    2    1    16     0      28   0    24   124  NIF  N
HundredGigE1/0/25          0x1f      0    0    0    0      0      0    0    25   125  NIF  Y
<SNIP>

C9600-Bottom#$
```

100G/40G line card block diagram



25G/10G/1G line card block diagram



Cisco Catalyst 9600 Series – Supervisor engine 1
Switch Database Management (SDM) template

Core template
Maximizes system resources for Layer 3 unicast and multicast **routes (default)**

SD-Access template
Maximizes system resources for **policy** to support **fabric** deployment

User-customizable template
Allows customizable ACL TCAM resources

Cisco® Catalyst® 9600 Series

Distribution template
Balances system resources between Layer 3 **routes** and Layer 2 **MAC** and **Netflow**

NAT template
Maximizes the **NAT** configurations on the switch

Cisco Catalyst 9600 Series
SDM templates and scale numbers

Feature		Distribution template	Core template (default)	SDA template	NAT template
Routes (IPv4/IPv6)		114K/114K	212K/212K	212K/212K	212K/212K
Multicast routes (IPv4/IPv6)		16K/16K	32K/32K	32K/32K	32K/32K
MAC address table		82K	32K	32K	32K
Flexible NetFlow		98K/ASIC	64K/ASIC	64K/ASIC	64K/ASIC
SGT label		32K	32K	32K	32K
Security ACL	Ingress	12K		8K	12K
	Egress	15K		19K	8K
QOS ACL	Ingress	8K		8K	4K
	Egress	8K		8K	4K
NetFlow ACL	Ingress	1K		1K	1K
	Egress	1K		1K	1K
SPAN	Ingress	0.5K		0.5K	0.5K
	Egress	0.5K		0.5K	0.5K
PBR/NAT		3K		2K	15.5K
CPP		1K		1K	1K
Tunnel termination and MACsec		3K		3K	2K
LISP		1K		2K	1K

Customizable ACL TCAM resources

Cisco Catalyst 9600 Series
SDM template – Customizable TCAM section

C9600-Bottom#sho sdm prefer
Showing SDM Template Info

This is the Core template.

Security Ingress IPv4 Access Control Entries*	: 6656 (current) - 6656 (proposed)
Security Ingress Non-IPv4 Access Control Entries*	: 5632 (current) - 5632 (proposed)
Security Egress IPv4 Access Control Entries*	: 6656 (current) - 6656 (proposed)
Security Egress Non-IPv4 Access Control Entries*	: 8704 (current) - 8704 (proposed)
QoS Ingress IPv4 Access Control Entries*	: 4608 (current) - 4608 (proposed)
QoS Ingress Non-IPv4 Access Control Entries*	: 3584 (current) - 3584 (proposed)
QoS Egress IPv4 Access Control Entries*	: 4608 (current) - 4608 (proposed)
QoS Egress Non-IPv4 Access Control Entries*	: 3584 (current) - 3584 (proposed)
Netflow Input Access Control Entries*	: 1024 (current) –1024 (proposed)
Netflow Output Access Control Entries*	: 1024 (current) – 1024 (proposed)
Flow SPAN Input Access Control Entries*	: 512 (current) – 512 (proposed)
Flow SPAN Output Access Control Entries*	: 512 (current) – 512 (proposed)

Cisco Catalyst 9600 Series
SDM customizable template – CLI

Customizable range: 10% - 90%

- Between input and output
- Between IPv4 and non-IPv4

Security-ACL allocation	Default	
27K	12K (input)	7K (v4)
		5K (non-v4)
	15K (output)	7K (v4)
		8K (non-v4)

Example 1

Security-ACL allocation	Input =10% Input V4 – 75% Output v4 – 75%	
27K	3K (input)	2K (v4)
		1K (non-v4)
	24K (output)	18K (v4)
		6K (non-v4)

Example 2

Security-ACL allocation	Input = 50% Input V4 – 75% Output v4 – 75%	
27K	13K (input)	9.5K (v4)
		3.5K (non-v4)
	14K (output)	10.5K (v4)
		3.5K (non-v4)

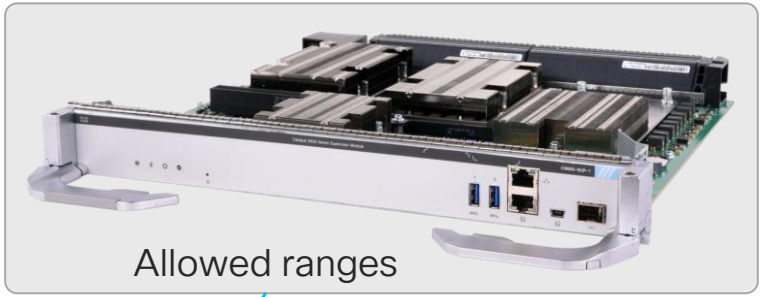
Example 3

Security-ACL allocation	Input = 90% Input V4 – 75% Output v4 – 75%	
27K	24K (input)	18K (v4)
		6K (v4)
	3K (output)	2K (v4)
		1K (non-v4)

Cisco Catalyst 9600 Series – Supervisor Engine 1
SDM customizable template – CLI

Reference

Command to modify ACL TCAM allocation




```
C9600(config)#sdm prefer template-modification?
  default       Default prefered template
  fspan         Filter Span
  nfl           NFL ACLs
  qos           QOS
  security-acl  Security ACLs
```

```
C9600 (config)# sdm prefer template-modification security-acl input allowed-range
Total_size: 27648 Suggested split percentage for input: 11 18 22 25 33 37 40 48 49 52 60 63 67 75 78 82 89
```

```
C9600(config)#sdm prefer template-modification security-acl input 15 input-ipv4 15 output-ipv4 85
Allocated Security Acl Input (IPv4:1024, Non-IPv4:4096) entries, Output (IPv4:18432, Non-IPv4:4096) entries
input=18.52 input_ipv4=20.00, output_ipv4=81.82
Modifications to the preferred template have been stored, but cannot take effect until the next reload. Allocations will be an approximation of user-specified percentages. Use 'show sdm prefer' to see proposed values.

C9600(config)#
```

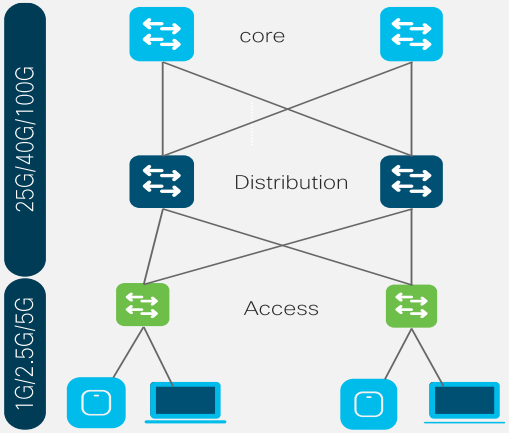
Catalyst 9600 Design Consideration

You make networking **possible**

Cisco live!

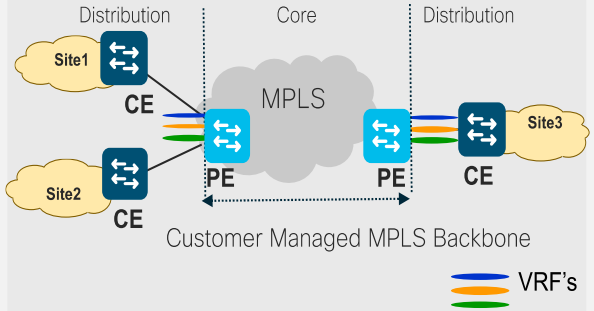
Catalyst 9600 for Multidomain Campus Core

L3/Collapsed Core



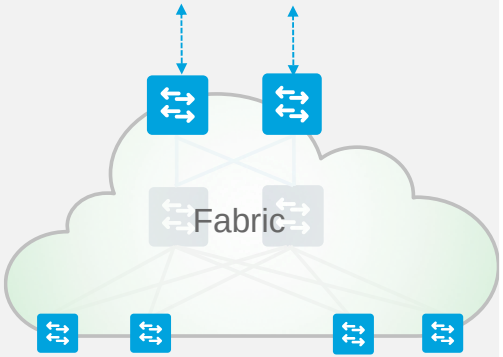
- Reduced Complexity, Resiliency & Scale
- IPv4/IPv6, Unicast & Multicast, QoS & ACL Scale

L3 Core + MPLS PE



- Segmentation, Scale, LAN/WAN Consistency
- MPLS VPNs (L2 & L3), MPLS over GRE

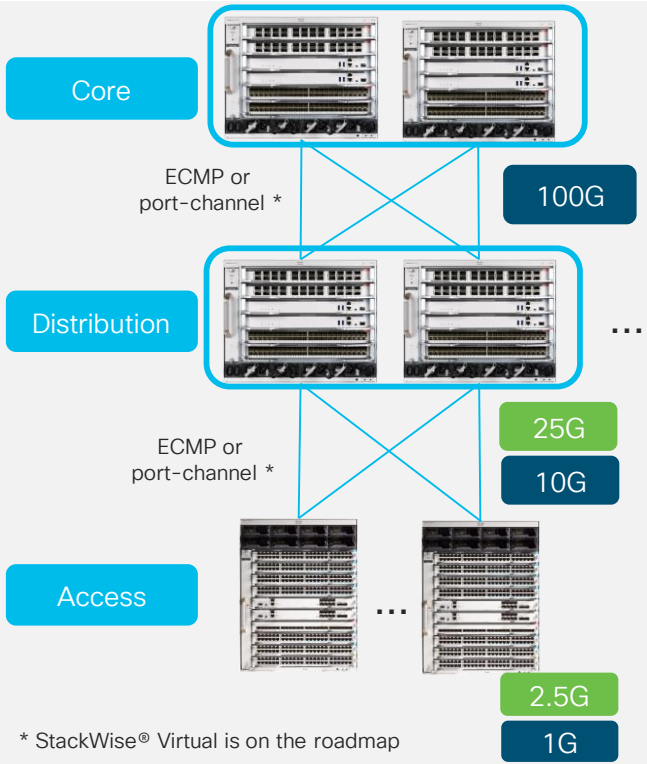
Fabric Border



- Segmentation & Automation/Programmability
- Turnkey Solution: SD-Access
- DIY : BGP EVPN VxLAN

One Platform. Any Place. Any Speed (1G to 100G)

Example of a Traditional Three-Tiers Campus Design



- Catalyst® 9606R Switch with 4x C9600-LC-24C for connection to the distribution layer, WAN, and between core devices
- Oversubscription ratio of 4:1 from distribution to core

Core

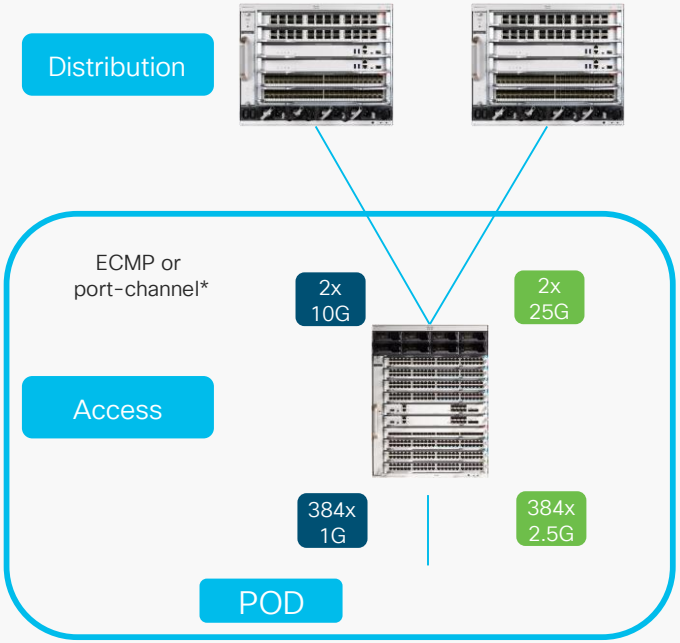
- Catalyst 9606R with 1x C9606-LC-24C as the uplink connection to the core and 3x C9606-LC-48YL as the downlink connection to the access layer
- Oversubscription ratio of 20:1 from access to distribution

Distribution

- Catalyst 9410 with 1G copper and/or mGig modules with Sup1-XL-Y
- 8x Catalyst 9300 StackWise-480 with 10G/25G uplinks

Access

Access Layer – POD



* StackWise® Virtual is on the roadmap

Cisco® Catalyst® 9400

- A Catalyst 9410 switch provides a total of 384 ports of 1G
- Catalyst 9410 can also provide 192x1G + 192x mGig ports (up to 10G)

Catalyst 9300 StackWise®-480

- Stack of 8 can provide a total of 384 ports of 1G or 2.5G (mGig)
- Stack of 8 can also provide 384 ports of 1G and mGig combination

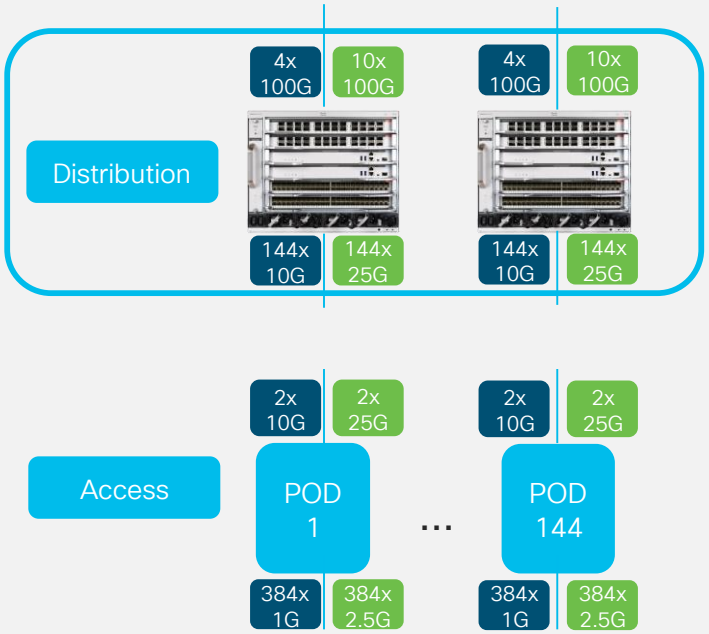
Aggregated downlink BW:

- 384G with 384x 1G
- 960G with 384x 2.5G

Uplinks BW needed for 20:1 oversubscription from access to distribution

- 2x 10G for 384x 1G
- 2x 25G for 384x 2.5G

Distribution Layer – Block



* StackWise® Virtual is on the roadmap

Cisco® Catalyst® 9606R Switch Downlinks:

- 3x C9600-LC-48YL per Catalyst 9606R
- A total of 144 x 10G/25G ports per chassis
- Aggregate downlink BW per Catalyst 9606 Switch
  1. With 10G uplinks: 144x 10G = 1.44T
  2. With 25G uplinks: 144x 25G = 3.6T

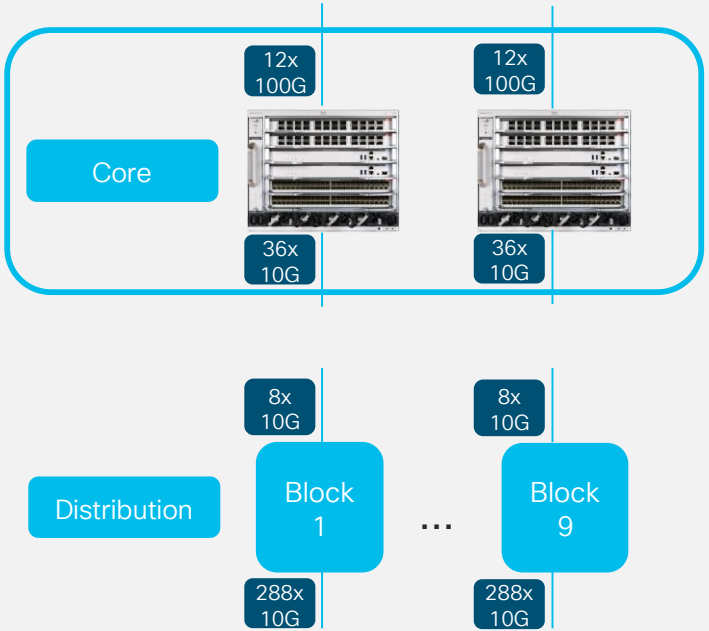
Uplinks

- 1x C9606-LC-24C per Catalyst 9606R
- To maintain 4:1 oversubscription between distribution and core layers
  1. With 10G uplinks: BW = 1.44T/4 = 360G => 4x 100G ports
  2. With 25G uplinks: BW = 3.6T/4 = 900G => 10x 100G ports

(The remaining 100G/40G ports can be used for ECMP or StackWise Virtual when it is available.)

Each distribution block can aggregate 144 access PODs.
That's 144 x 384 = **55,296** of 1G, or 2.5G ports

Core Layer with 1G in the Access Layer



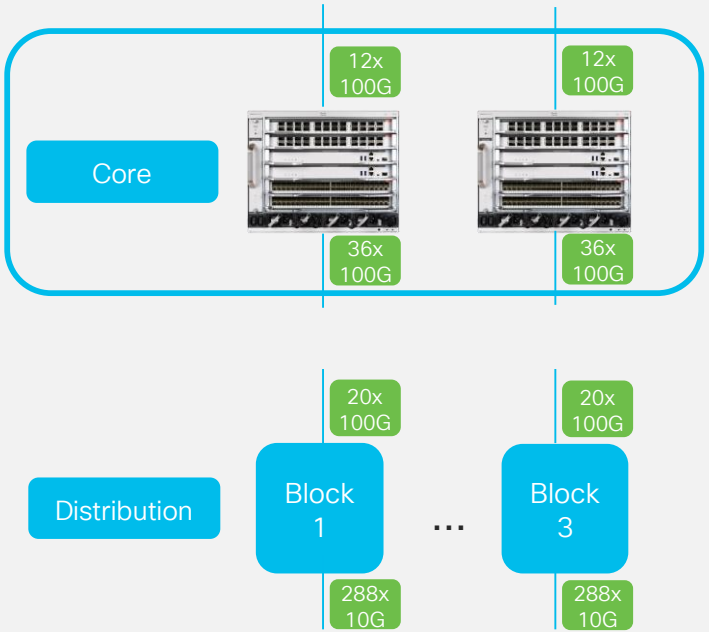
Cisco® Catalyst® 9606R Switch

- 4x C9606-LC-24C
  - 75% of ports (36x 100G) to distribution
  - 25% of ports (12x 100G) for connections between the two cores and the WAN
- Two of the core devices will provide 72x 100G for the distribution layer

- 1G aggregation
  - With 8x 100G per distribution block, two Catalyst 9606R Switches with the above configuration can aggregate 72/8, or 9 distribution blocks

The total number of 1G ports:
9x 144 x 384 = **497,664** of 1G ports

Core Layer with 2.5G in the Access Layer



Cisco® Catalyst® 9606R Switch

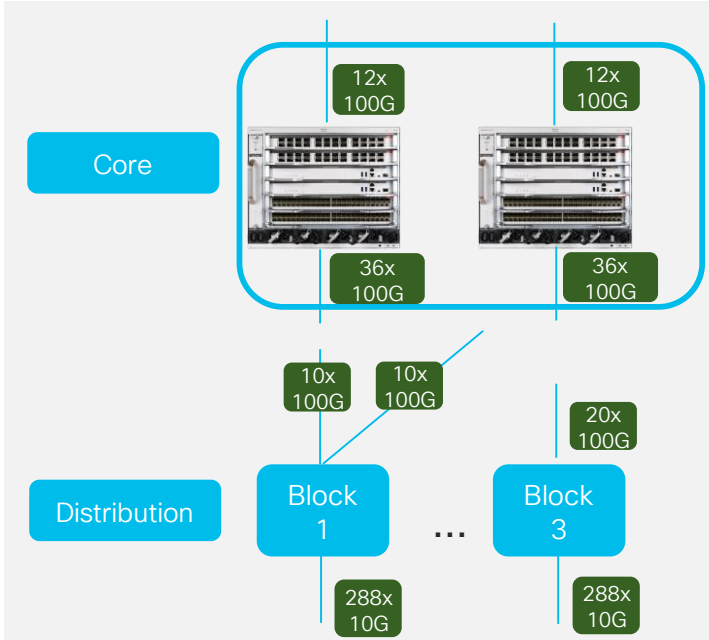
- 4x C9606-LC-24C
  - 75% of ports (36x 100G) to distribution
  - 25% of ports (12x 100G) for connections between the two cores and the WAN
- Two of the core devices will provide 72x 100G for the distribution layer

- 2.5G aggregation
  - With 20x 100G per distribution block, two of Catalyst 9606R Switches with the above configuration can aggregate 72/20, or 3 distribution blocks

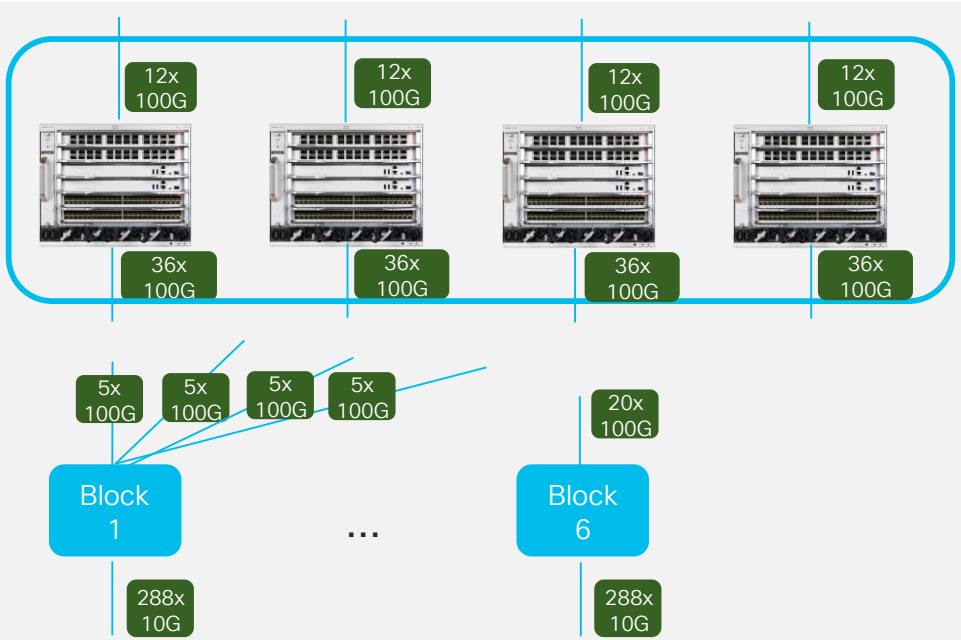
The total number of 2.5G ports:
3x 144 x 384 = **165,888** of 2.5G ports

Core Layer with 2.5G in the Access Layer

With 4x Catalyst 9606 in the core

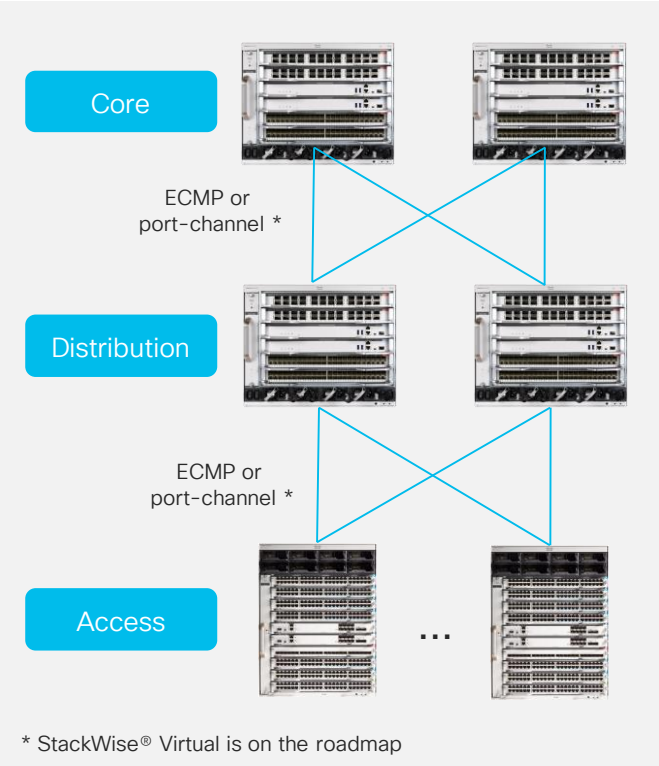


The total number of 2.5G ports:
3x 144 x 384 = **165,888** of 2.5G ports



The total number of 2.5G ports:
6x 144 x 384 = **331,776** of 2.5G ports

Summary



Two Cisco Catalyst 9606R Switches in the core can provide:

1. 497K of 1G ports, or
2. 165K of 2.5G ports

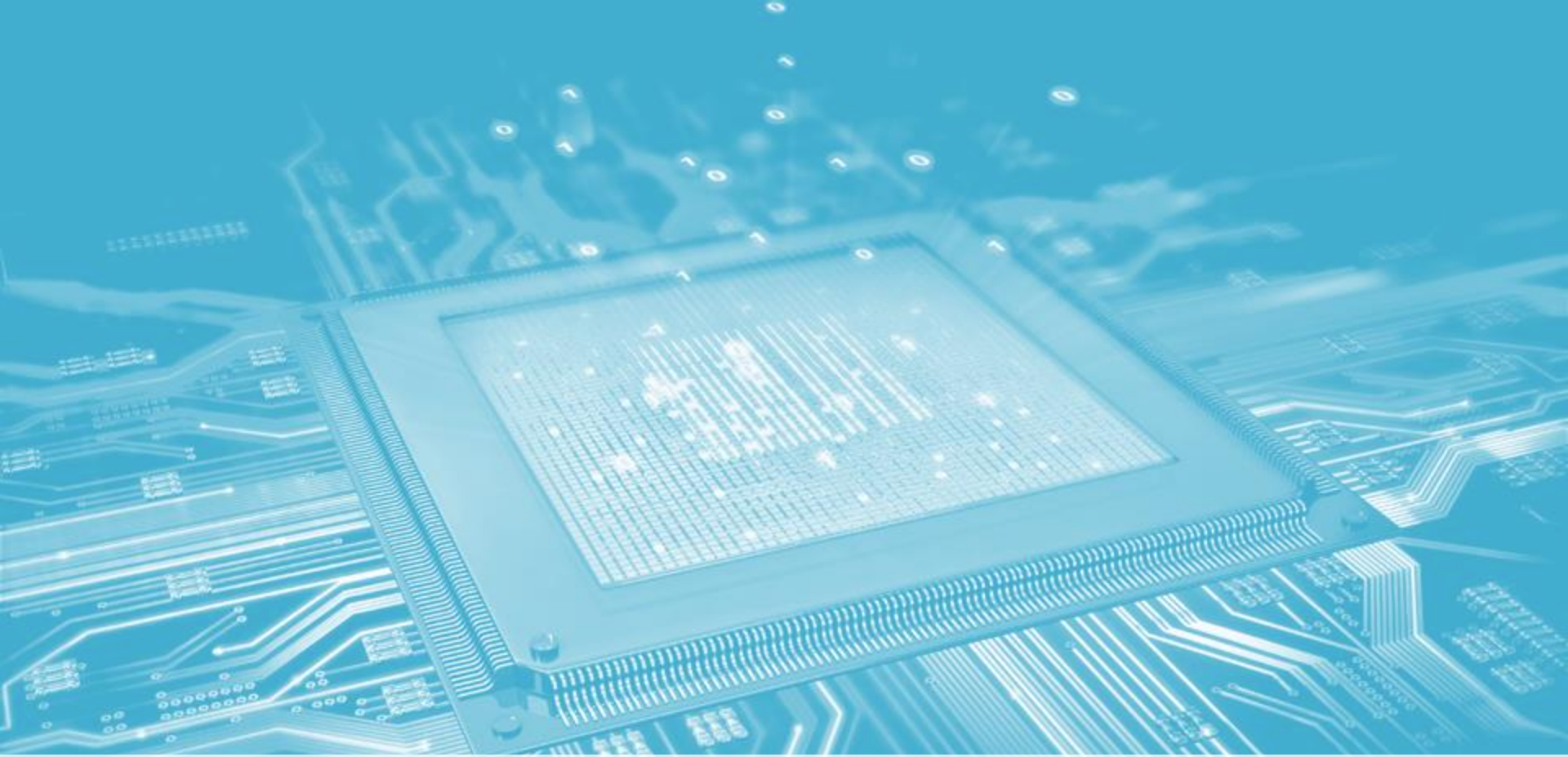
Oversubscription = 4:1		
Uplinks (40/100G module):	4x 100G	10x 100G
Downlinks (10/25G modules):	144x 10G	144x 25G

Oversubscription: 20:1		
Uplinks (Supervisor or uplink module):	2x 10G	2x 25G
Downlinks (1G/mGIG module):	384x 1G	384x 2.5G

UADP ASIC

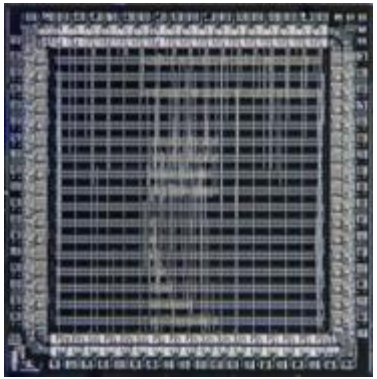
You make networking **possible**

Cisco live!

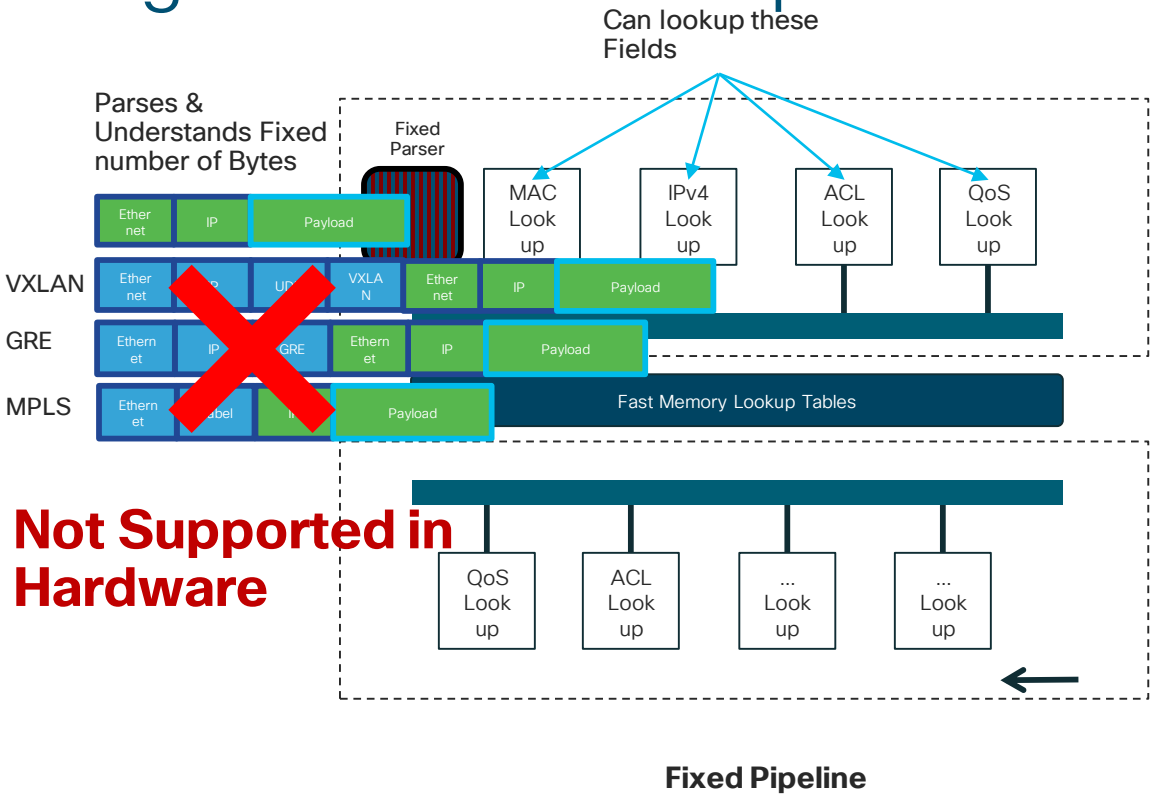


ASICs are a Pillar of Cisco Innovation…

Traditional Networking ASICs - Fixed Pipelines

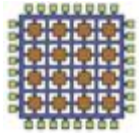


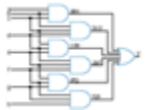
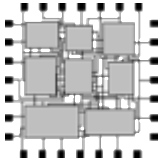
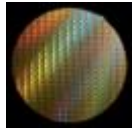
Traditional ASIC



Fixed Pipeline

New ASICs for New Technology ?

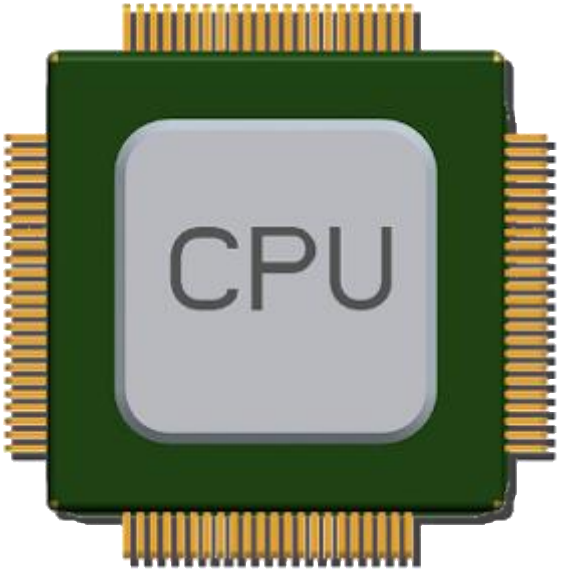

Marketing Requirements | Architecture | RTL Design | Synthesis | Floor Planning | Fabrication

2 – 4 Years

Building a new ASIC takes a lot of time & money

How about CPUs ?

CPUs are highly Programmable

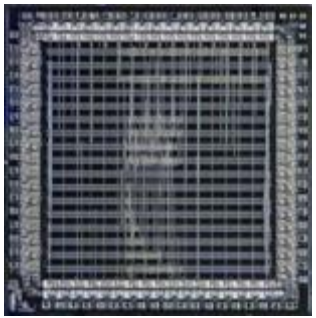


CPUs are not as fast

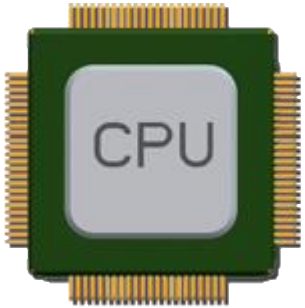
Traditional Networking ASICs vs CPUs

Performance

Flexibility



Traditional Networking ASIC



General Purpose CPU

Performance

Flexibility

Purpose Built – High Performance

General Purpose – Highly Flexible

Cisco Innovation – UADP ASIC

In 2013 Cisco Introduced UADP

(Unified Access Data Plane)

- Performance
- Flexibility
- Programmability

UADP brings Flexibility without compromise on Performance

UADP 1.x

UADP 1.0
1.6 Billion
Transistors

UADP 1.1
3.2 Billion
Transistors

Catalyst 3850
Copper

Catalyst 3650

Catalyst SFP Fiber

Catalyst
3850
Multigigabit

Catalyst
3850 SFP+

Catalyst
3650
Mini

Catalyst
3650
Multigigabi
t

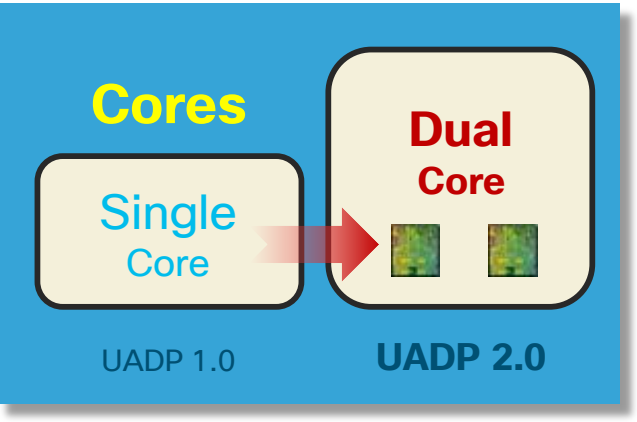
UADP 2.0

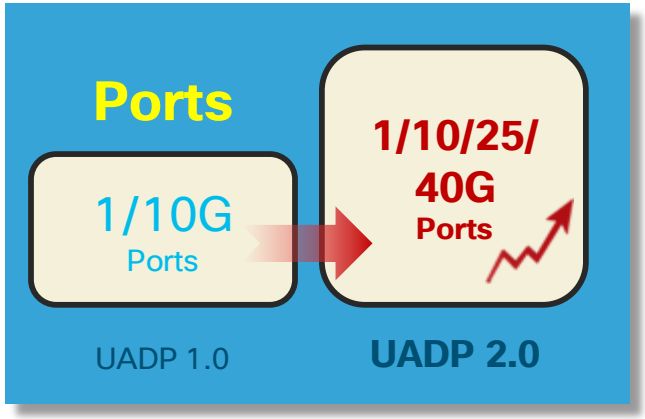
7.46B Transistors

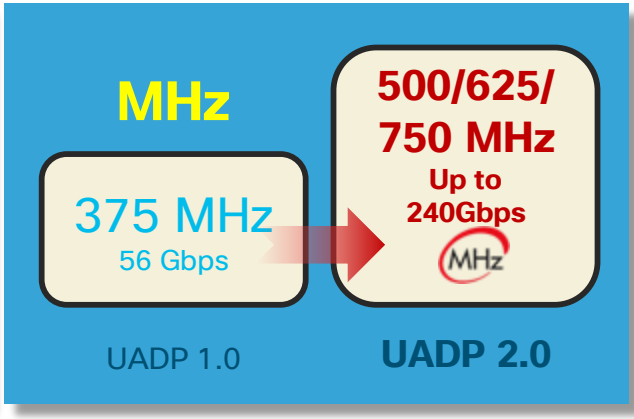
28nm Technology

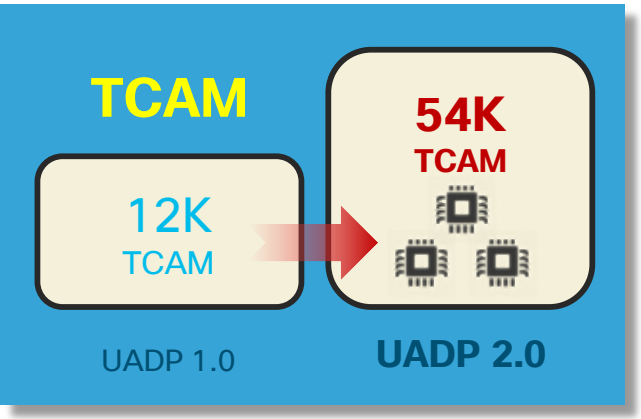
Catalyst 9K Family

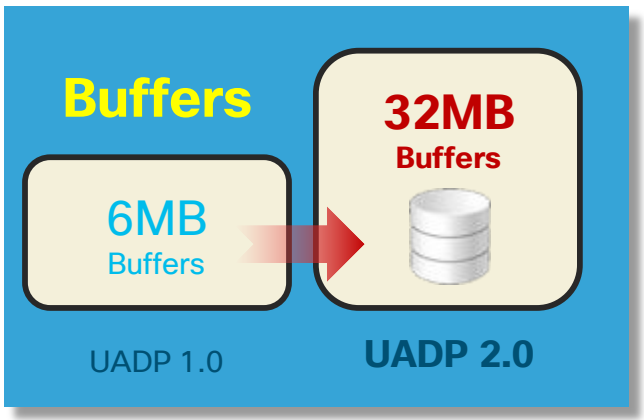
UADP Evolution – 1.0 vs 2.0

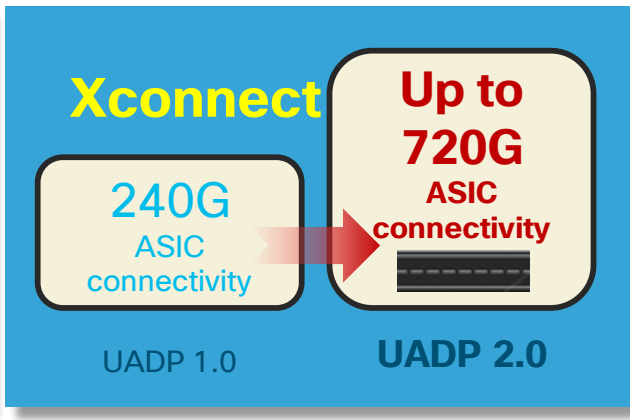












UADP 2.0 Family

	UADP 2.0 mini	UADP 2.0	UADP 2.0 XL
Total Bandwidth	Up to 100G	Up to 160G	Up to 240G
Frequency	500 MHz	500 MHz	625, 750 MHz
Table Sizes	Mini	Standard	XL Tables
TCAM Entries	5K	20K	54K
Buffers	6MB	16MB	32 MB
Stack Bandwidth	160G	240G	720G
Stack Ring	1	1	2

UADP 2.0 Mini
Architectural simplicity with powerful innovations

Investment Protection
Flexible Pipeline

Enhanced Scale/Buffering

100GE
Bandwidth

6MB
Packet Buffer

1/2.5/5/10/40G
Supports Different Speeds

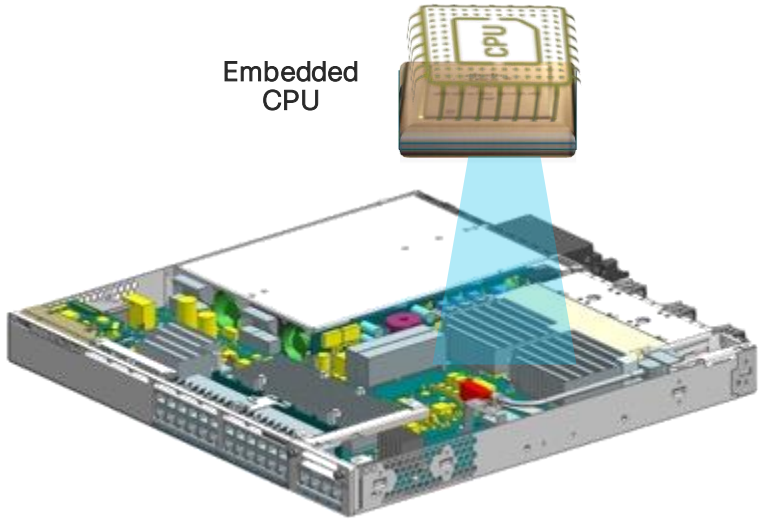
16K
Netflow Records

Flexible
Programmable Modules

SDM Templates
Flexibility

160/80G
Stacking Capacity

Up to 2X to 4X
forwarding + TCAM



Catalyst 9200

UADP 3.0

~20B transistors
16-nm technology

- Customizable ASIC templates
- 36-MB unified buffer
- Double-width tables
- 3x more FIB scale
- Up to 1.6 TB bandwidth
- 1G, 10G, 20G, 25G, 40G, and 100G speeds

Catalyst 9500 High Performance and Catalyst 9600

UADP evolution
UADP 2.0 vs. 3.0 per-ASIC capabilities

Throughput

UADP 2.0	UADP 3.0
Up to **240 Gbps** 500, 625, 750 MHz	Up to **1.6 Tbps** 750, 875 MHz, 1 GHz

Ports

UADP 2.0	UADP 3.0
1, 10, 25, 40G Ports	1, 10, 25, 40, 100G Ports

Forwarding

UADP 2.0	UADP 3.0
375 Mpps	1000 Mpps

Buffers

UADP 2.0	UADP 3.0
32 MB Shared buffers: 16 MB, 16 MB	36 MB Unified buffers: 36 MB

Backplane

UADP 2.0	UADP 3.0
720G (36x 15G) Stack interconnect	1600G (32x 28G) ASIC interconnect

UADP ASIC 2.0 and 3.0 comparison

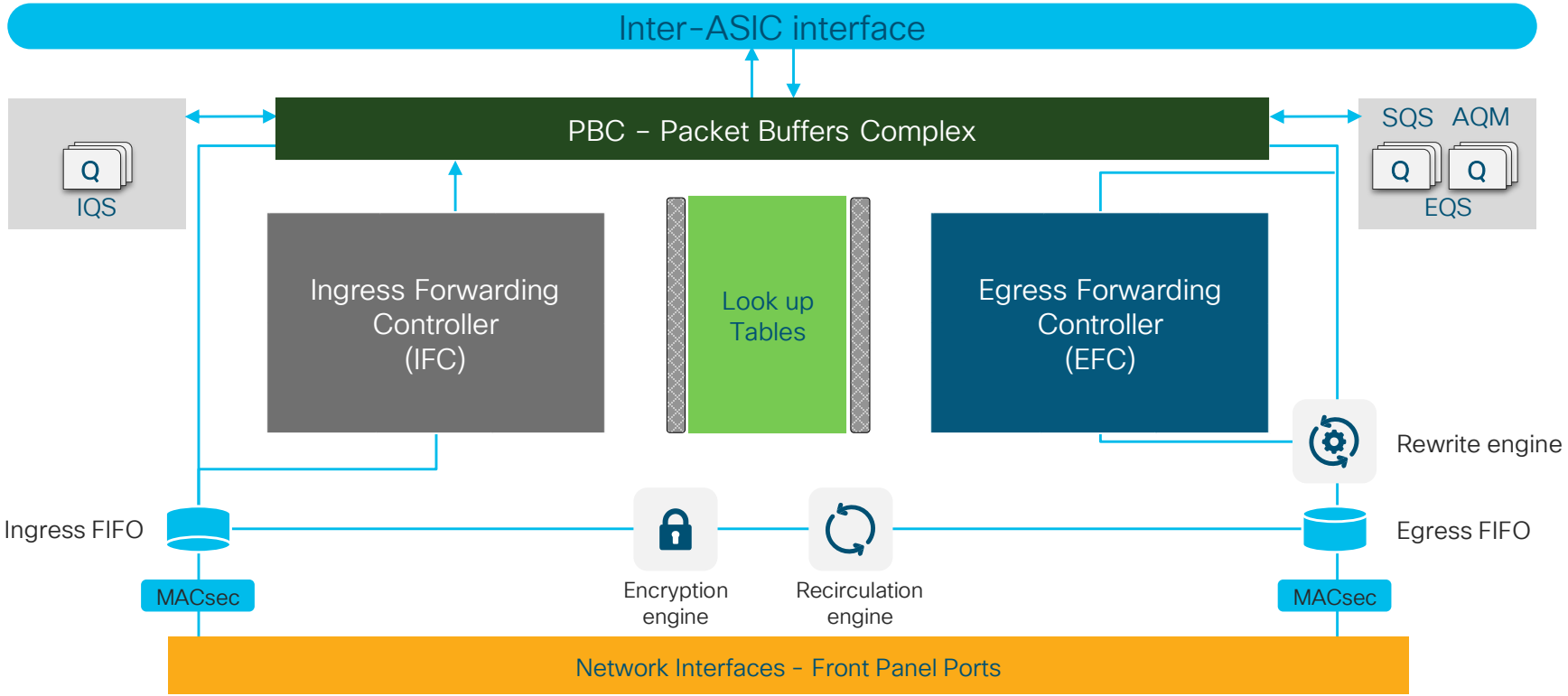
Capabilities (per ASIC)	UADP 2.0 XL	UADP 3.0
Switching and forwarding capacity	240 Gbps/360 Mpps	1.6 Tbps/1 Bpps
Stack bandwidth	Upto 2x 360 Gbps	Upto 2x 800 Gbps
Buffer capability	2x 16 MB	36 MB shared buffer
Switch Database Management (SDM) template	Fixed templates	Customizable templates
NetFlow capabilities	Dedicated NetFlow table	Shared NetFlow table
v4 FIB scale	Total 228,000*	Total 412,000*
v4 and v6 scale	**v6 reduced by half**	**v4 and v6 same scale**

* Maximum ASIC Capability

UADP ASIC Core

ASIC Family	Core
UADP 2.0 mini	Single
UADP 2.0/2.0XL	Dual
UADP 3.0	Dual

UADP Core Architecture



Some of the Key Capabilities of UADP ASIC

Flex Parser & Programmable Pipelines

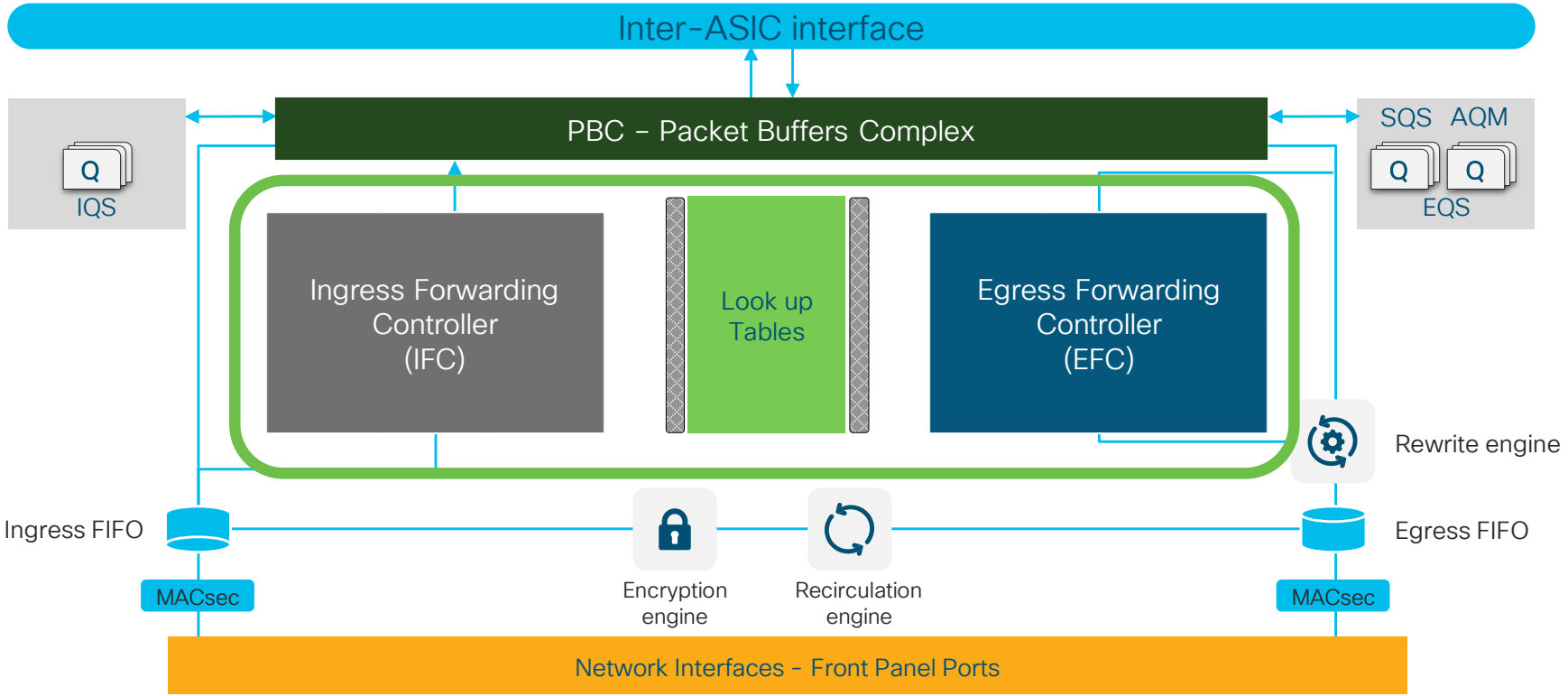
Recirculation Capability

Micro Engines

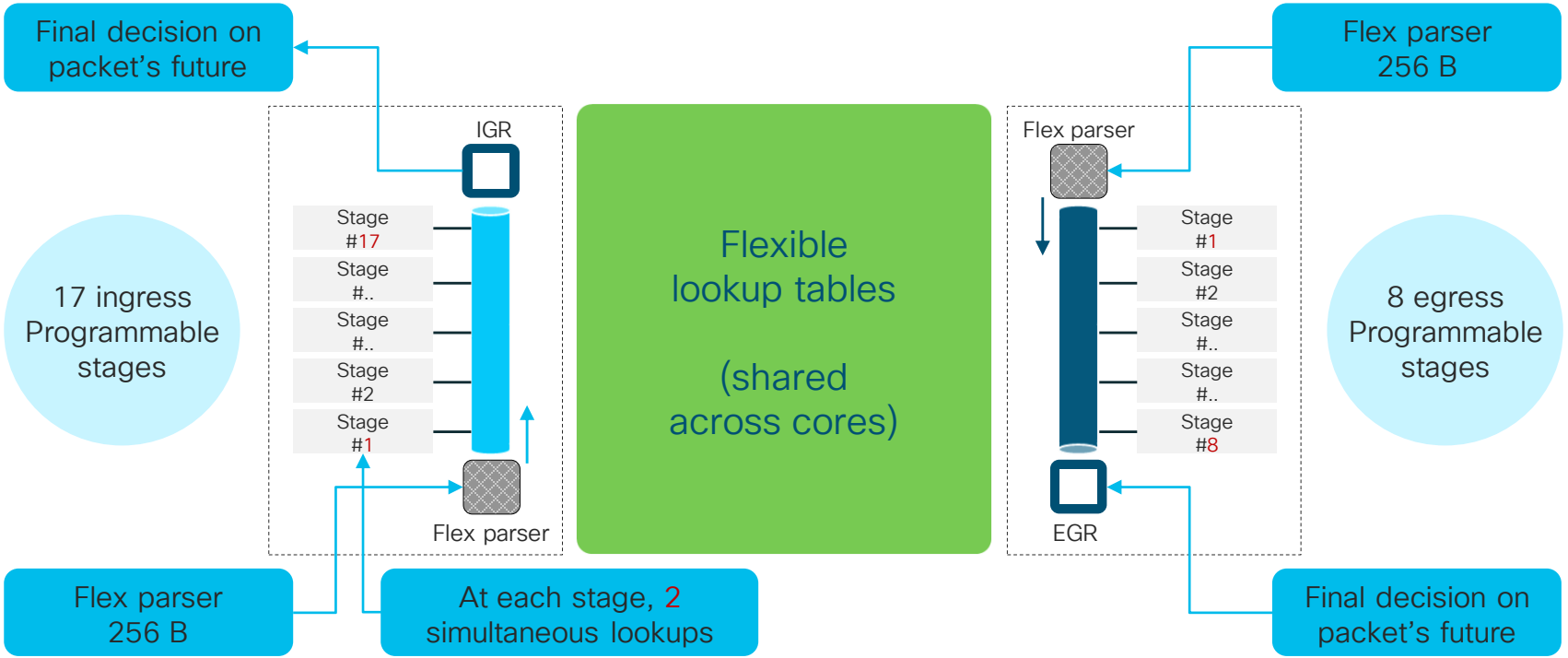
Adaptable Tables

No Compromise on Performance

UADP – Programmable Pipeline



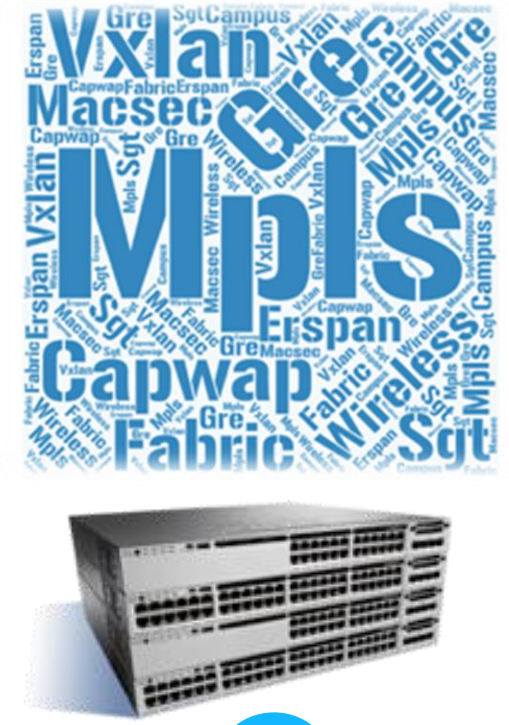
Programmable Pipelines – Closer Look



Proven Investment Protection with UADP 1.0

2013

2015



2017

UADP 2.0 extends it to the Catalyst 9K Family

Some of the Key Capabilities of UADP ASIC

Flex Parser & Programmable Pipelines

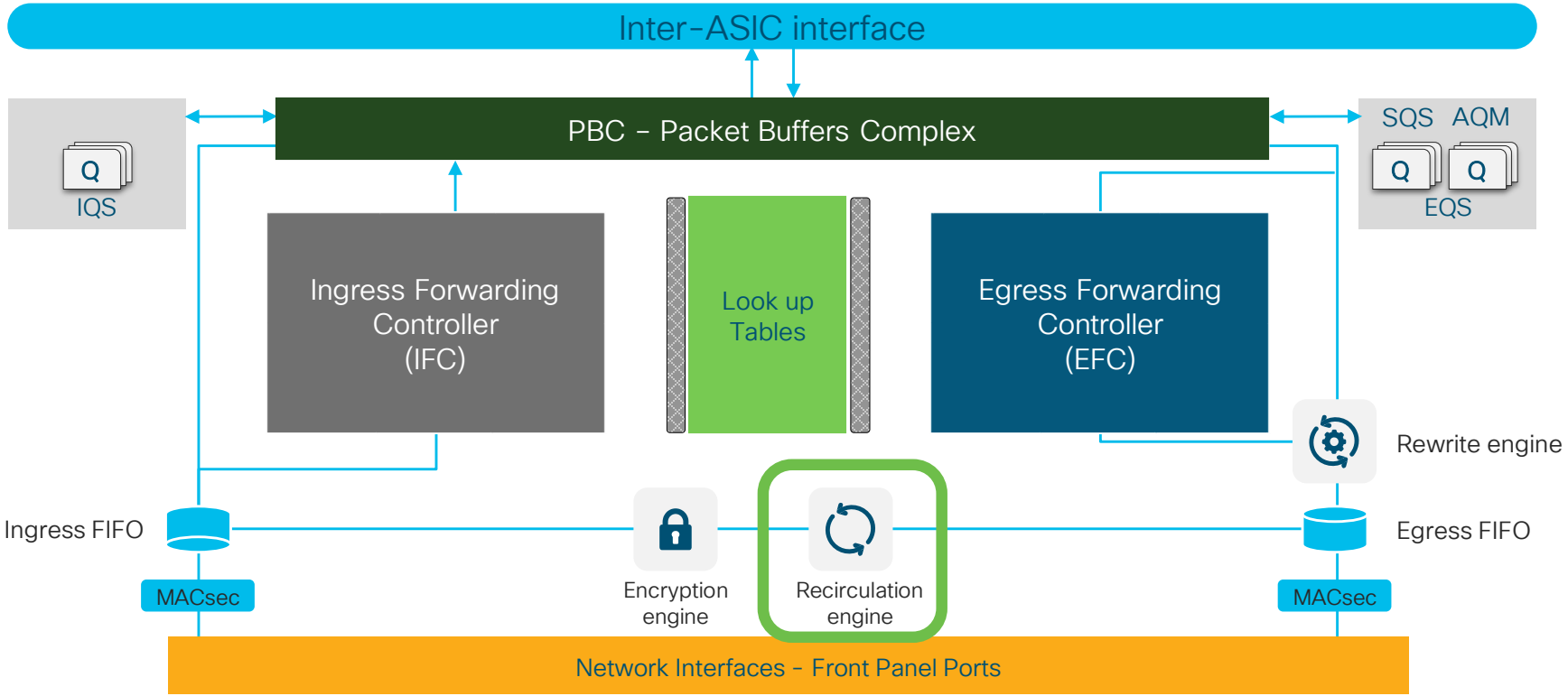
Recirculation Capability

Micro Engines

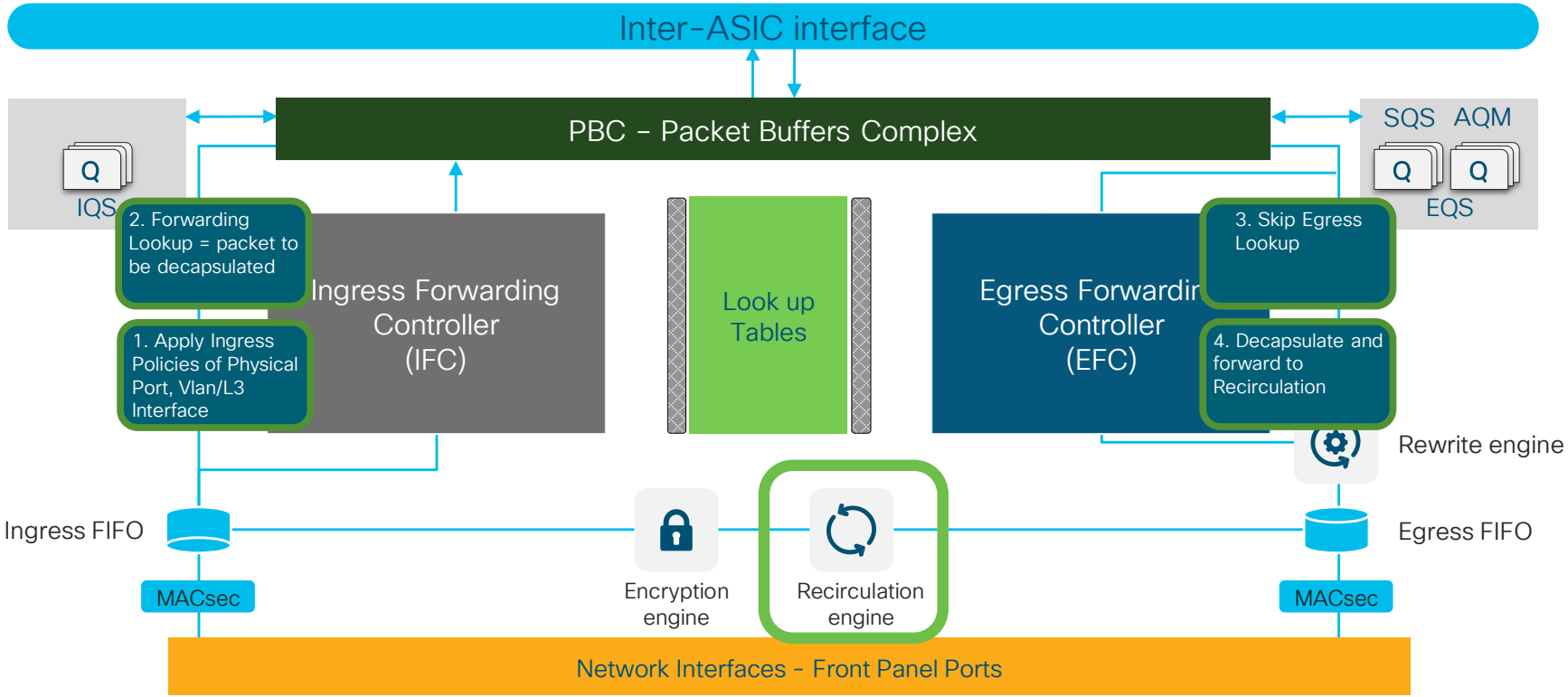
Adaptable Tables

No Compromise on Performance

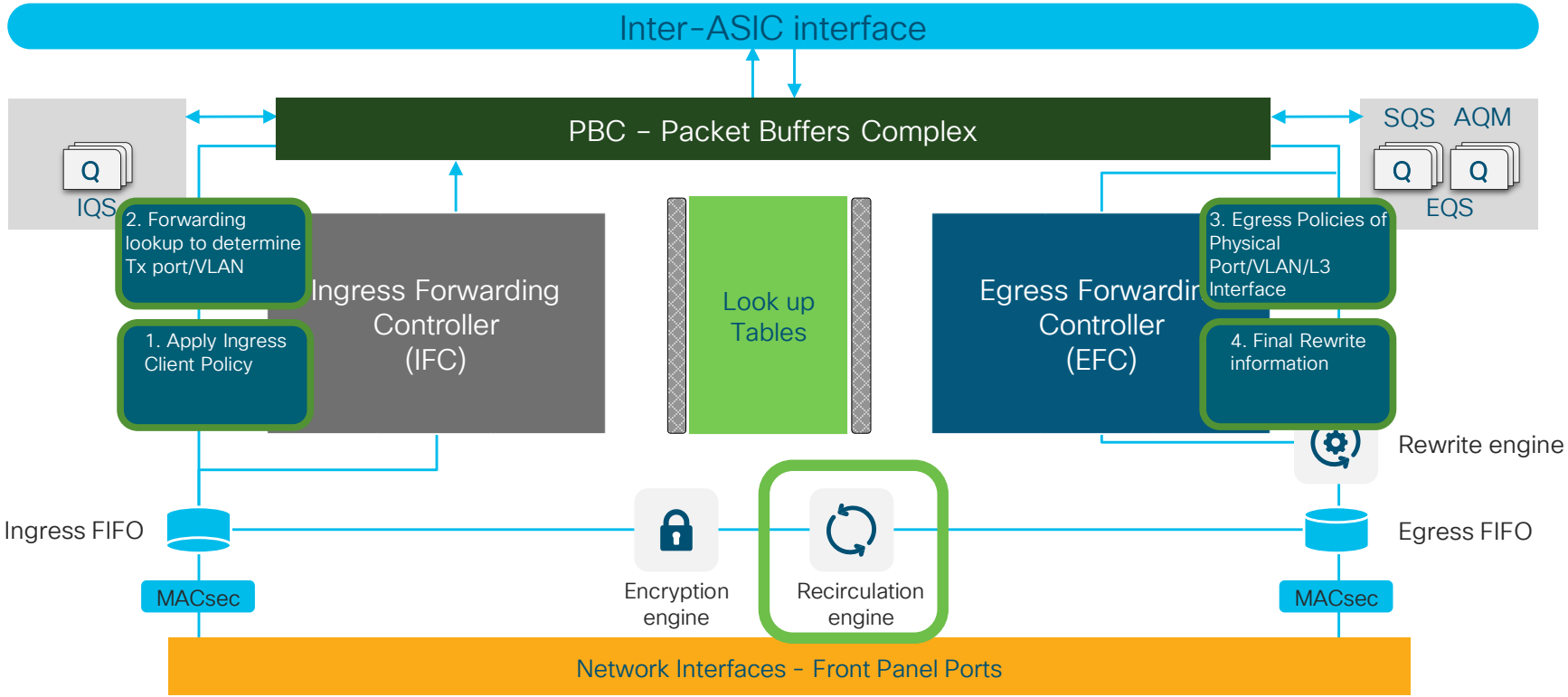
UADP – Recirculation Engine



UADP – Recirculation First Pass



UADP – Recirculation Second Pass



Some of the Key Capabilities of UADP ASIC

Flex Parser
&
Programmable
Pipelines

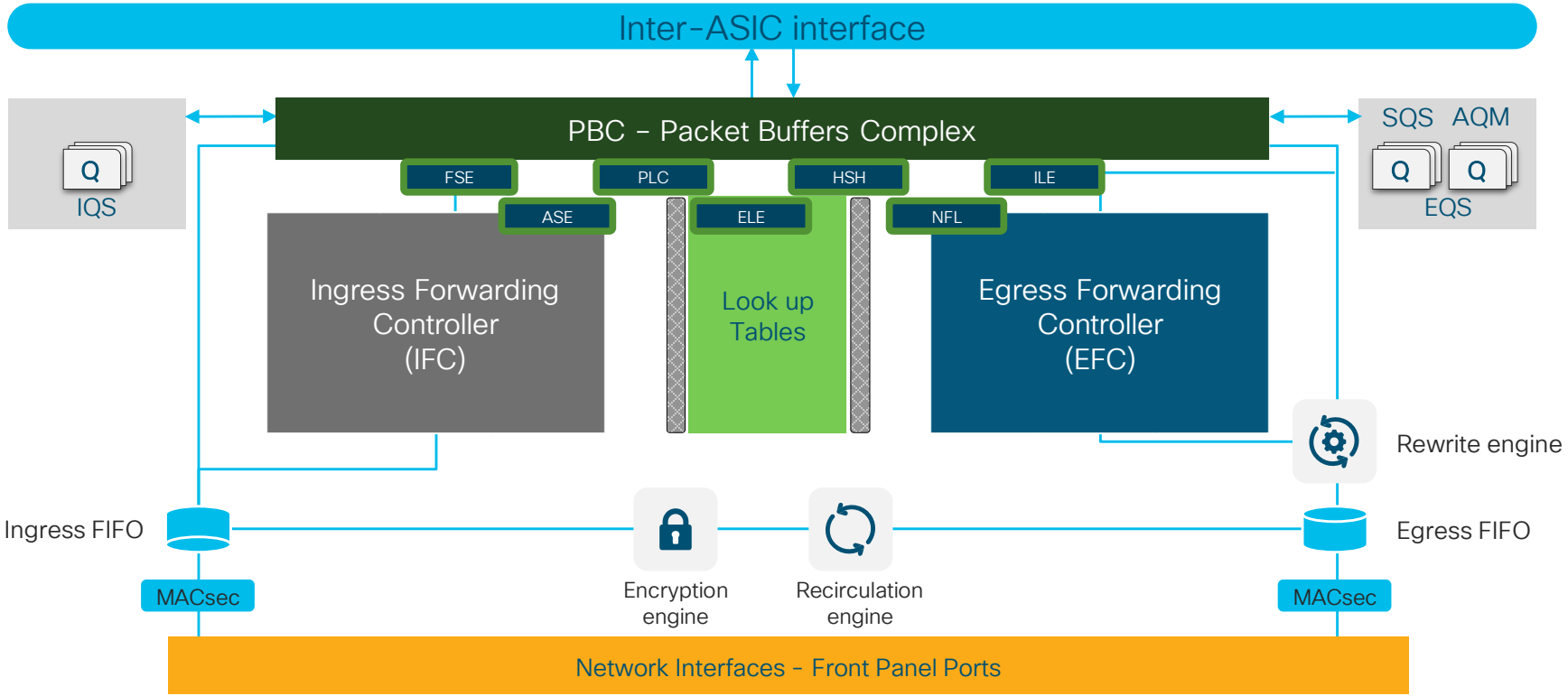
Recirculation
Capability

Micro Engines

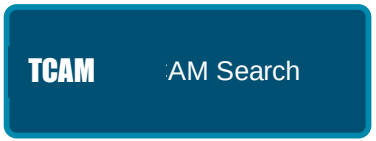
Adaptable Tables

No Compromise on Performance

UADP – Micro Engines



Integrated & Micro Engines can help with …



Some of the Key Capabilities of UADP ASIC

Flex Parser & Programmable Pipelines

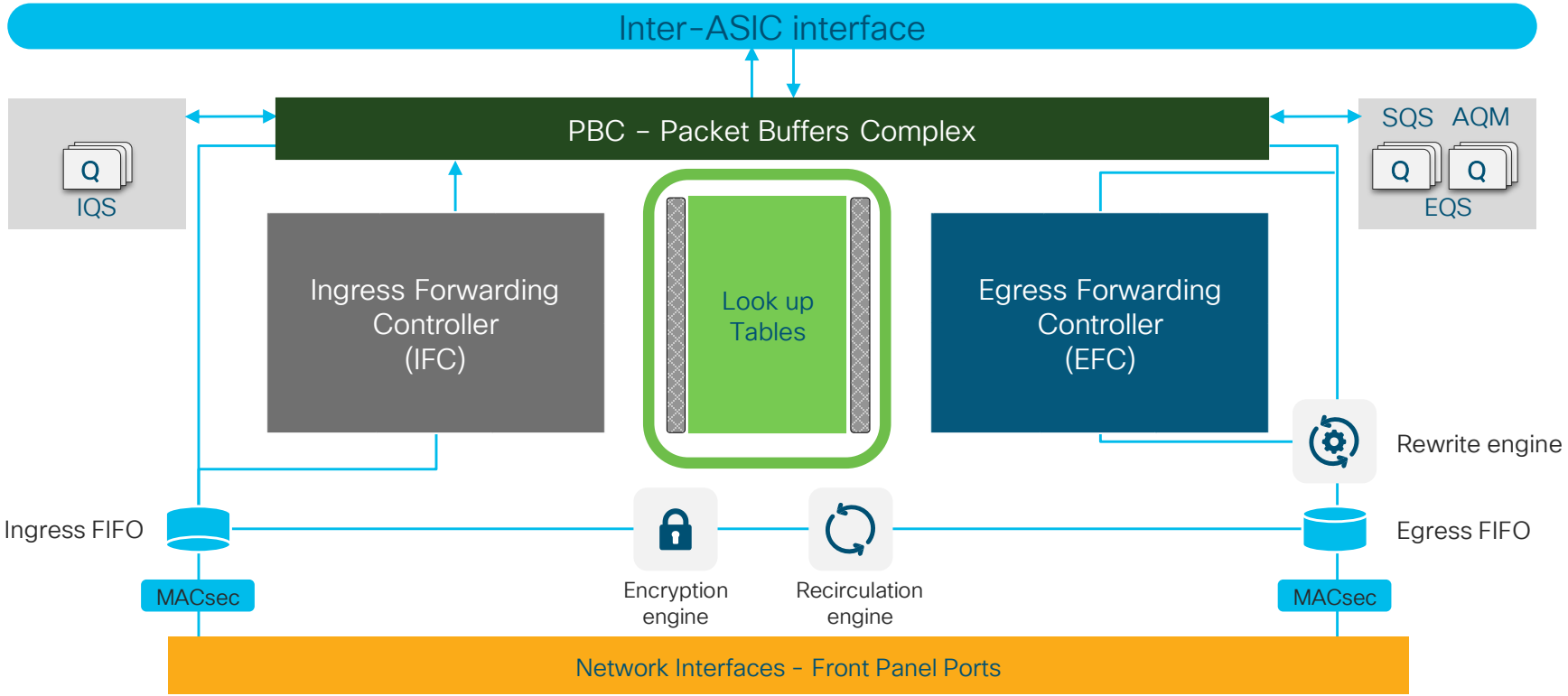
Recirculation Capability

Micro Engines

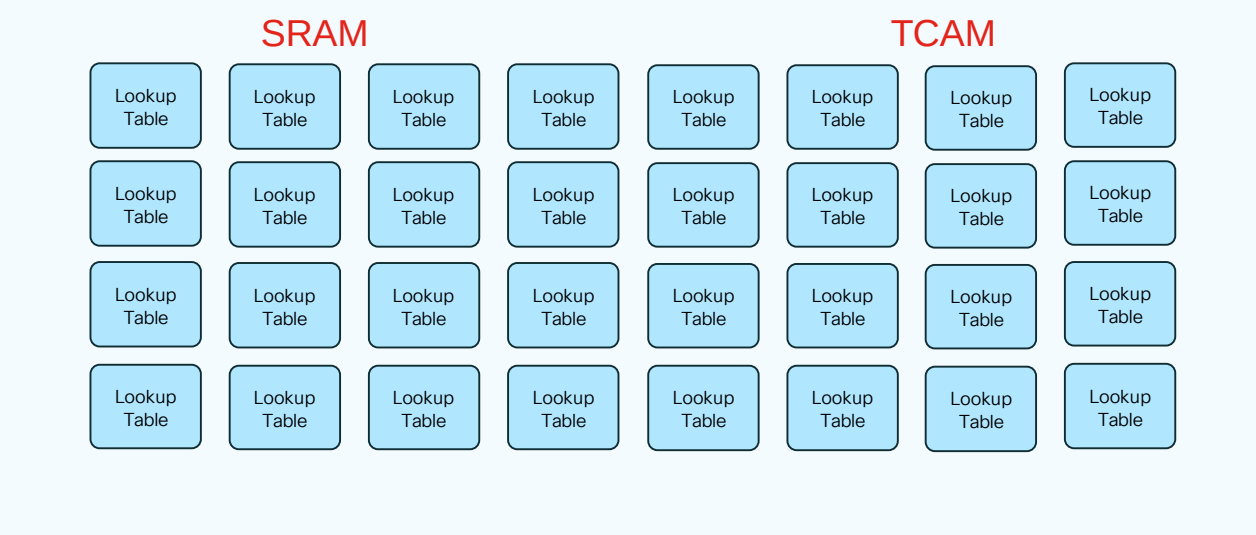
Adaptable Tables

No Compromise on Performance

UADP – Lookup Tables



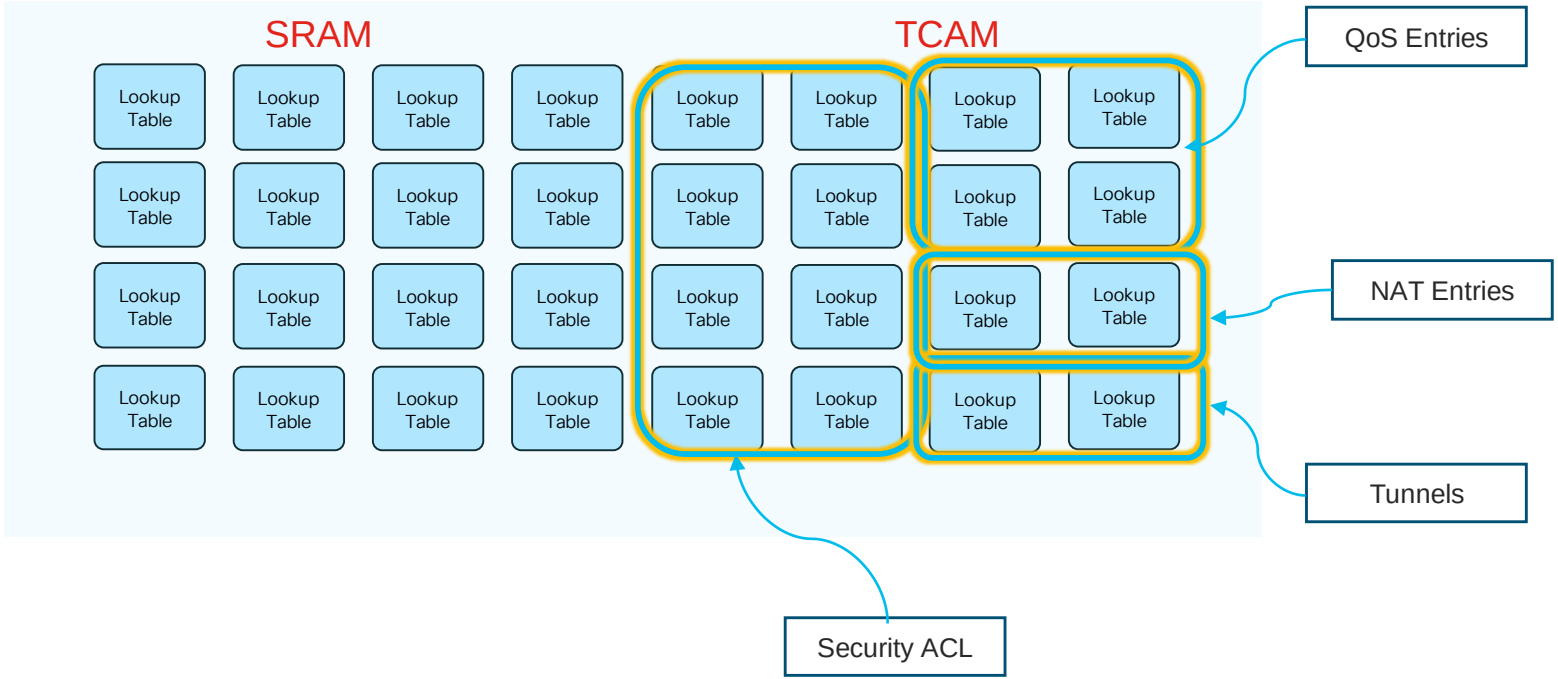
Flex Tables



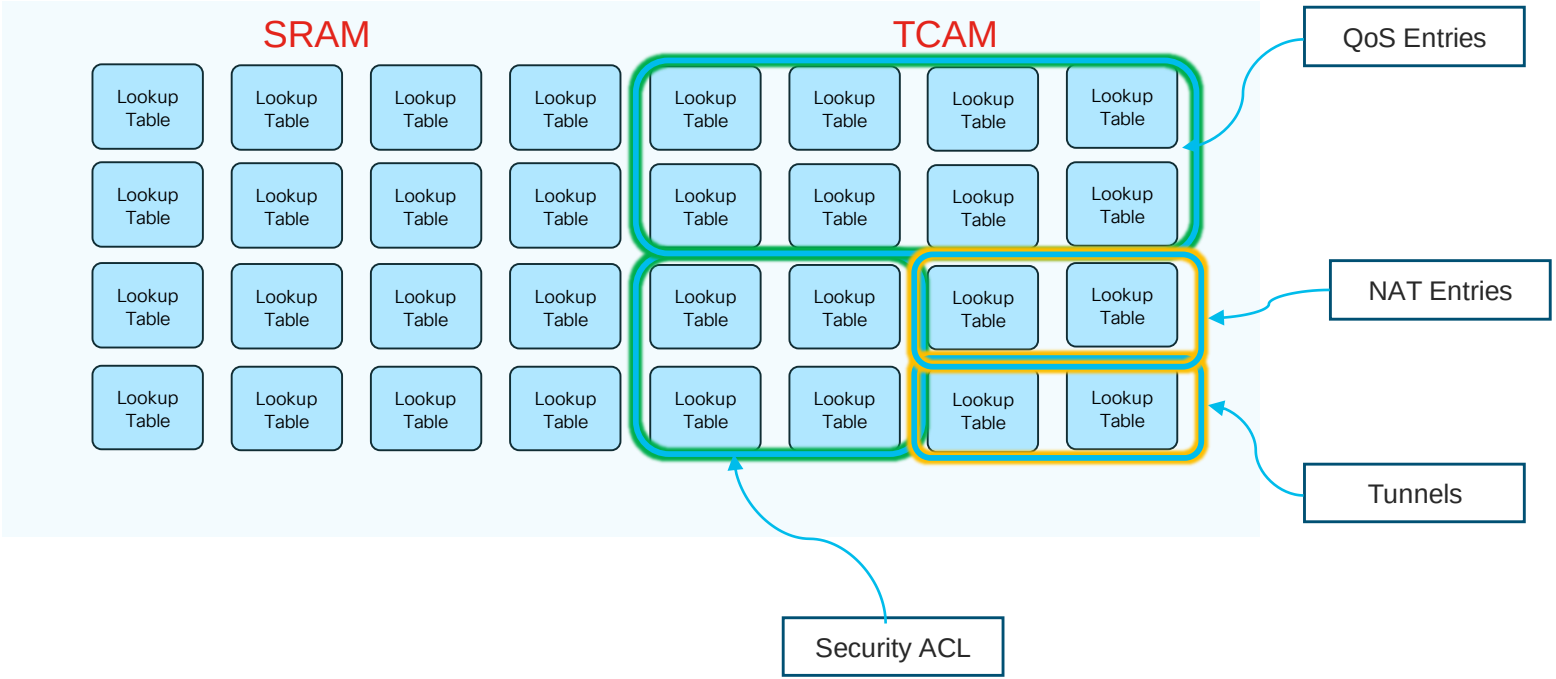
Pool of Lookup Tables

Flexible Tables consists of different types of TCAM & SRAM

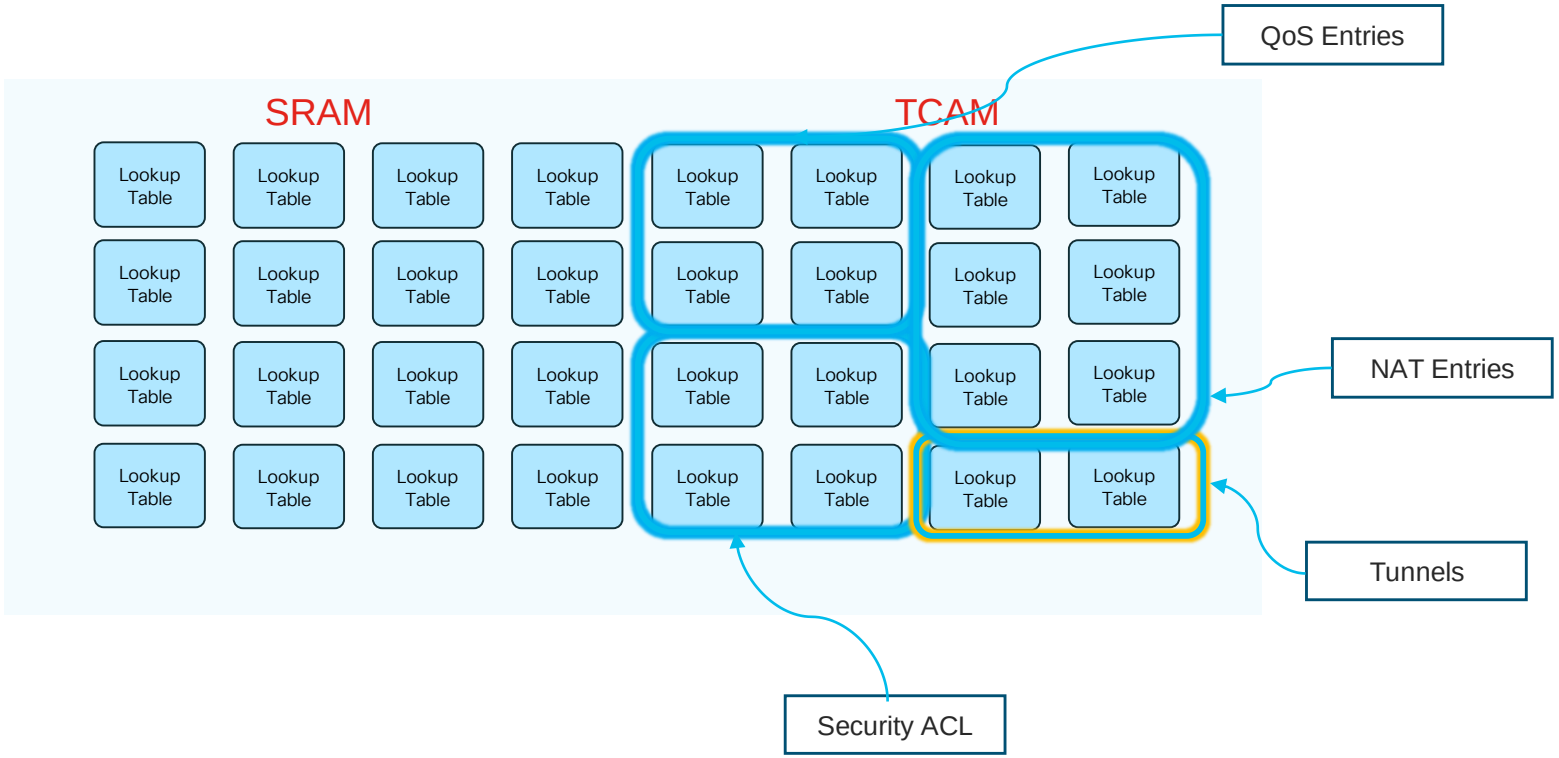
Flex Tables - Example



Flex Tables - Example



Flex Tables - Example



Catalyst 9K

Sample Profiles

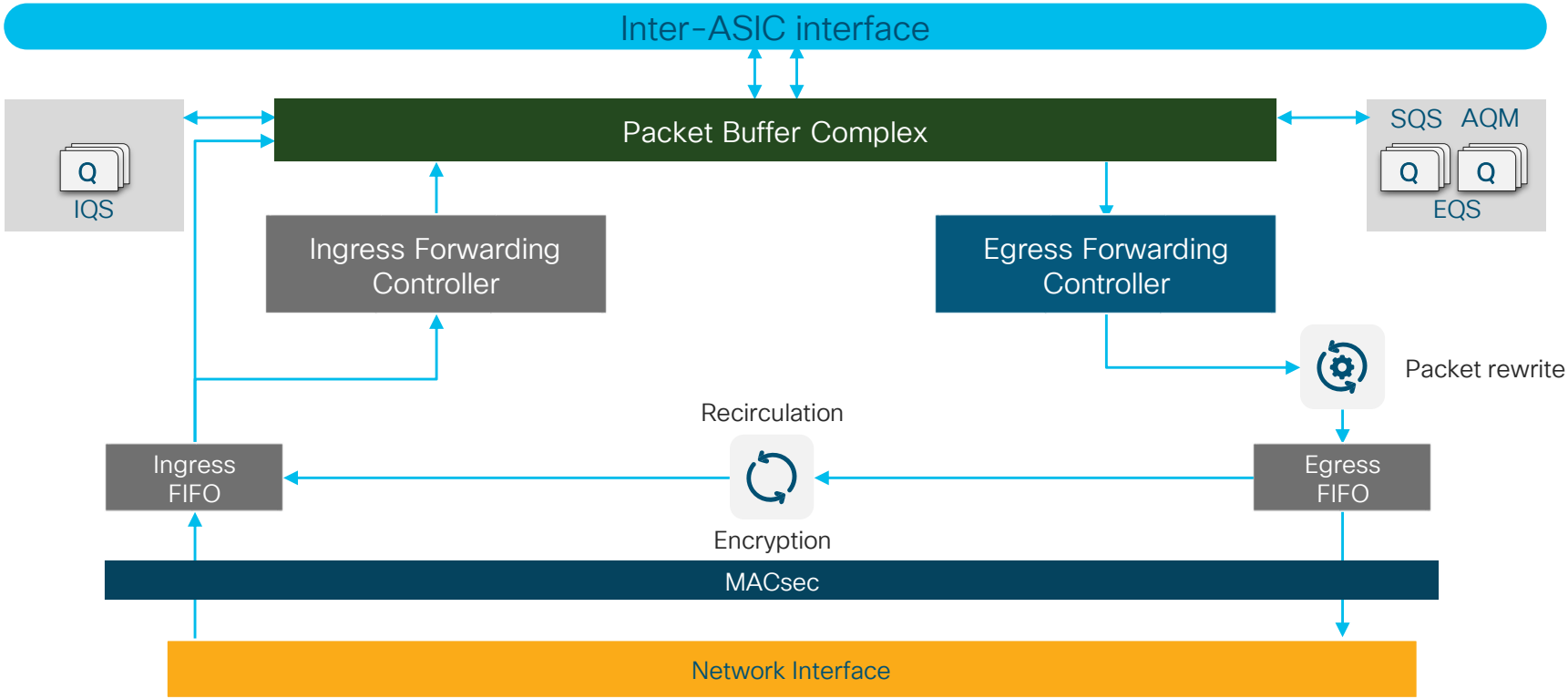
Scale Profile	Aggregation Profile Mix of L2/L3 Capabilities	NAT Profile Network Address Translation	Border Profile Cross Domain Policy
IPv4 / IPv6 LPM	64K / 32K	64K / 32K	64K / 32K
IPv4 / IPv6 Host	48K / 24K	48K/ 24K	80K/ 40K
Multicast Route	16K (IPv4) 8K (IPv6)	32K (IPv4) 16K (IPv6)	16K (IPv4) 8K (IPv6)
IGMP/MLD Snooping	16K	16K	16K
MAC Address	64K	16K	16K
SGT Label	8K	8K	8K
Netflow	128K/ASIC	128K/ASIC	128K/ASIC
Security ACL	18K	18K	4K
QoS ACL	18K	3K	16K
Service ACL- PBR / NAT	2K	16K	16K

Packet walks

You make networking **possible**

Cisco live!

UADP block diagram

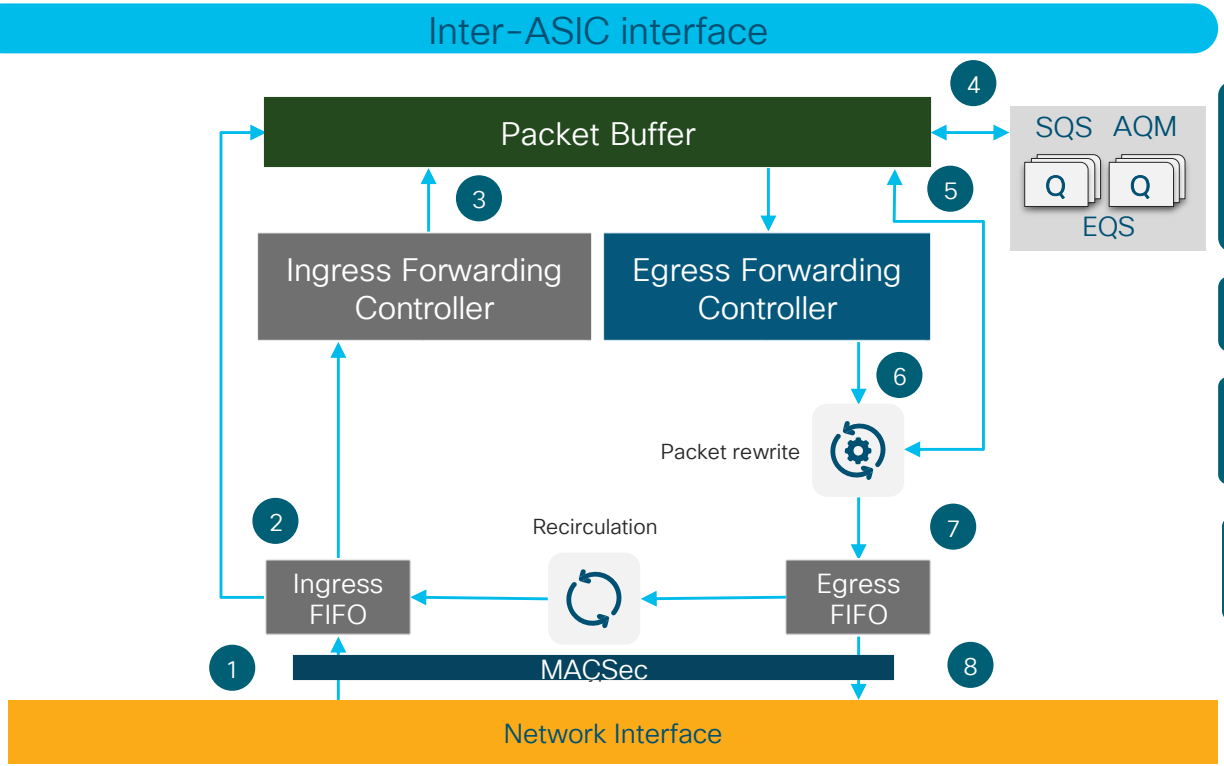


Abbreviations used

IFC	Ingress Forwarding Controller
PBC	Packet Buffer Complex
IQS	Ingress Queues
EFC	egress Forwarding Controller
EQS	Egress Queueing and scheduling
AQM	Active Queue Management

Unicast: Within the ASIC

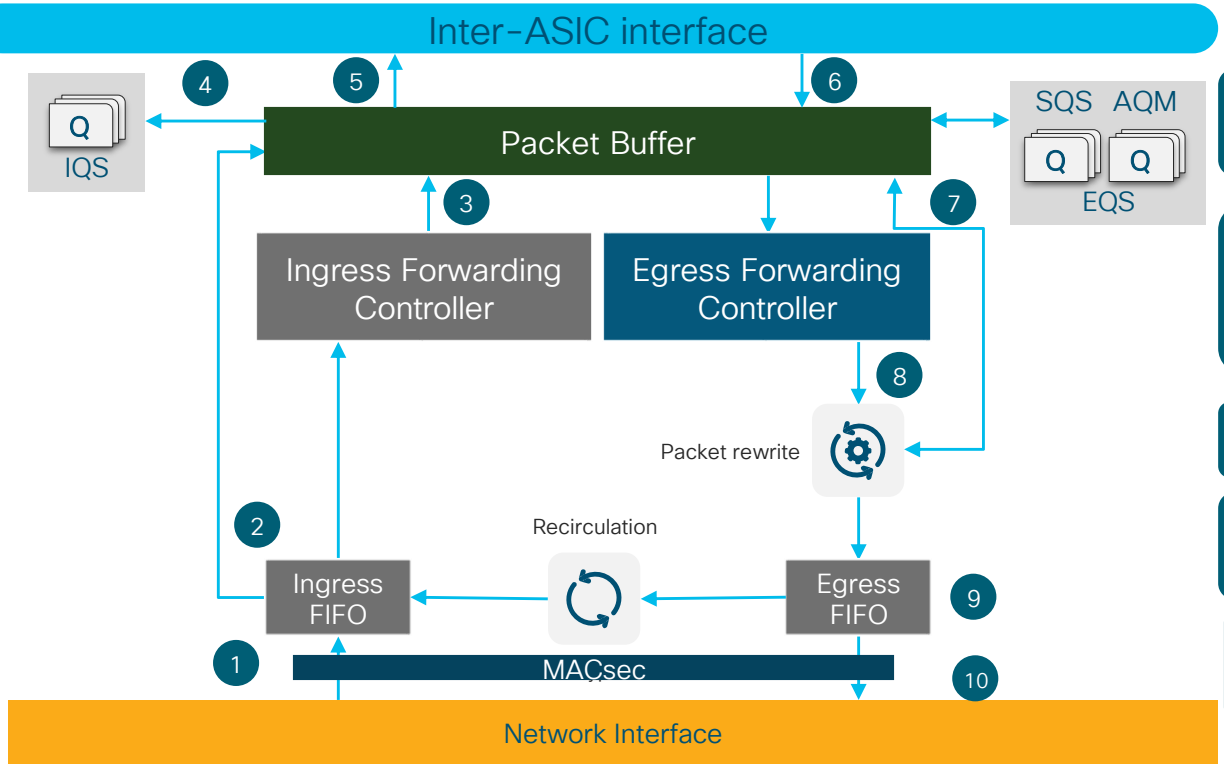
1. Received, processed by MACSec if needed and into FIFO
2. A copy to buffer, a copy to IFC
3. Goes through IFC, result descriptor send to PBC
4. Descriptor has local destination, PBC sends the info to EQS



5. EQS schedule PBC to send a copy to EFC and a copy to ReWrite (includes descriptor)
6. EFC sends results to ReWrite
7. Rewrite the packet and send though the egress FIFO
8. Packet is encrypted by MACSec if needed

Unicast: Across ASICs/Stack Members

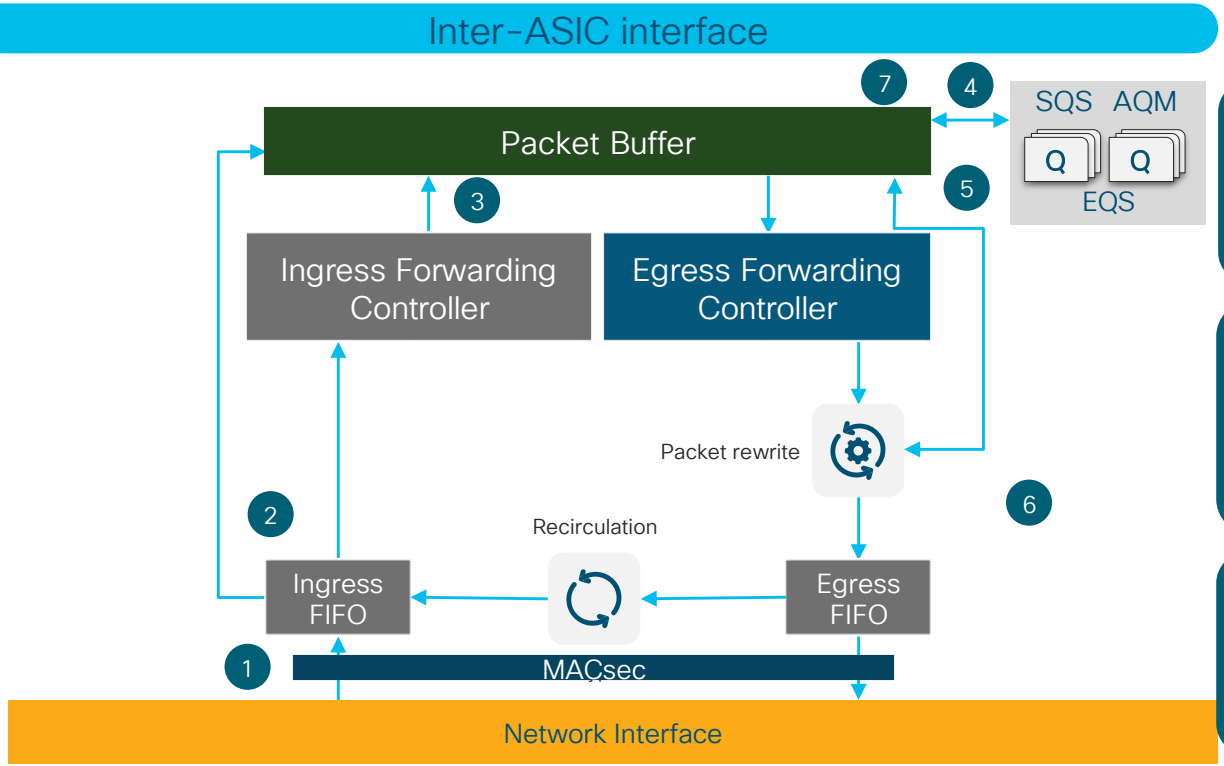
1. Received, processed by MACSEec if needed and into FIFO
2. A copy to buffer, a copy to IFC
3. Goes through IFC, result descriptor send to PBC
4. Descriptor has remote destination, PBC sends the info to IQS
5. IQS schedule PBC to send the packet with descriptor to Inter-ASIC Interface



6. PBC received the frame and sends the info to EQS
7. EQS schedule PBC to send a copy to EFC and a copy to ReWrite (includes descriptor)
8. EFC sends results to ReWrite
9. Rewrite the packet sent it to egress FIFO
10. Packet is encrypted by MACSec if needed

Multicast: Egress local

1. Received, processed by MACSec if needed and into FIFO
2. A copy to buffer, a copy to IFC
3. Goes through IFC, result descriptor send to PBC
4. Descriptor has local destination, PBC sends the info to EQS

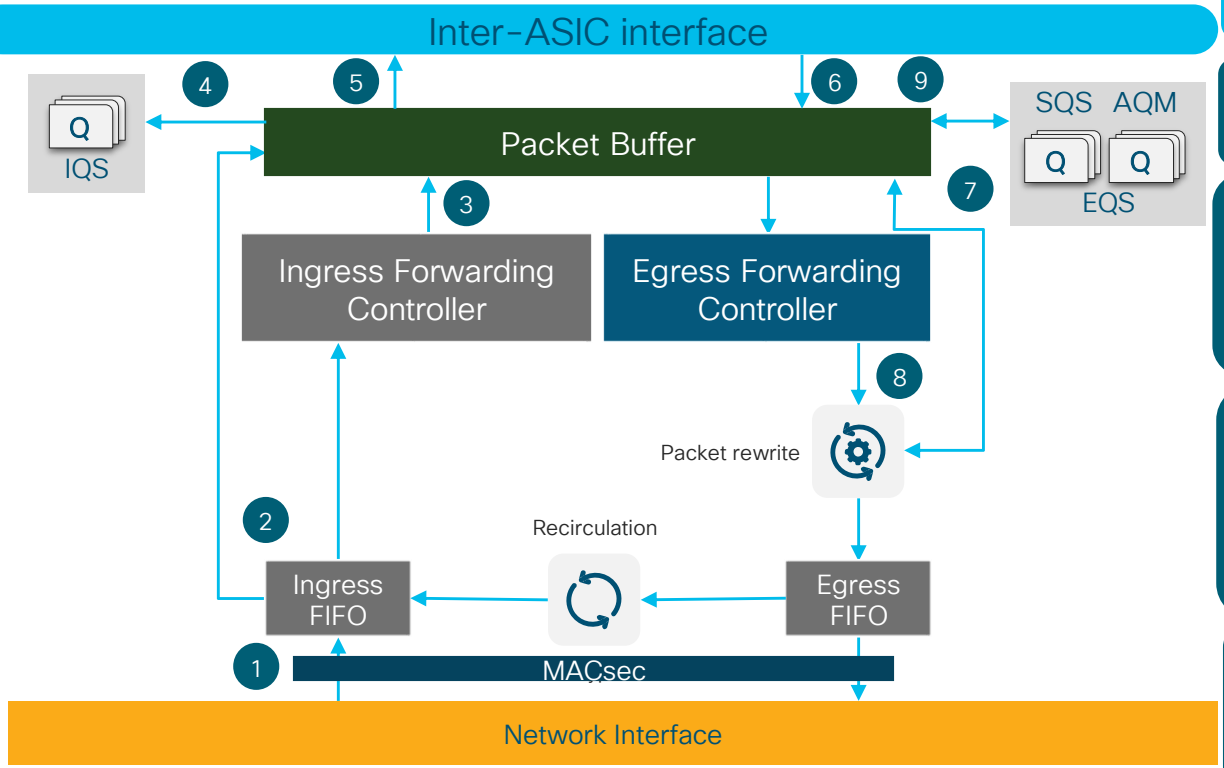


5. AQM within EQS generate the list of egress port based on descriptor, schedule for each egress port.
6. For each egress port, frame goes though the EFC, ReWrite, Egress FIFO, and encrypted by MACSec if needed
7. Once the replication for the last port is done, PBC remove the packet from the buffer

Multicast: Egress remote

1. Received, processed by MACSec if needed and into FIFO
2. A copy to buffer, a copy to IFC
3. Goes through IFC, result descriptor send to PBC
4. Descriptor has remote destination, PBC sends the info to IQS
5. IQS schedule PBC to send the packet with descriptor to Inter-ASIC Interface

Descriptor contains both local and remote destinations



Replication done on egress => Efficient use of BW

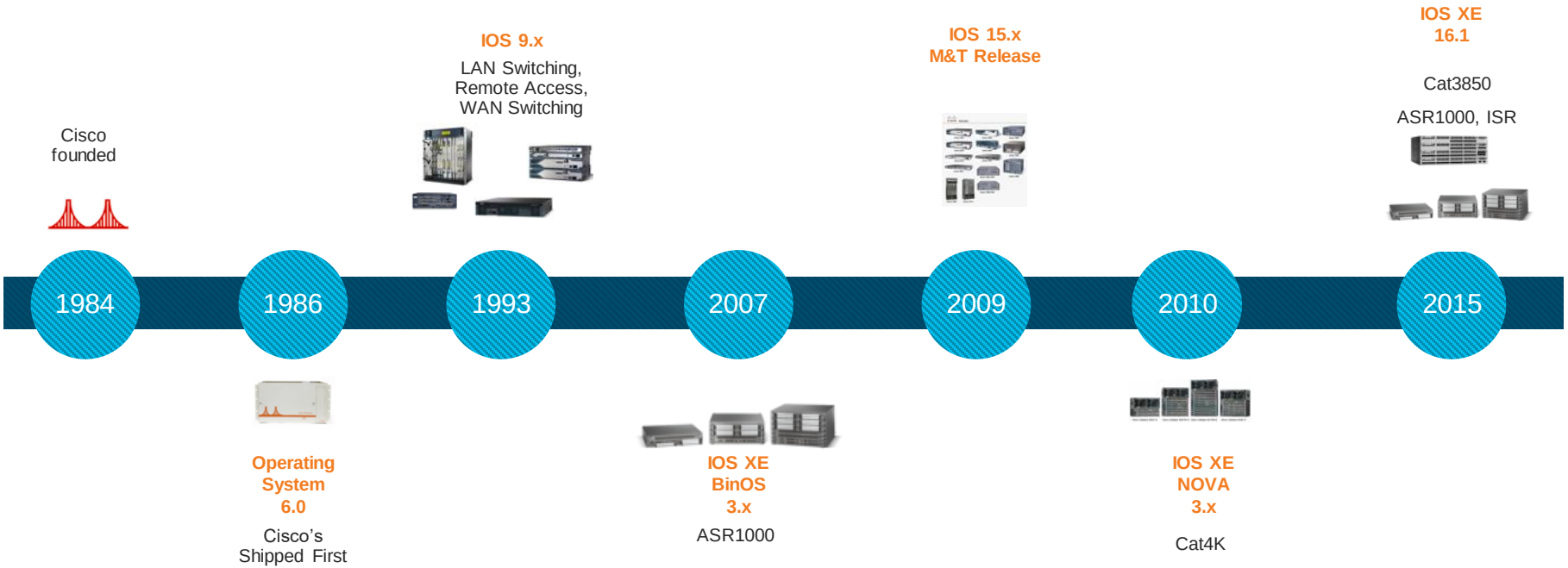
6. PBC received the frame and sends the info to EQS
7. AQM within EQS generate the list of egress port based on descriptor, schedule for each egress port.
8. For each egress port, frame goes though the EFC, ReWrite, Egress FIFO, and encrypted by MACSec if needed
9. Once the replication for the last port is done, PBC remove the packet from the buffer

Open IOS XE Software

You make networking **possible**

Cisco live!

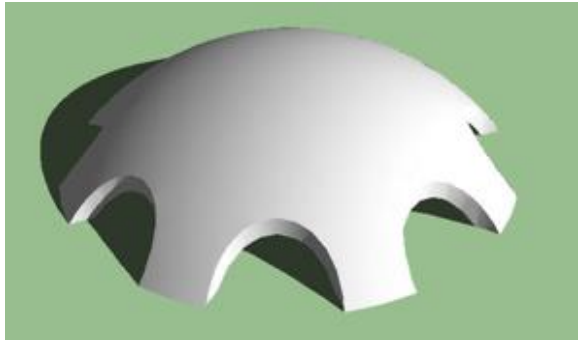
Historical View of Cisco IOS



Timeline unevenly distributed


Monolithic
Growing
All in One

Challenges with Classis IOS

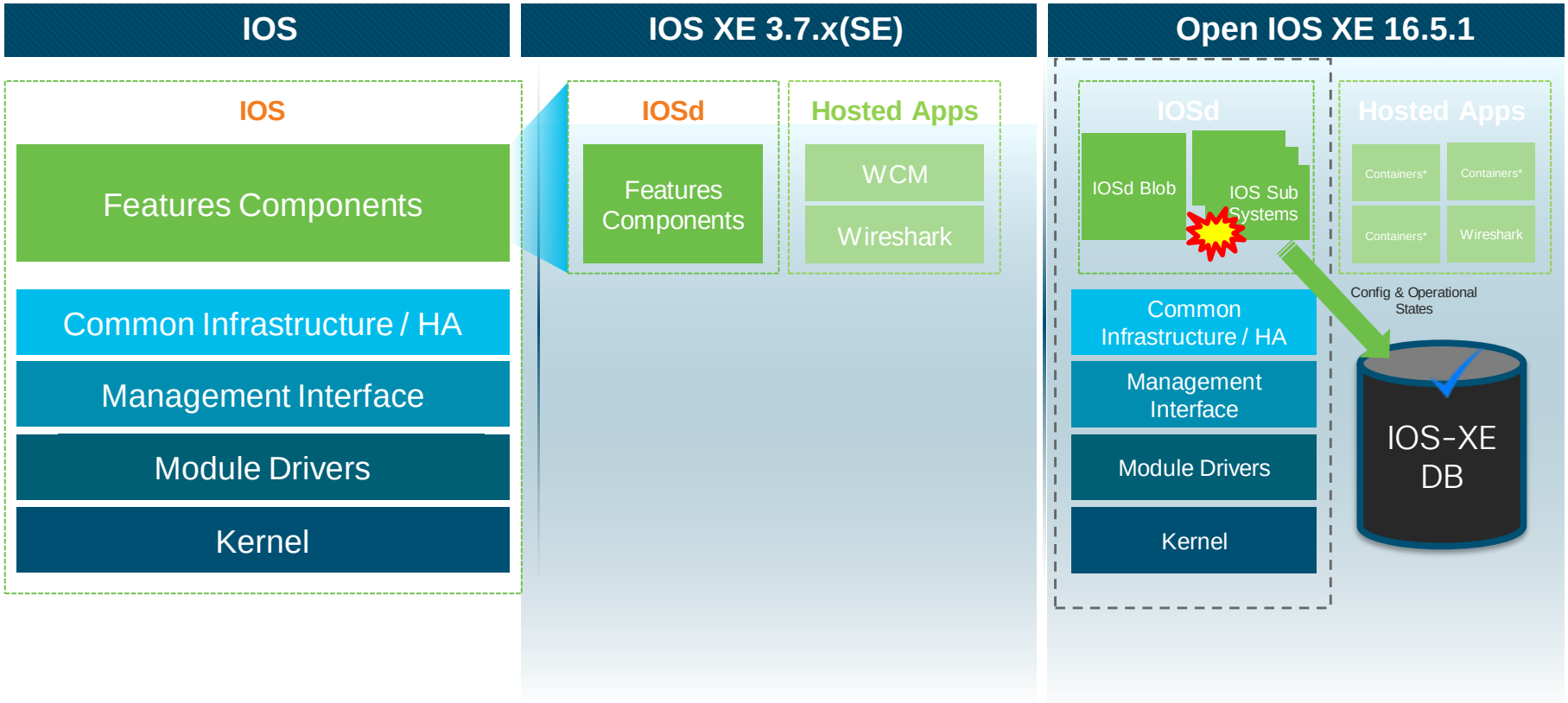


Monolithic
One Big Process
Process not independent of one another

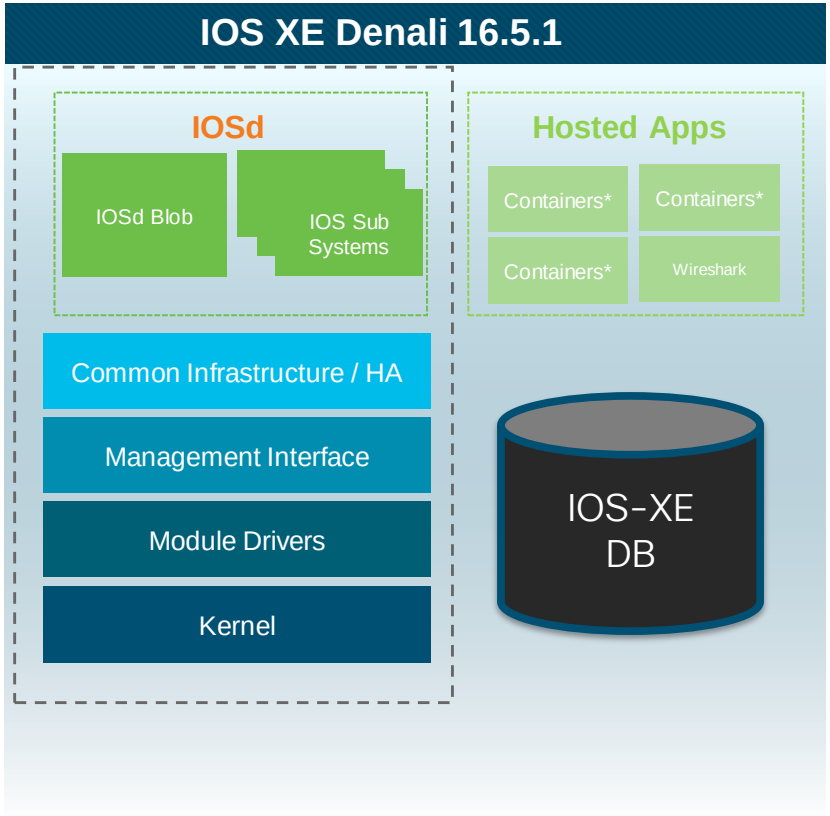
Unified control/data plane
Non Modular
No clean separation between path calc. and forwarding

Common Memory
Config/oper data centralized, not easily shared

Open IOS-XE



Open IOS XE – Key Architectural Enhancements

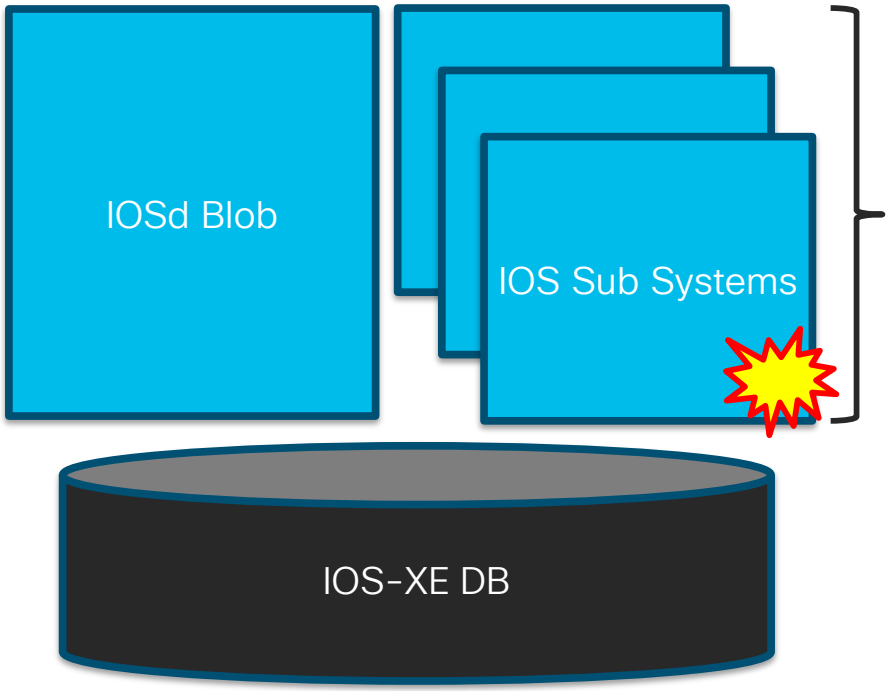


IOS Sub Systems

IOS XE Database
(Crimson Database)

LXCs Support

Open IOS XE – IOS Sub Systems



BGP

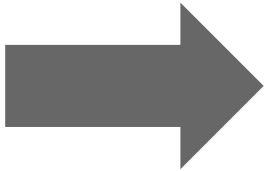
OSPF

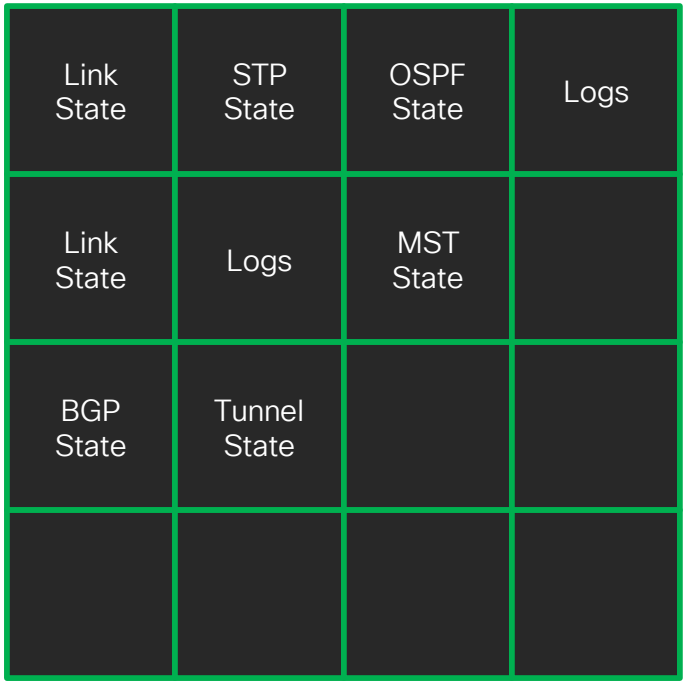
MPLS, etc

Failure of one of the Sub Systems Keeps Rest of the System intact

IOS Sub Systems Enhances IOS Resiliency

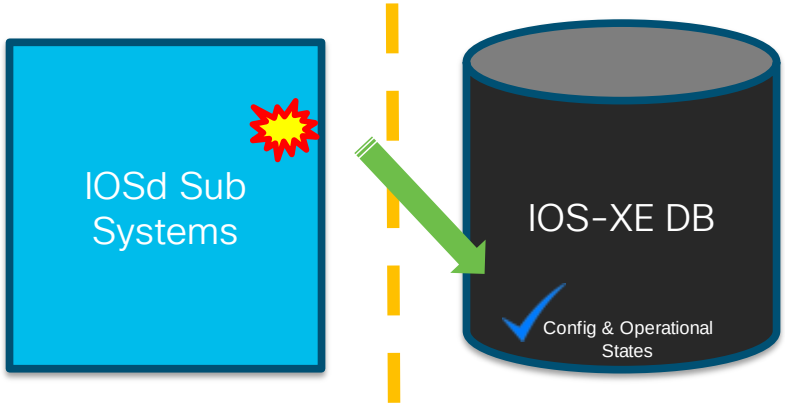
Open IOS XE – DB





The DB contains the Operational and Configurational States

Open IOS XE – DB



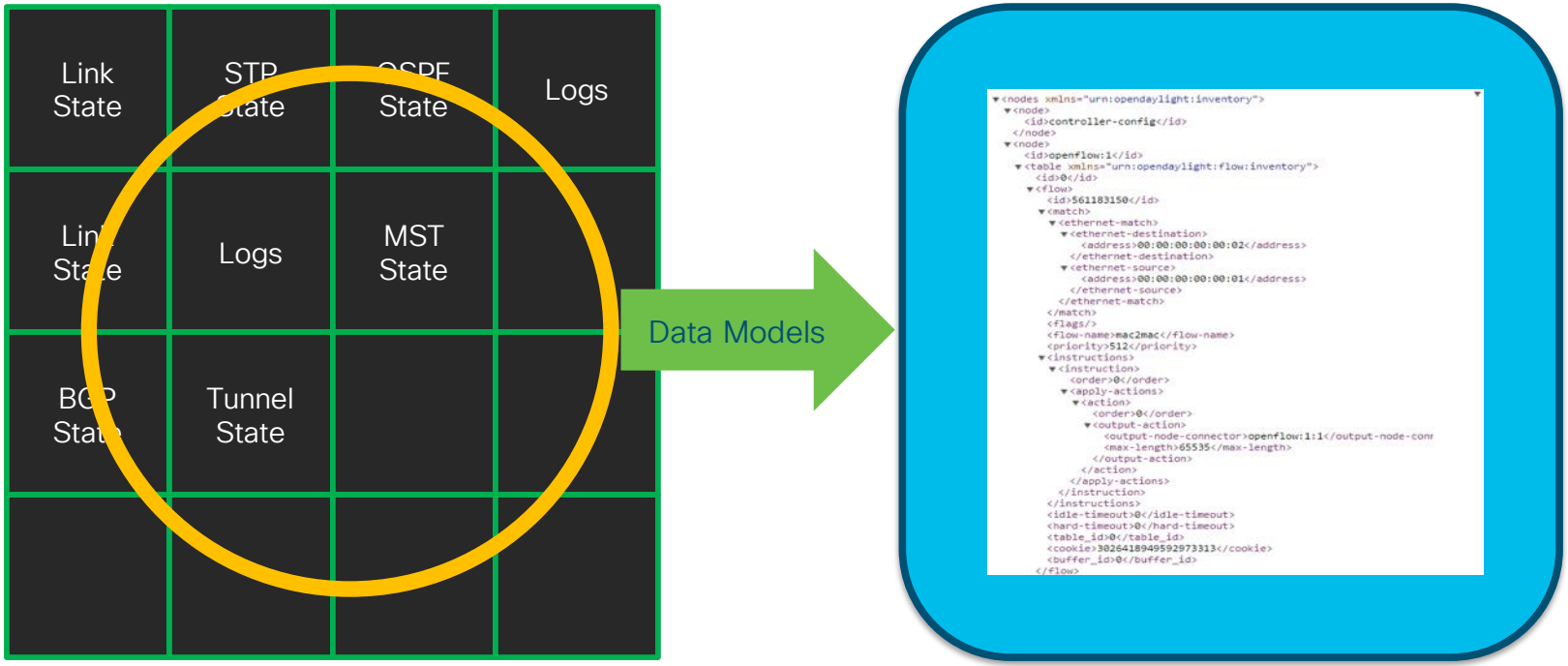
Decoupling Code & Data protects the Operational & Configurational States

Higher Application UP Time

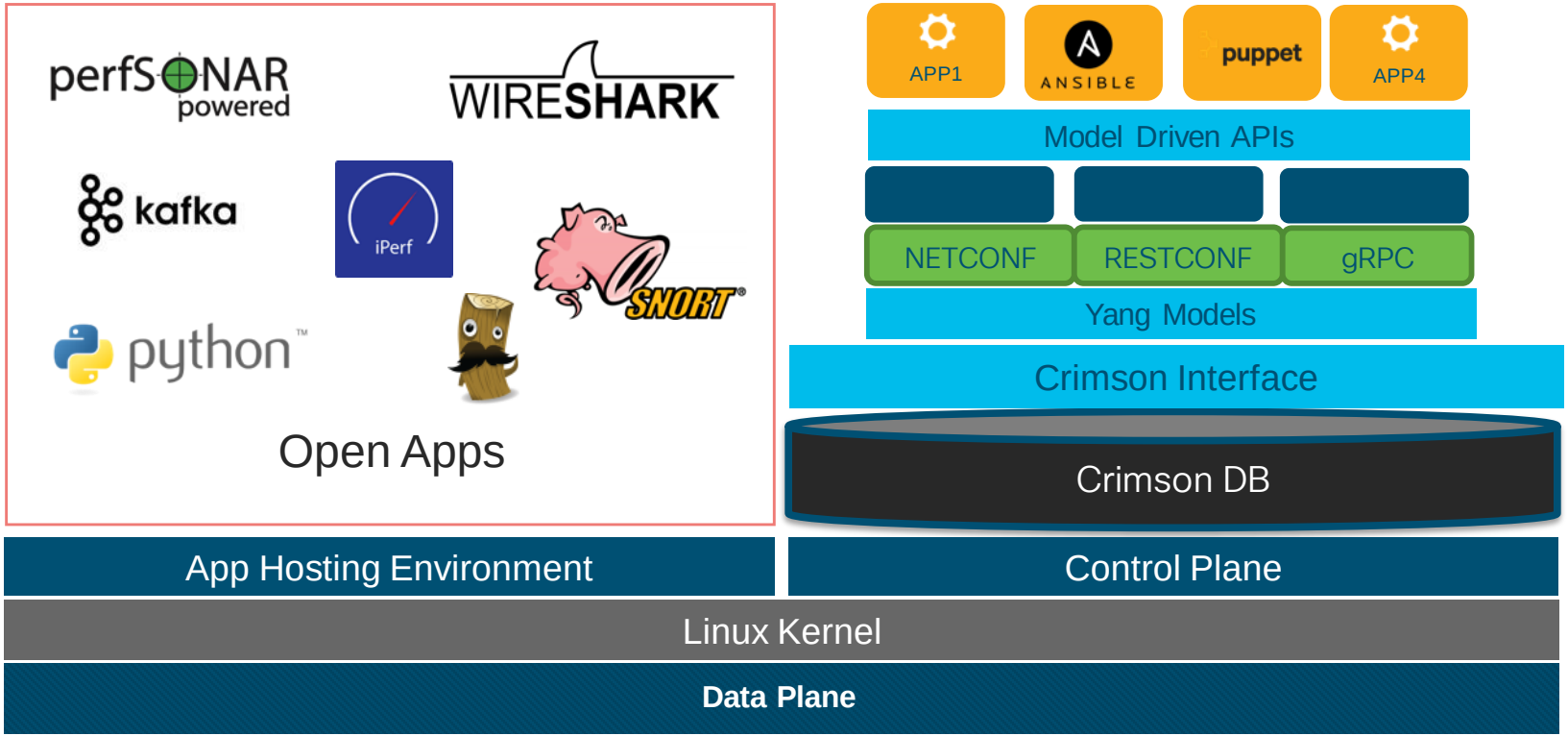
Quicker Recovery

Better Convergence

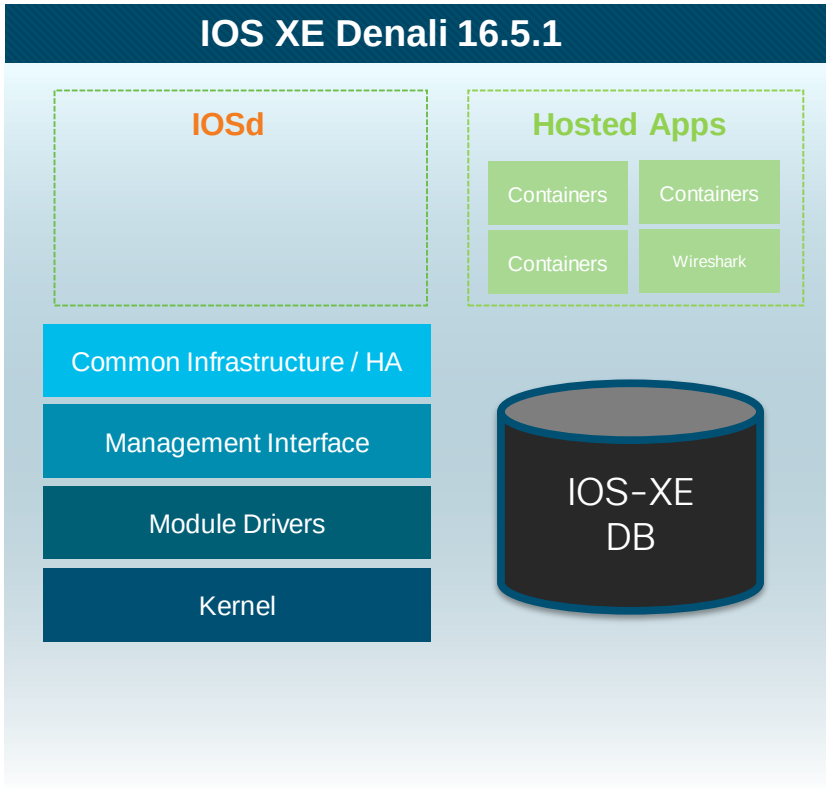
Open IOS XE – DB



App Hosting – Dockers Based



Open IOS XE – Containers

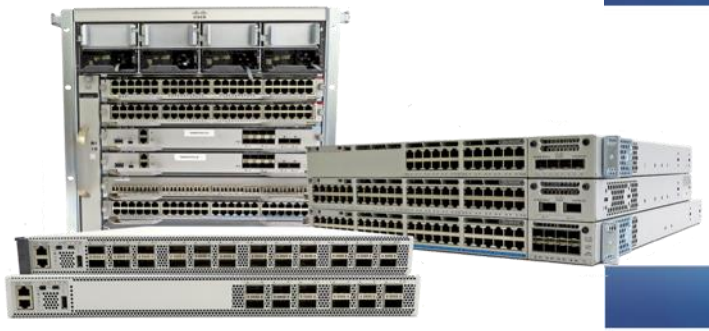


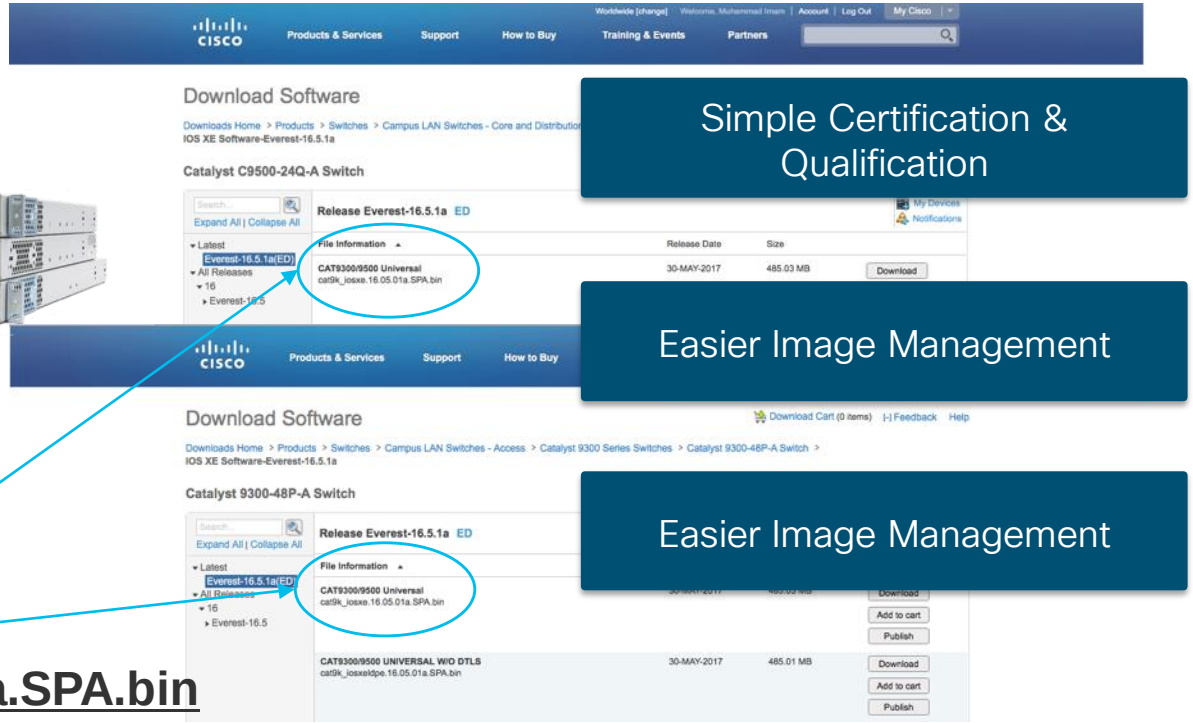
Decoupled Execution Space

Benefits for our Customers

One Release Train	Single Binary across Catalyst 9K
RAFA (Run Any Feature Anywhere)	MPLS, GRE, NAT, etc.
Patch Updates	Patching Available NOW!
Comprehensive Programmability	NETCONF, RESTCONF, YANG Models
Trustworthy & Secure Platform	ASLR 64 bit, Mandatory Access Control

IOS XE – Same Software on all 9K Platforms





Simple Certification & Qualification

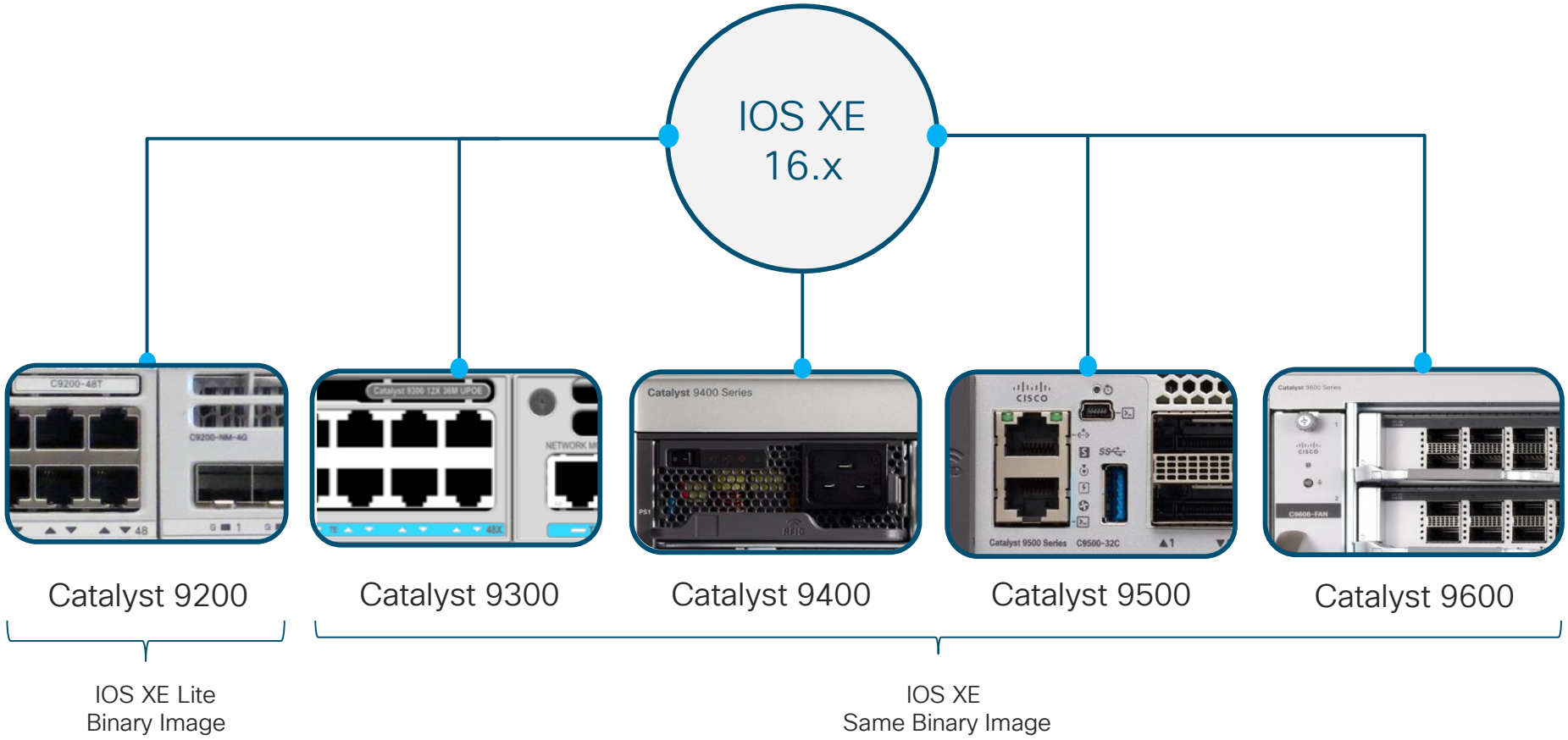
Easier Image Management

Easier Image Management

Same Binary Image
On all C9K

cat9k_iosxe.16.05.01a.SPA.bin

Single Binary for the entire Catalyst 9K Family



Catalyst 9000 runs the same Operating System

High Availability on C9K

You make networking **possible**

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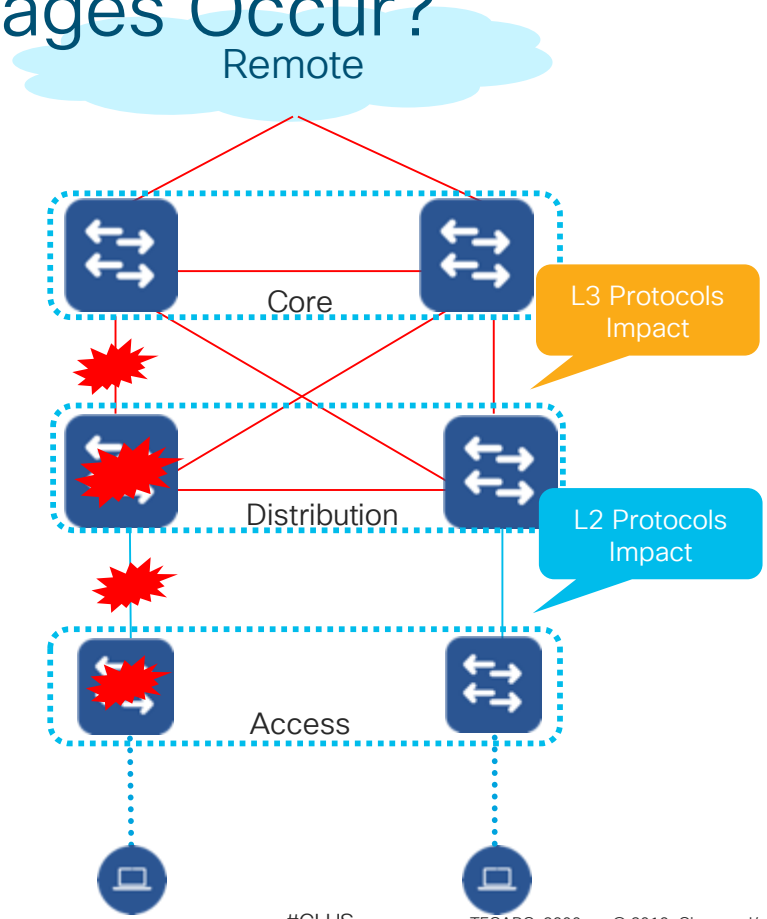
Goals

- Efficiently utilize available bandwidth
- Dynamically respond to all types of disruptions
- Leverage most effective design techniques that meet the design requirements

Where Can Outages Occur?

- Unplanned Outage
- Planned Outage



Link or Device Failure

L3 Link

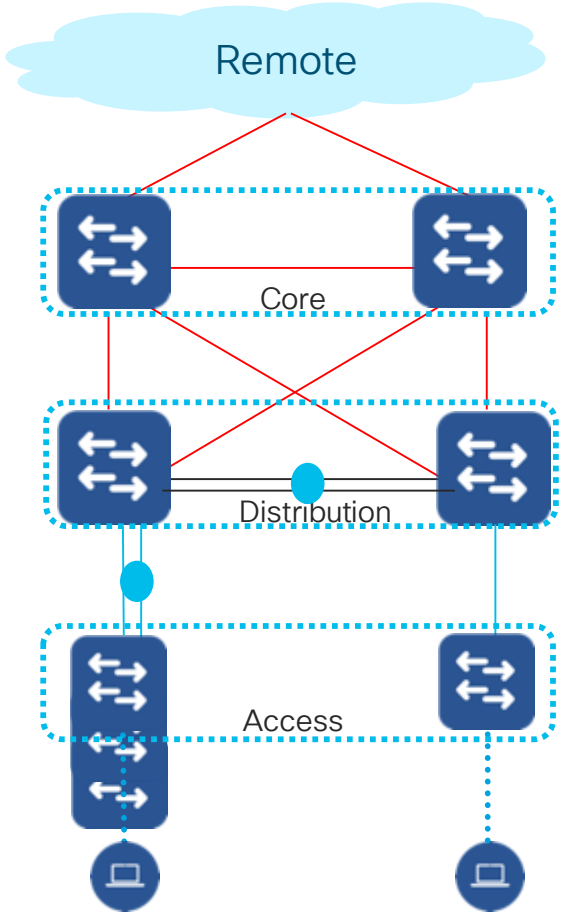
L2 Link

Application Layer

Protocol Layer

Physical Layer

Options to Mitigate the outages



- Add more links
- Add more devices
- Leverage FHRP like HSRP and VRRP
- Change the timers
- Tune the application performance
- Etc…

L3 Link

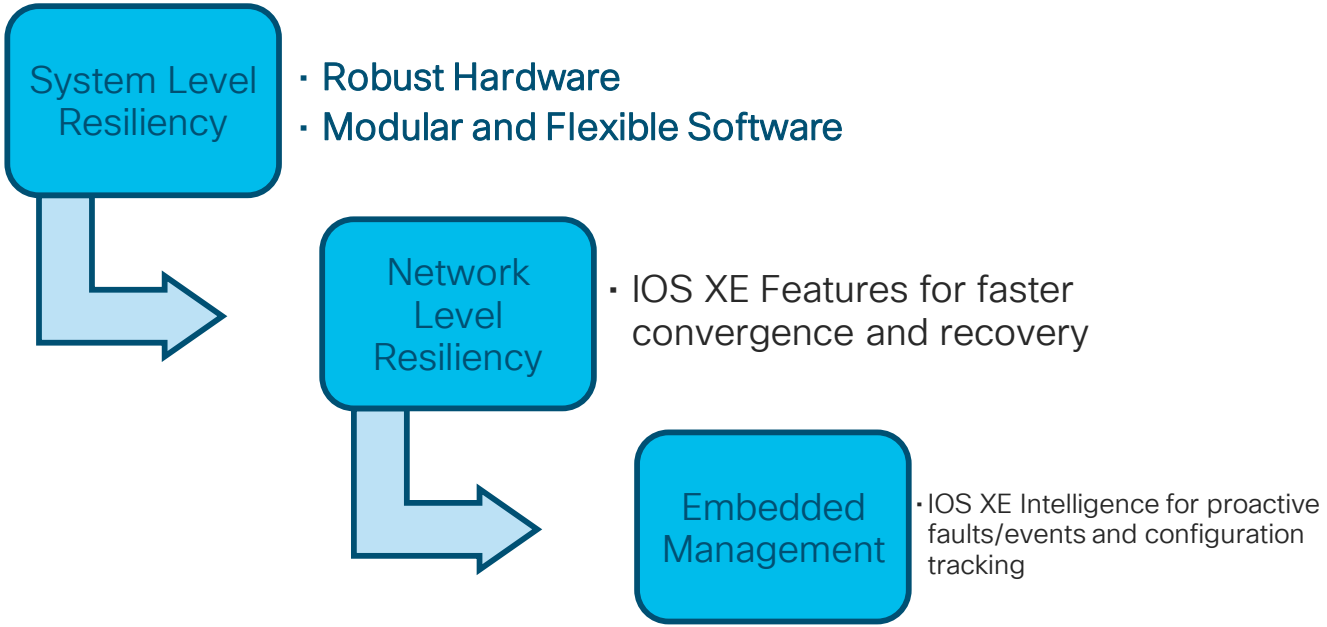
L2 Link

Convergence Time?
Failover Detection?

What is the best way ?

Cisco IOS High Availability Strategy:
Based on Customer Needs

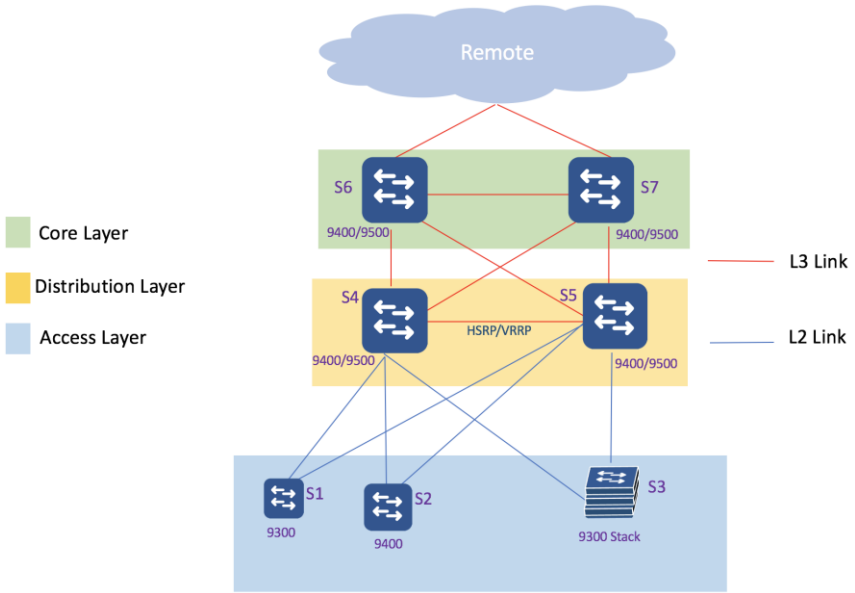
Provide continuous access to applications, data, and content anywhere, anytime



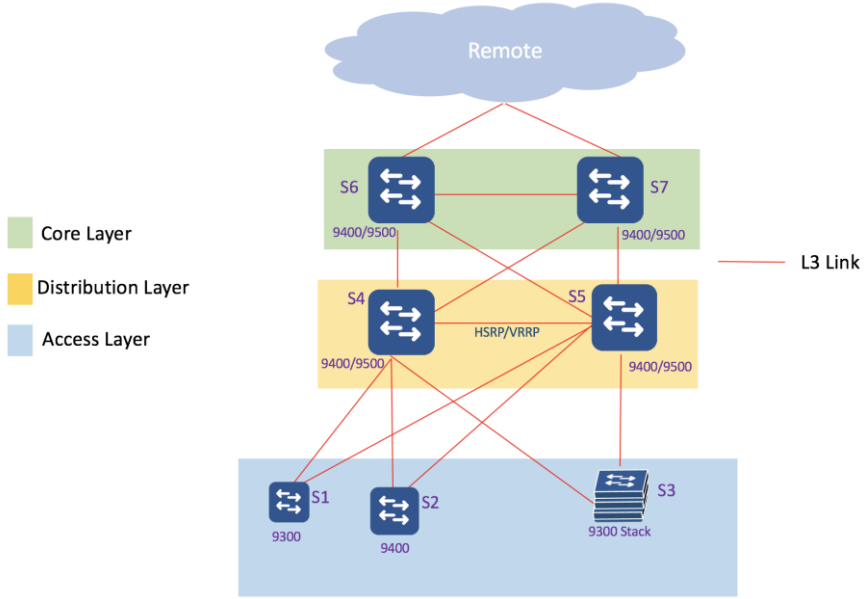
Address every potential cause of downtime with functionality, design, or best practice

Enterprise Campus Network Designs

Multi-Tier **Layer2/3** Topology



Multi-Tier **Layer3** Topology



Industry's Broadest Portfolio of End-to-End High Availability Technologies

Requirements	Technologies
System-Level Resiliency	▪ In-Service Software Upgrade (ISSU) ▪ IP NSF/SSO ▪ MPLS NSF/SSO–LDP, VPNs ▪ IOS Software Modularity ▪ Fast Software Upgrade ▪ Fast Reload ▪ Control Plane Policing
Network- Level Resiliency	▪ NSF/GR Awareness (BGP, OSPF, IS-IS, EIGRP, LDP,) ▪ Routing Convergence Optimization Incremental SPF optimization IP Event Dampening ▪ Multicast Sub-second Convergence ▪ Fast Convergence (OSPF, IS-IS) ▪ Bi-Directional Forwarding Detection (BFD)
Embedded Management	▪ Embedded Event Manager ▪ Embedded Resource Manager (ERM)

High Availability Architecture in Campus

You make security **possible**

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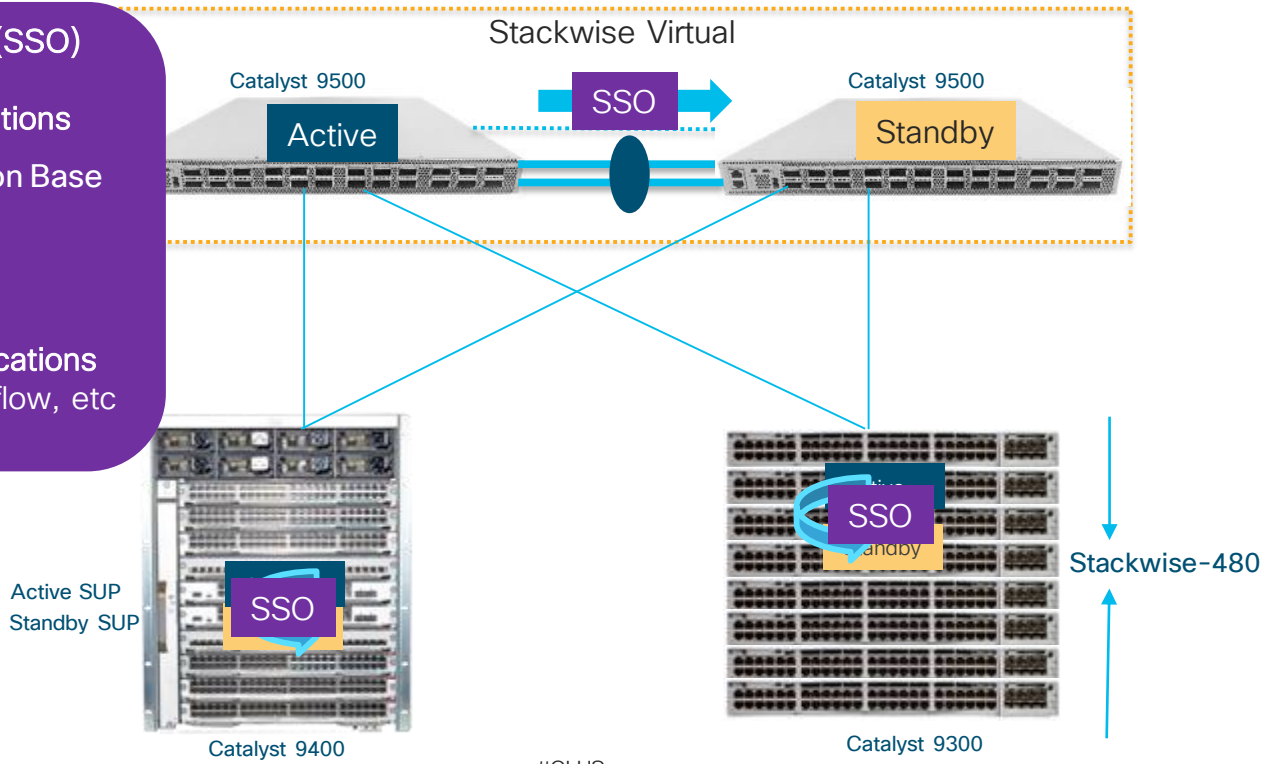
High Availability Architecture in Campus – SSO

Stateful Switchover (SSO)

SSO Aware Applications

Forwarding Information Base
IEEE 802.1x
PAgP / LACP
...and more

SSO Compliant Applications
Routing Protocols, Netflow, etc



SSO by itself Does Not Provide Redundancy for the Routing Protocols

Routing Protocol Redundancy With NSF

Active Supervisor/Switch

EIGRP RIB	
Prefix	Next Hop
10.0.0.0	10.1.1.1
10.1.0.0	10.1.1.1
10.20.0.0	10.1.1.1

OSPF RIB	
Prefix	Next Hop
192.168.0	192.168.0.1
192.168.55..0	192.168.55.1
192.168.32.0	192.168.32.1

ARP Table	
IP	MAC
10.1.1.1	aabbcc:ddee32
10.1.1.2	adbb32:d34e43
10.20.1.1	aa25cc:ddeee8

Standby Supervisor/Switch

EIGRP RIB	
Prefix	Next Hop
-	-
-	-
-	-

OSPF RIB	
Prefix	Next Hop
-	-
-	-
-	-

ARP Table	
IP	MAC
-	-
-	-
-	-

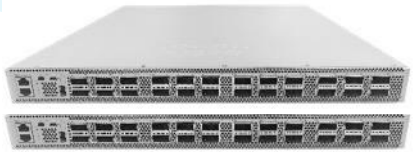
FIB Table	
Prefix	Next HOP
10.1.1.1	aabbcc:ddee32
10.1.1.2	adbb32:d34e43
192.168.0.0	aa25cc:ddeee8

SSO

Redundancy Facility

Checkpoint Facility

FIB Table	
Prefix	Next HOP
10.1.1.1	aabbcc:ddee32
10.1.1.2	adbb32:d34e43
192.168.0.0	aa25cc:ddeee8



Routing Protocol Redundancy With NSF

Active Supervisor/S

EIGR RIB

Prefix	Next Hop
10.0.0.0	10.1.1.1
10.1.0.0	10.1.1.1
10.20.0.0	10.1.1.1

Pref	Hop
192.1	
192.168.3	
192.168.32.0	

RP Table

	MAC
.1.1	aabbcc:ddee32
.0.1.1.2	adbb32:d34e43
10.20.1.1	aa25cc:ddeee8

Pref	OP
1	occ:ddee32
	dbb32:d34e43
	aa25cc:ddeee8

Standby Supervisor/Switch

EIGRP RIB

Prefix	Next Hop
-	-
-	-
-	-

OSPF RIB

Prefix	Next Hop
-	-
-	-
-	-

ARP Table

IP	MAC
-	-
-	-
-	-

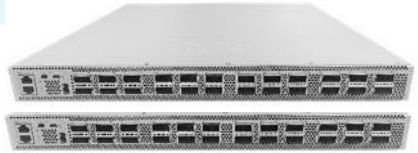
SSO

Redundancy Facility

Checkpoint Facility

FIB Table

Prefix	Next HOP
10.1.1.1	aabbcc:ddee32
10.1.1.2	adbb32:d34e43
192.168.0.0	aa25cc:ddeee8



Routing Protocol Redundancy With NSF

Standby Supervisor/Switch

EIGRP RIB	
Prefix	Next Hop
1-0.0.0.0	-10.1.1.1
-10.1.0.0	-10.1.1.1
-10.20.0.0	1-0.1.1.1

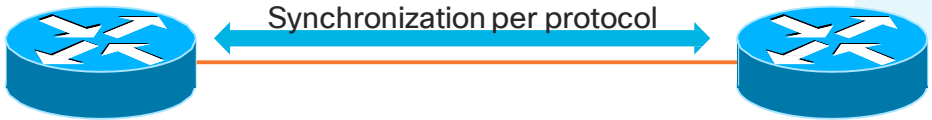
OSPF RIB	
Prefix	Next Hop
192.168.0	192.168.0.1
192.168.55..0	192.168.55.1
192.168.32.0	192.168.32.1

ARP Table	
IP	MAC
-10.1.1.1	a-abbcc:ddee32
-10.1.1.2	-adbb32:d34e43
-10.20.1.1	-aa25cc:ddeee8

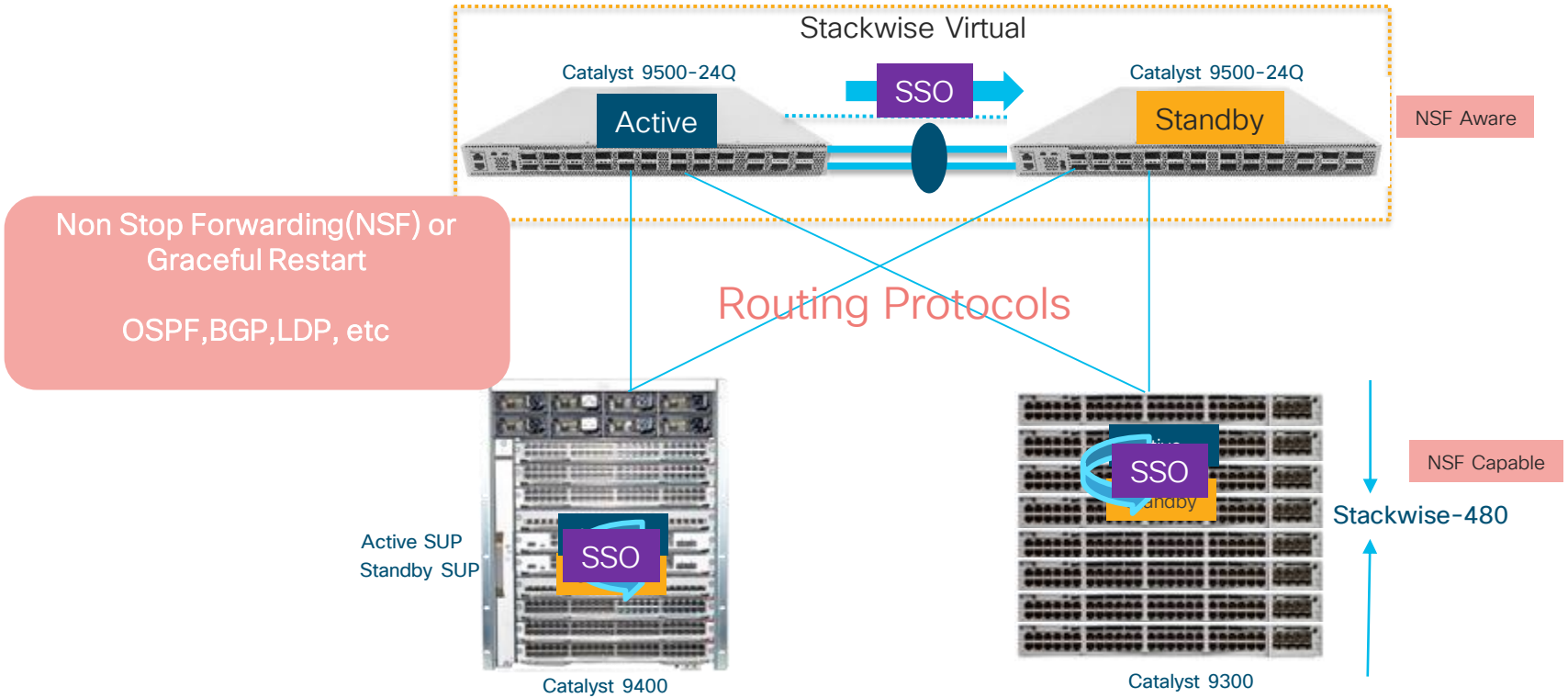
FIB Table	
Prefix	Next HOP
10.1.1.1	aabbcc:ddee32
10.1.1.2	adbb32:d34e43
192.168.0.0	aa25cc:ddeee8

GR/NSF Signaling per protocol

Synchronization per protocol



High Availability Architecture in Campus – SSO/NSF



High Availability in Fixed Access – Catalyst 9300

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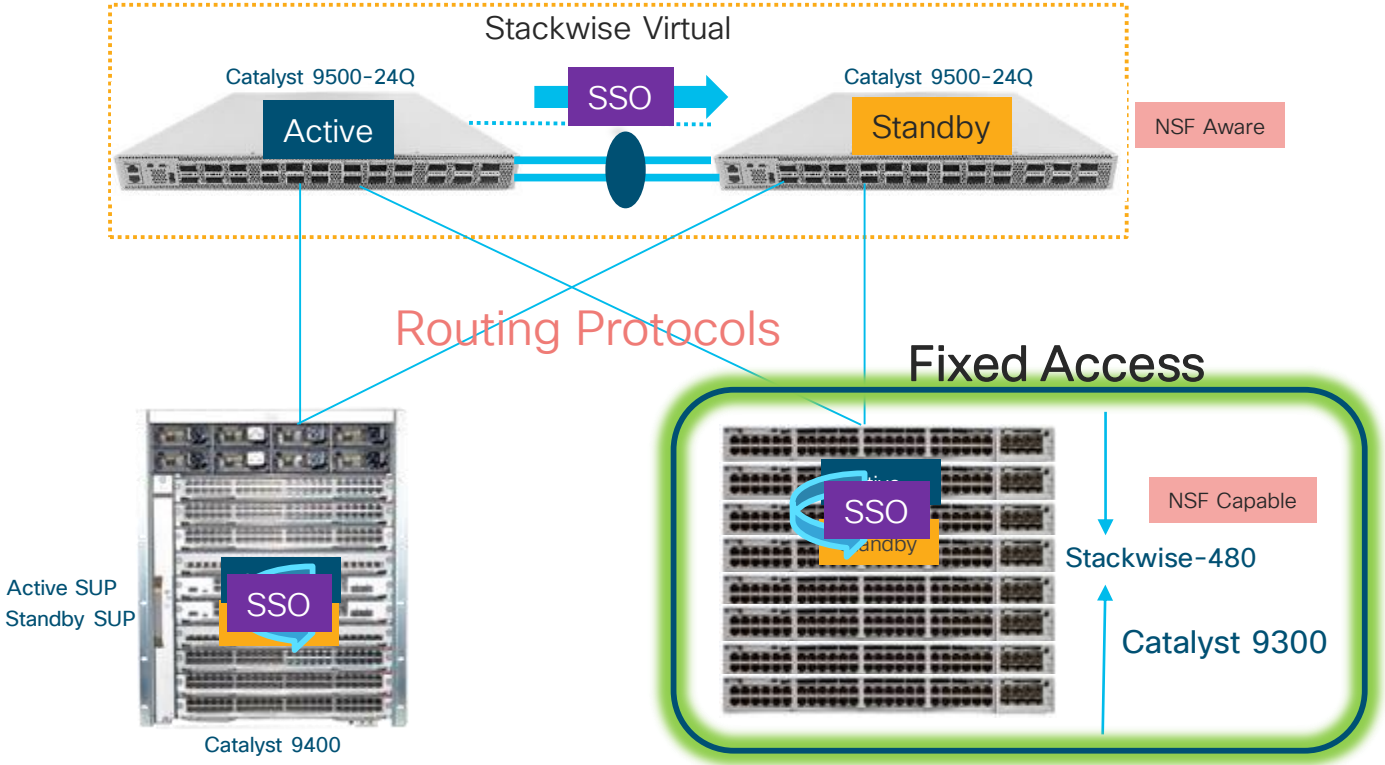
High Availability in Campus – Fixed Access



Enhanced Fast Software Upgrade

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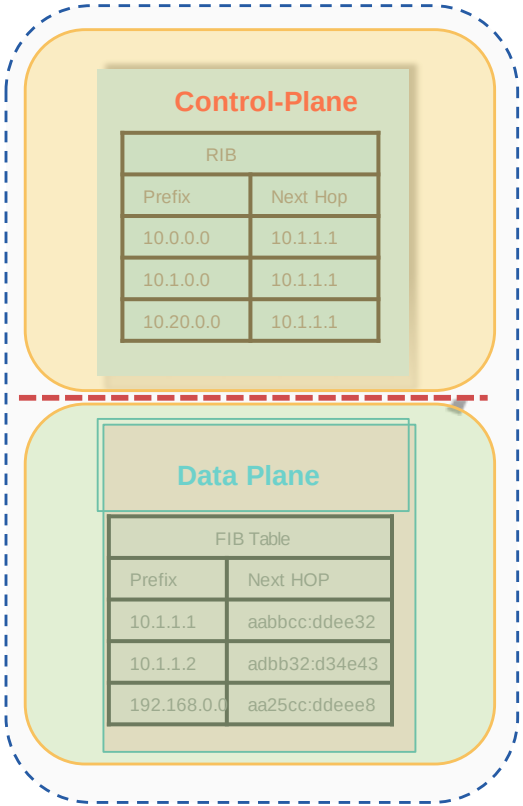
Achieving High Availability on Catalyst 9300

Enhanced Fast Software Upgrade

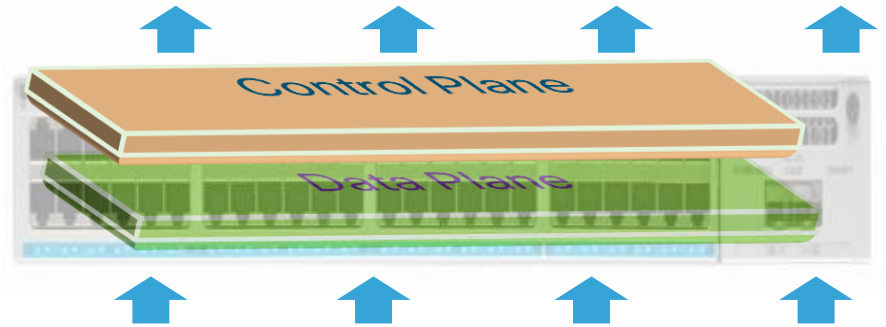
- eFSU provides a mechanism to upgrade and downgrade the software image by segregating the Control plane and Data Plane update
- It updates the control plane by leveraging the NSF/GR Architecture with Flush and Re-Learn mechanism to reduce the impact on the data plane



Fast Software Upgrade

- Regular Upgrade Vs Enhanced Fast Software Upgrade Process

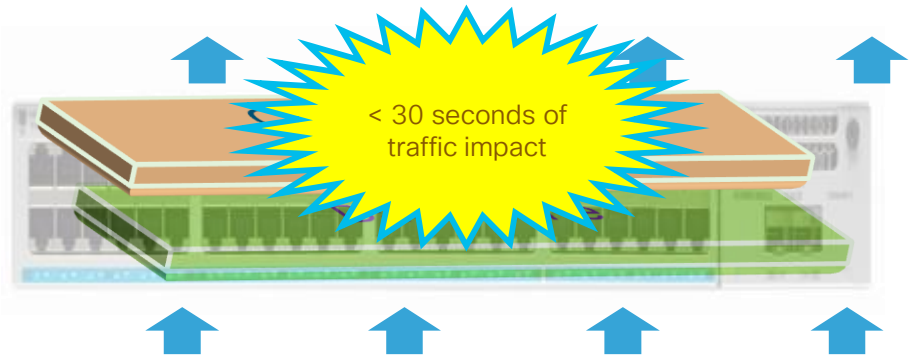
#Install add file image activate commit



Traffic is impacted throughout the upgrade cycle

Enhanced Fast Software Upgrade

#Install add file image activate reloadfast commit

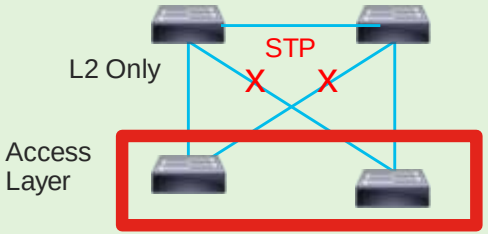


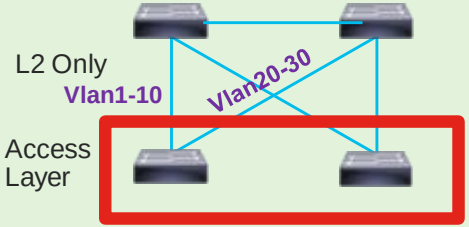
* Limited Controlled Availability in 16.10.1

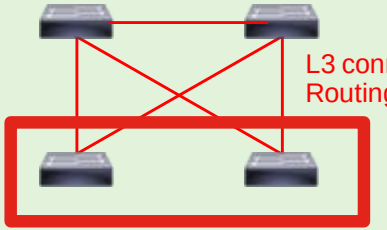
Enhanced Fast Software Upgrade

- Supported and Unsupported Designs without Stackwise-480

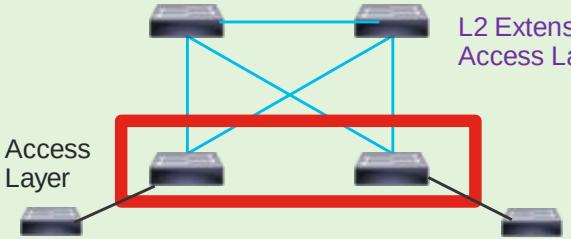
Layer 2/3 Access Layer Designs– eFSU Supported

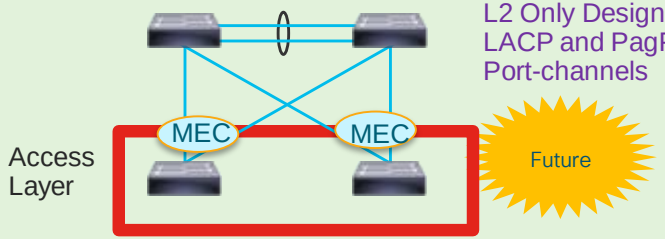






Unsupported Designs





Enhanced Fast Software Upgrade
CLI Commands

- FSU is supported only in install mode
- One step command which activates the fast software upgrade and commits it

```
9300# install add file flash:cat9k_iosxe.BLD_V1610 activate reloadfast commit
```

- **Fast Reload without Software upgrade**

```
9300# Reload Fast
```

Enhanced Fast Software Upgrade

Restrictions

- Enhanced FSU is not supported on a Stackwise-480
- Enhanced FSU is only supported and tested on Catalyst 9300-48U model for (16.10.1*)
- Enhanced FSU is not supported on the switch configured with LACP/PAGP Port-channels

*** All 9300 models will be supported in 16.11.1 Release**

High Availability in Modular Chassis – Catalyst 9400/9600

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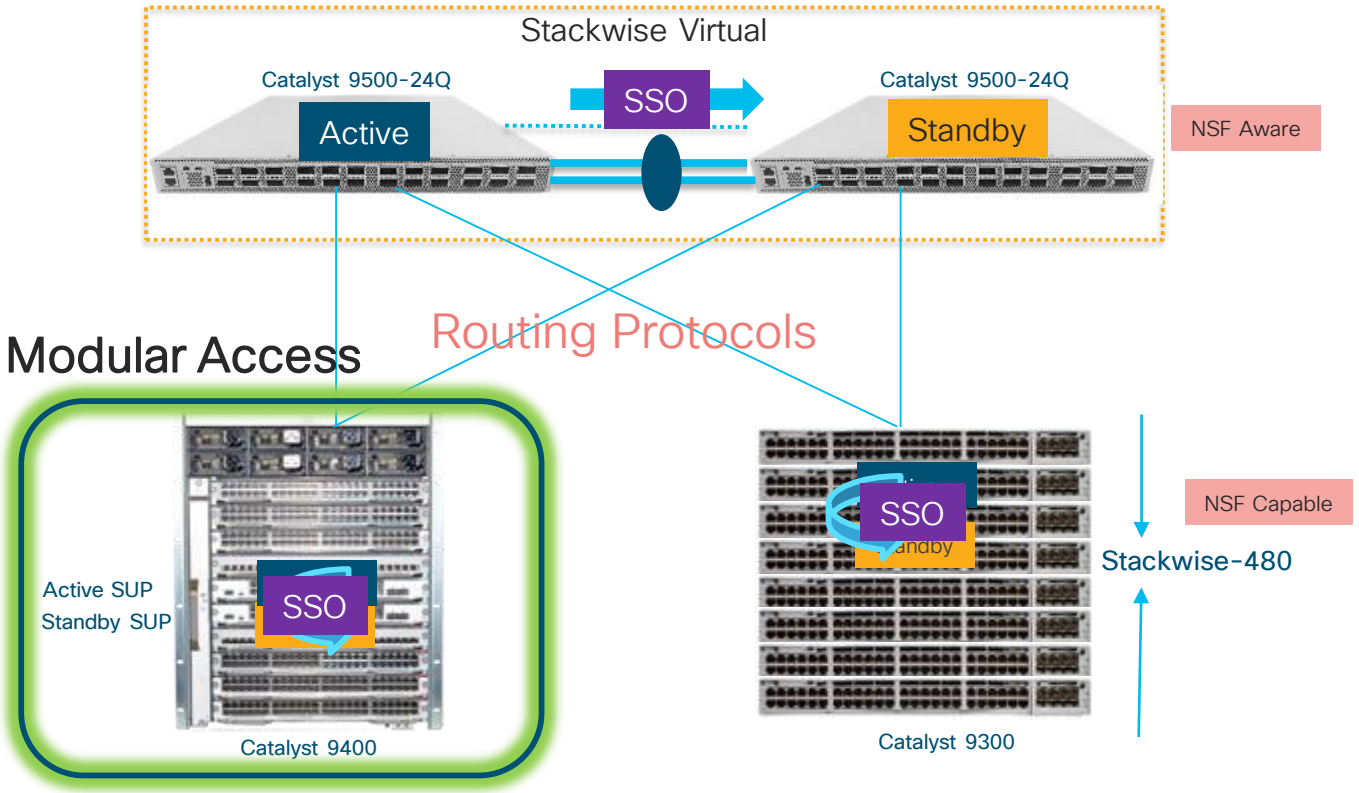
High Availability in Campus – Modular Access



In-Service Software Upgrade(ISSU) with Dual Supervisors

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Supervisor Redundancy

Eliminate single points of failure
for hardware and software components

Control/data plane resiliency

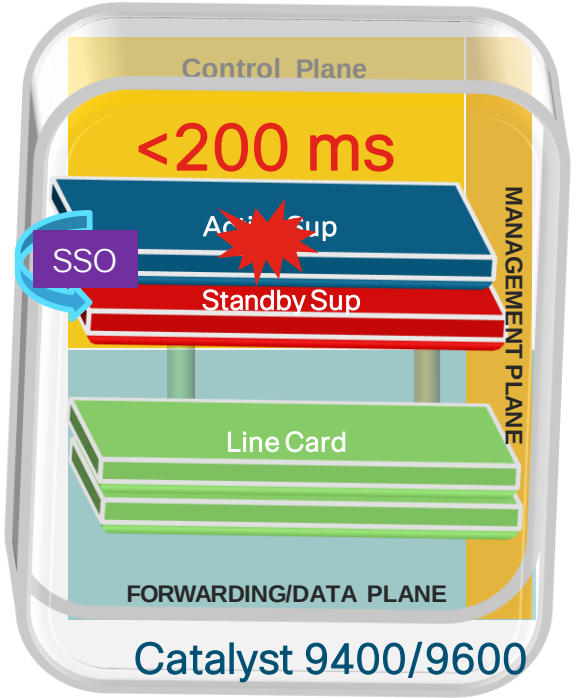
- Separation of control and forwarding plane
- Seamless restoration of Route Processor control and data plane failures

Link resiliency and Load Balancing

- Reduced impact of Line Card hardware and software failures

Planned outages

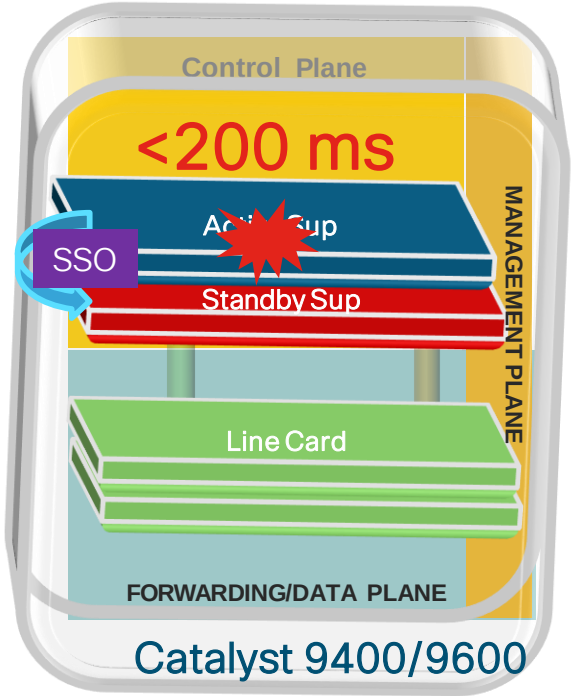
- Seamless software and hardware upgrades



Dual Supervisor ISSU

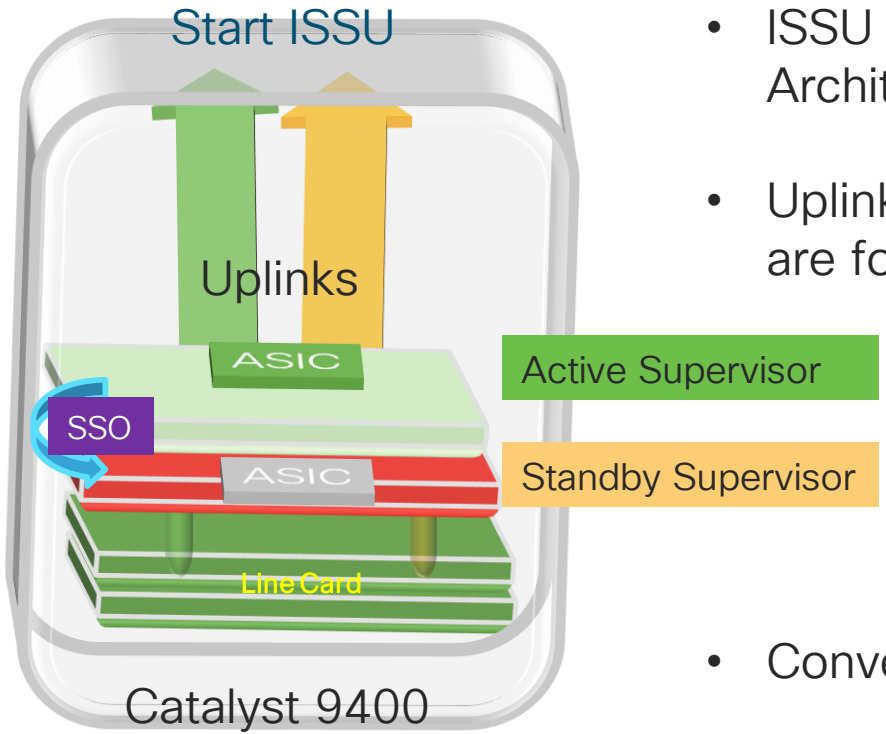
ISSU Overview

- ISSU provides a mechanism to perform software upgrades and downgrades without taking the switch out of service
- Leverages the capabilities of NSF and SSO to allow the switch to forward traffic during Supervisor IOS upgrade (or downgrade)
- Key technology is the ISSU Infrastructure
  - Allows SSO between different versions



ISSU Process

Dual Supervisors



- ISSU Process leverages SSO/NSF Architecture
- Uplinks on both active and standby SUP are forwarding traffic
- Convergence is less than 200 msec

C9K ISSU

Dual Supervisor ISSU

3 Step Process

- Install add file <tftp/ftp/flash/disk:*.bin>
- Install activate ISSU
- Install commit

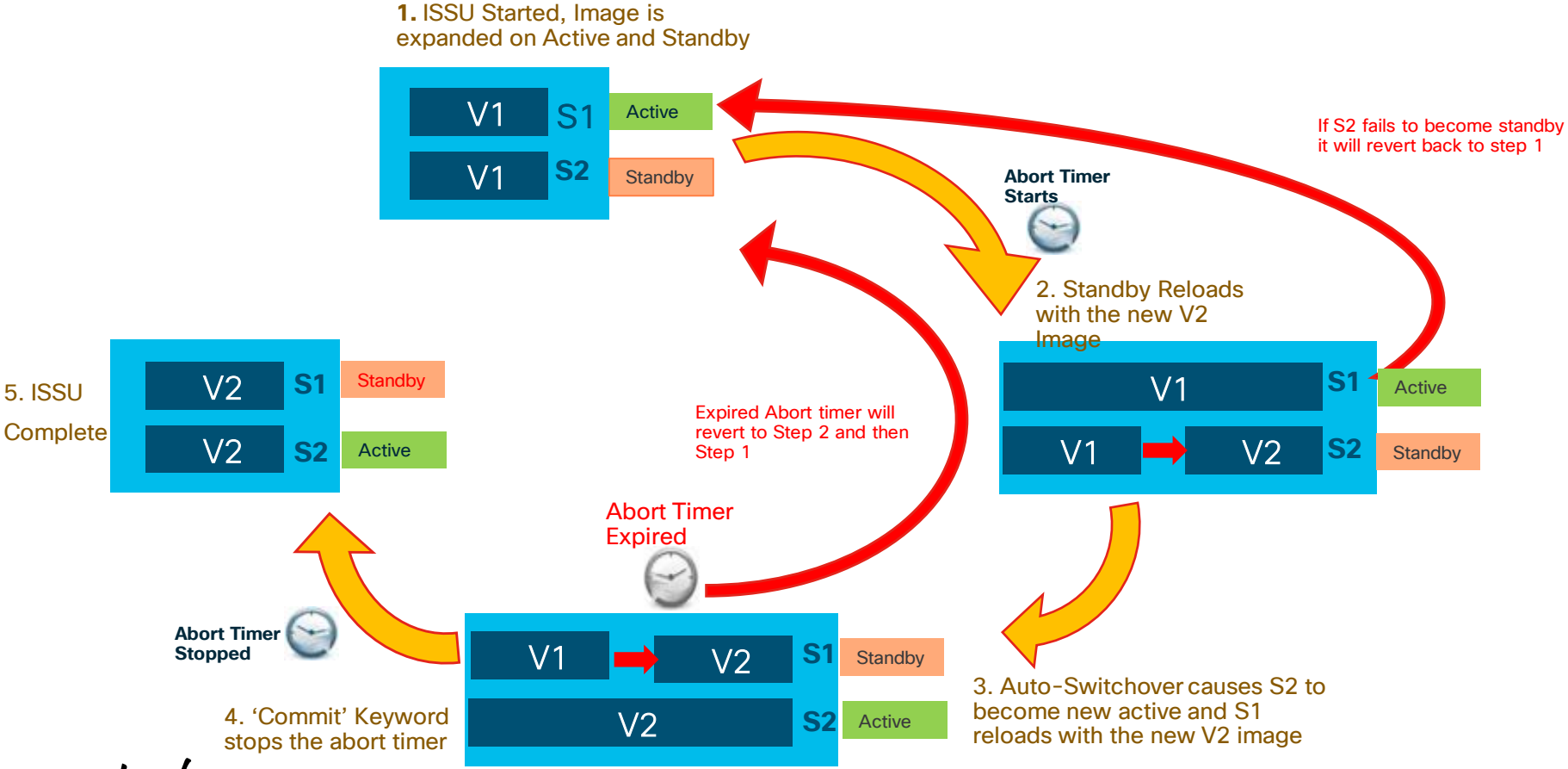
Granular Control on the upgrade process with ability to rollback

1 Step Process

- Install add file <tftp/ftp/flash/disk:*.bin>activate ISSU commit

Single Command to perform complete ISSU

C9K ISSU Workflow



High Availability in Distribution/Core- Catalyst 9400/9500/9600

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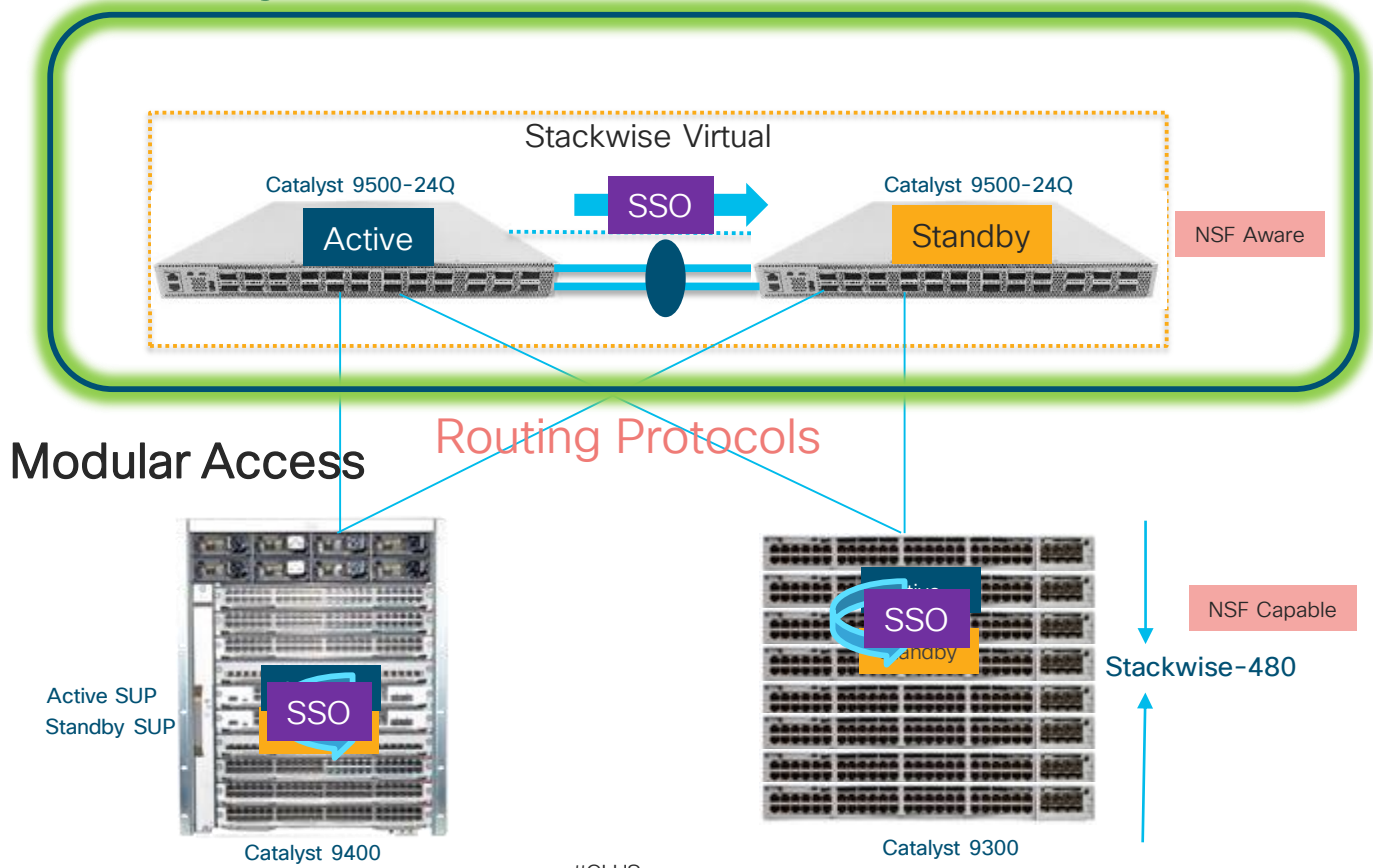
High Availability in Campus – Distribution/Core



Stackwise Virtual

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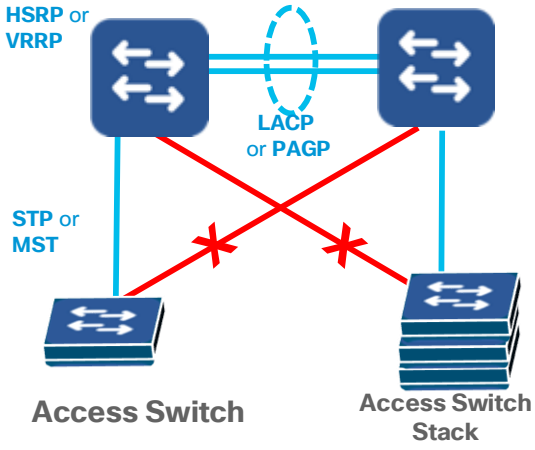
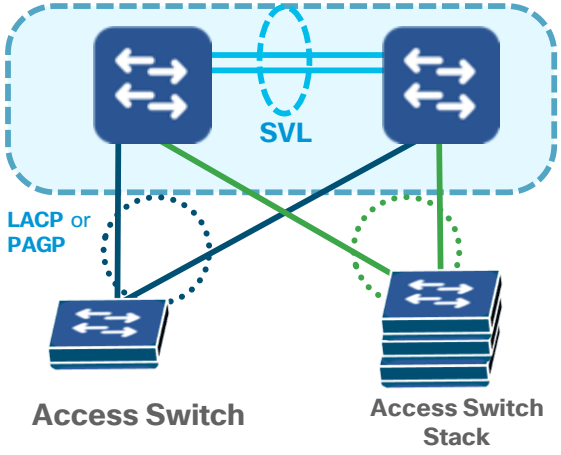
Stackwise Virtual
Topology Comparisons

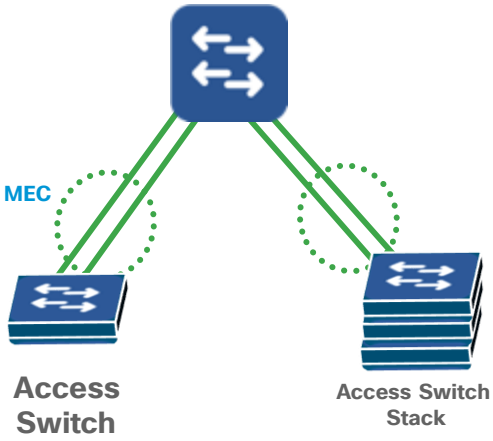
Traditional



SV - Physical



SV- Logical



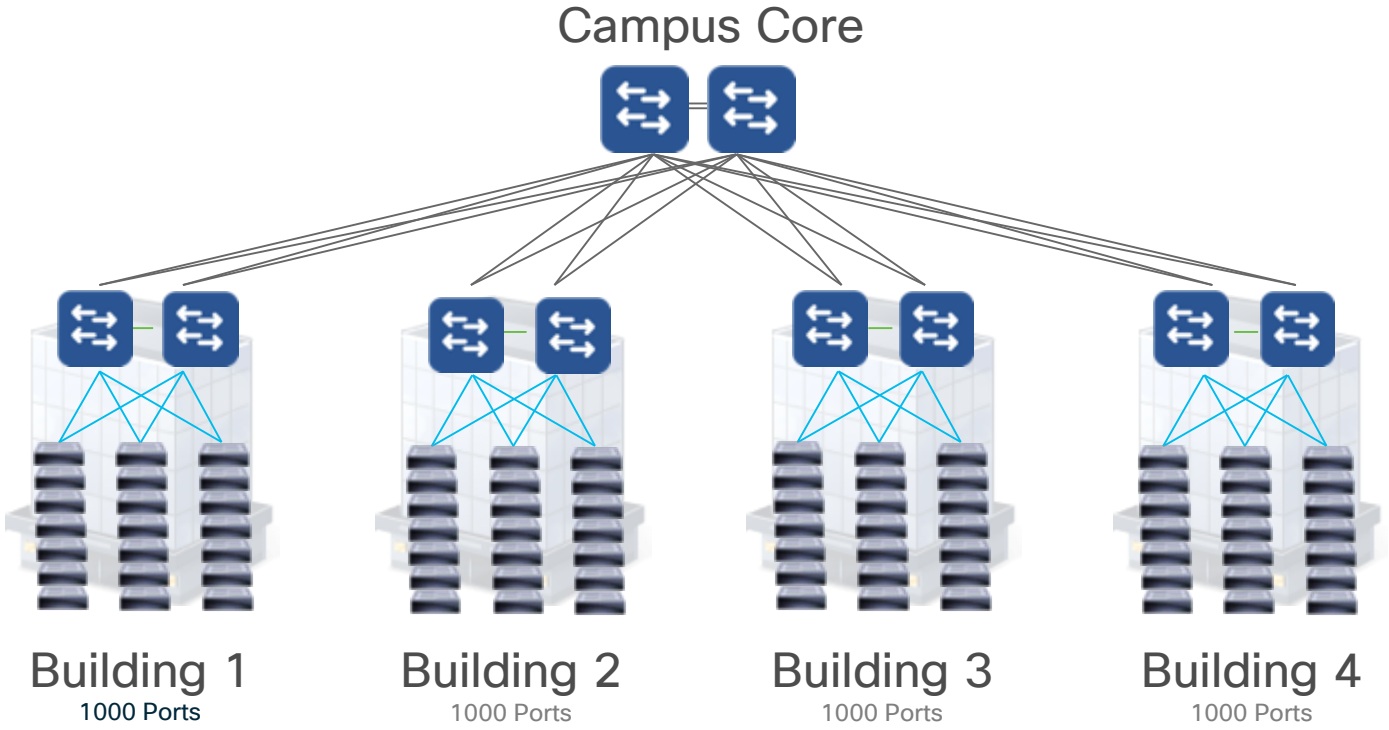
Benefits of Stackwise Virtual

Simplify Operations by Eliminating STP, FHRP and Multiple Touch-Points

Double Bandwidth & Reduce Latency with Active-Active Multi-chassis EtherChannel (MEC)

Minimizes Convergence with Sub-second Stateful and Graceful Recovery (SSO/NSF)

Traditional L2 / L3 Campus



Multi-Layer Switches

Non-Stack L2 Switches

Network Design

94 Total Devices of Image & Configuration Management

168 Port-Channels

168 Access Trunks

4032 User Ports

Design Considerations:

STP Loop Prevention

CAM & ARP Tuning

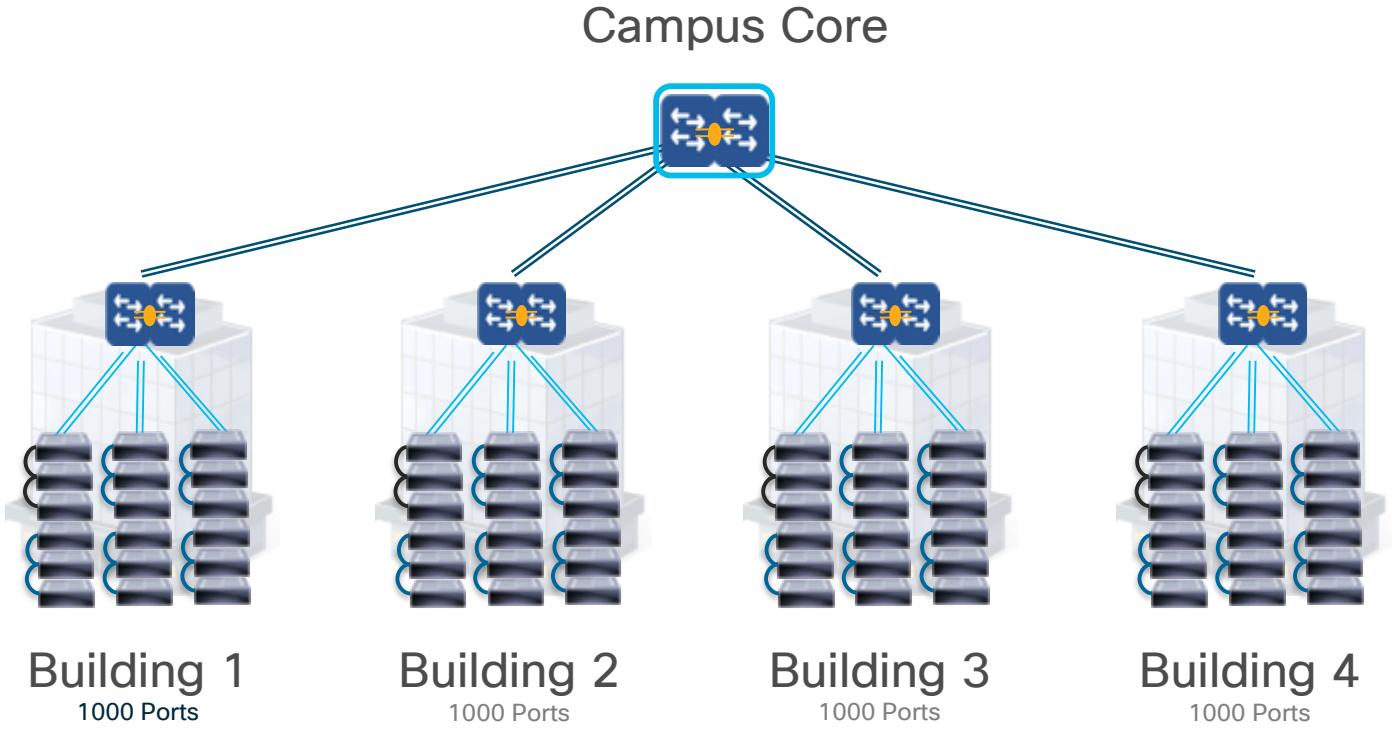
FHRP Tuning / Priority

Routing Protocol Tuning

PIM Tuning / DR priority

94 Separate Configurations of Hostname, VLAN DB, IP/GW, SNMP, NTP, TACACS, VTY, etc.

Stackwise Virtual Core with Access Stacking



Network Design

25 Total Devices of Image & Configuration Management

24 Port-Channels

24 Access Trunks

4032 User Ports

Design Considerations:

~~STP Loop Prevention~~

~~CAM & ARP Tuning~~

~~FHRP Tuning / Priority~~

~~Routing Protocol Tuning~~

~~PIM Tuning / DR priority~~

25 Separate Configurations of Hostname, VLAN DB, IP/GW, SNMP, NTP, TACACS, VTY, etc.

Stackwise Virtual Architecture

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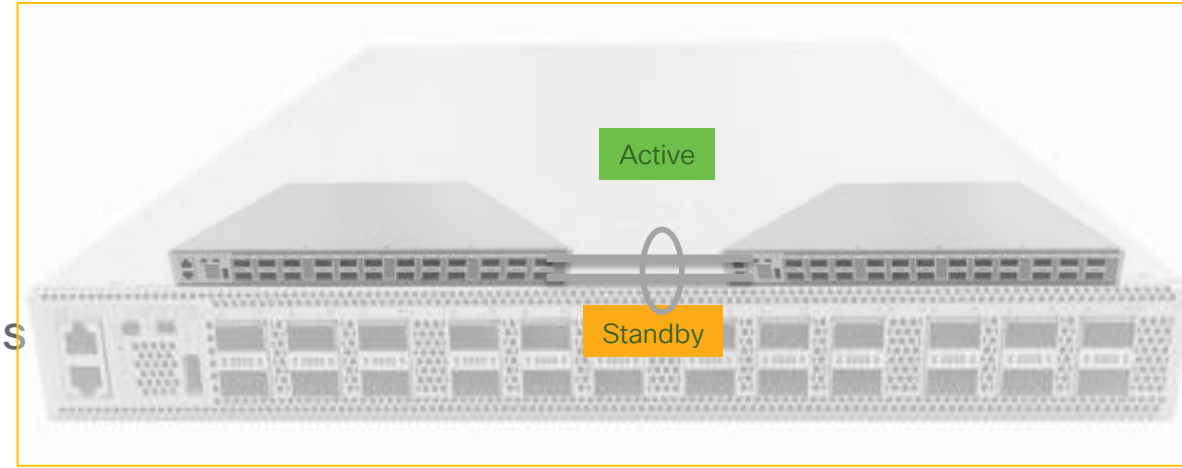
Stackwise Virtual Architecture

Control Plane

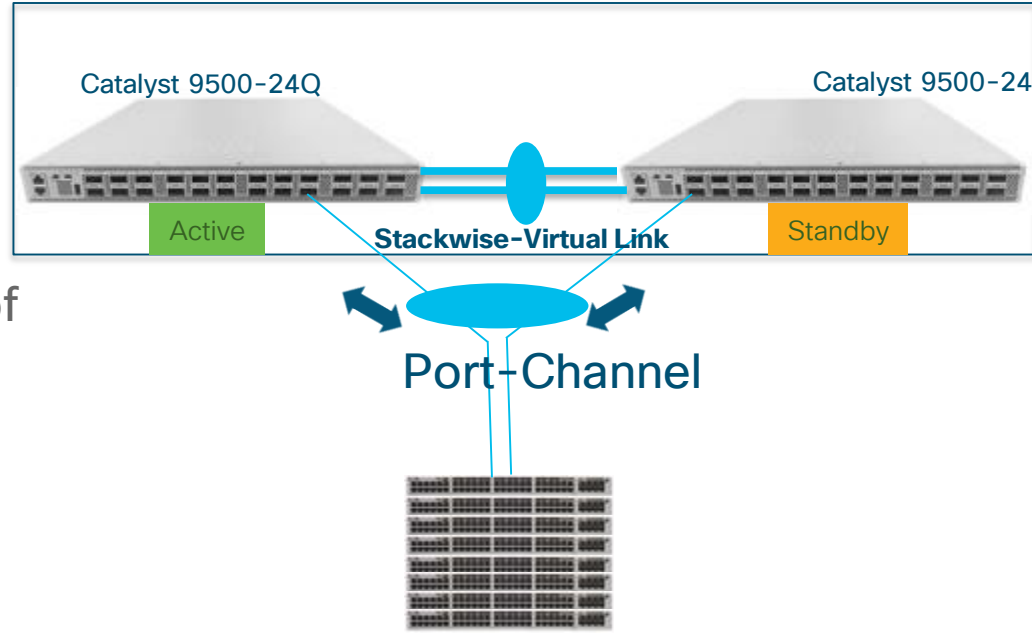
- **Unified Control Plane**
  - Manage, Configure and troubleshoot two switches as a single switch



Stackwise Virtual Architecture

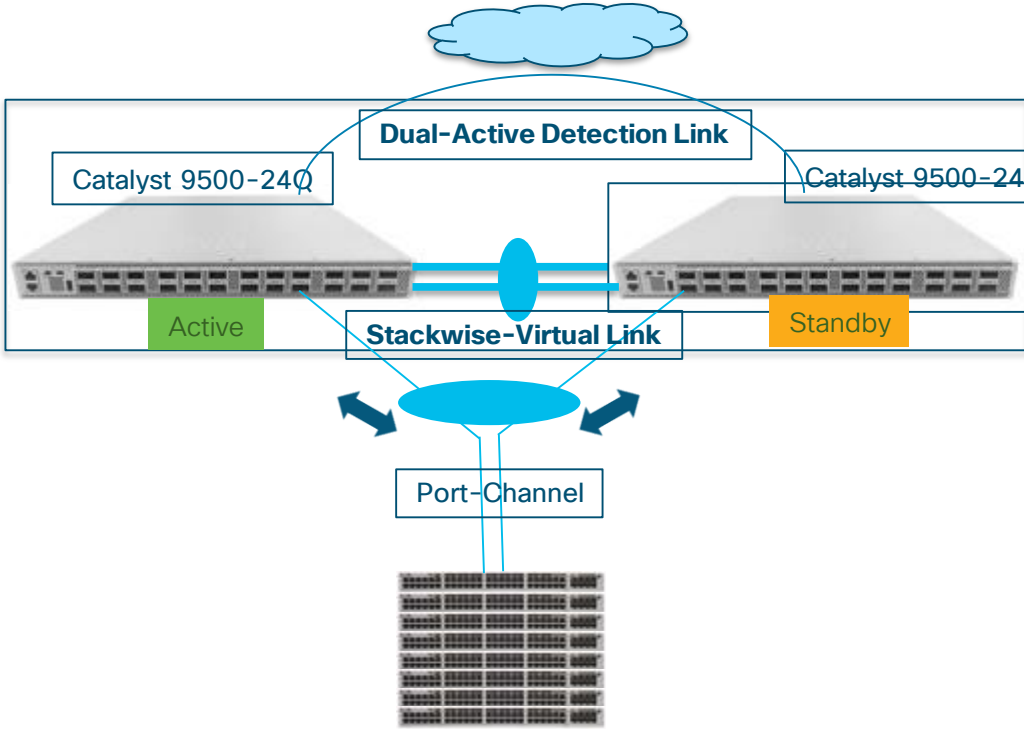
Data Plane

- **Active/Active Data Plane**
  - Both the switches are capable of forwarding the traffic locally



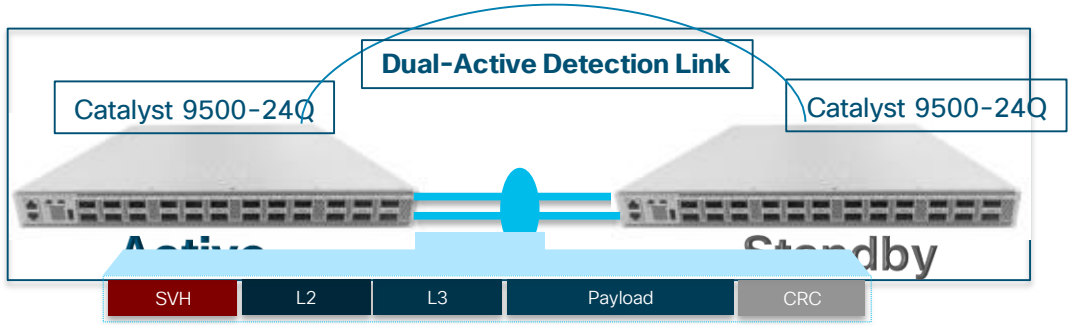
Stackwise Virtual Components

- **Stackwise Virtual Link**
  - Dedicated Stacking Link facilitating communication between the switches
- **Dual Active Detection Link**
  - Dedicated Connection to check and avoid dual-active scenario
- **Multi-Chassis Ether-channel**
  - Port-Channel Spanning across Stackwise virtual switches
  - L2 and L3 Port-channels



Stackwise Virtual Link

- **Inter-Chassis System Link**
  - No network protocol operations
  - Invisible in network topology
  - Transparent to network level troubleshooting
- **SVL Control Link**
  - Carries all system internal control traffic
  - Single member-link and dynamic election during bootup
  - Shared interface for network/data traffic
- **Payload Overhead**
  - Every single packet encapsulated with 64B of StackWise Virtual Header (SVH)
  - Non-bridgeable and Non-routeable.
  - SVL must be directly connected between two stack-member switch systems

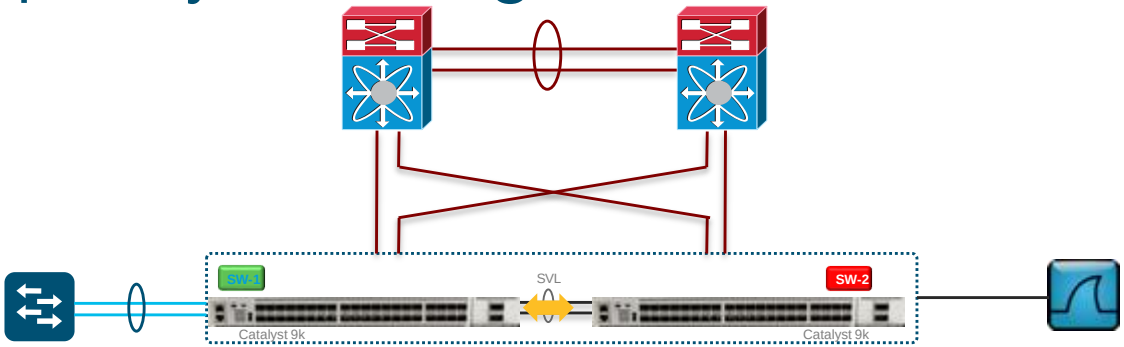



```
Dist-1# show stackwise-virtual link

Stackwise Virtual Link(SVL) Information:
----------------------------------------------------------
Flags:
--------
Link Status
---------------
U-Up D-Down
Protocol Status
---------------------
S-Suspended P-Pending E-Error T-Timeout R-Ready

Switch  SVL  Ports                  Link-Status  Protocol-Status
------  ---  -----                  -----------  ---------------
1       1    FortyGigabitEthernet1/1/1  U        R
             FortyGigabitEthernet1/1/2  U        R
2       1    FortyGigabitEthernet2/1/1  U        R
             FortyGigabitEthernet2/1/2  U        R
```

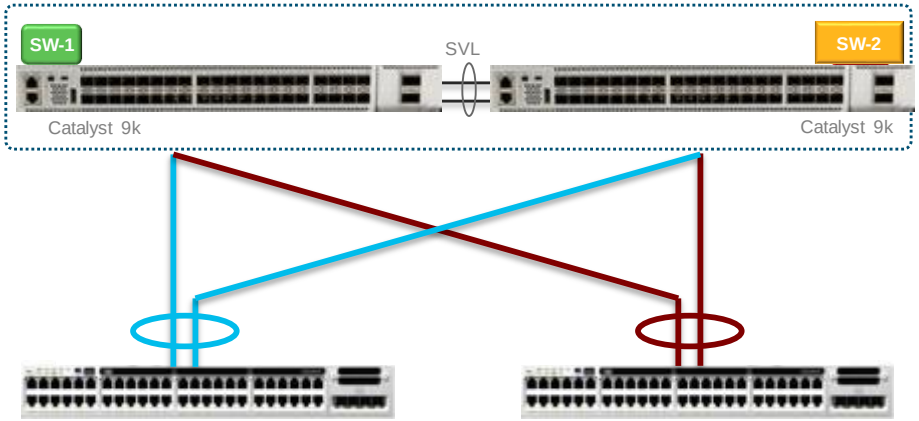
SVL – Capacity Planning



- Plan SVL bandwidth capacity to reduce congestion point, handle failures and specific configurations
- Three major points to consider for planning :
  - Total Uplink BW Per Stack-Member. Ability to handle data re-route during uplink failures without network congestion
  - Handling egress data to single-homed devices (Non-recommended design)
  - Remote network services such as SPAN

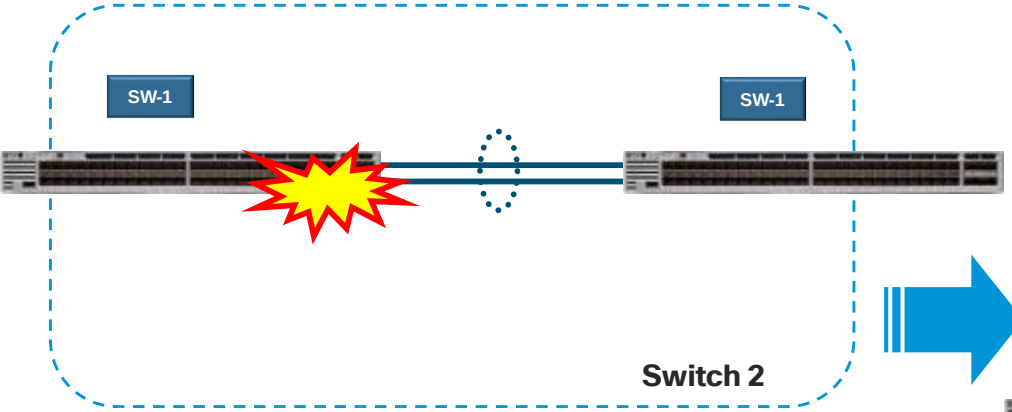
StackWise Virtual – Multi-Chassis EtherChannel

- Multi-Chassis EtherChannel (MEC) in StackWise Virtual enables cross stack-member link bundling into single logical L2/L3 Interface
- StackWise Virtual supports 128 maximum MEC –
  - Port-Channel ID 1-127 available for L2/L3 network configurations
  - Port-Channel ID 128 is internally reserved for SVL purpose
- MECs can be deployed in three modes –
  - Cisco PAgP, LACP and Static (ON)
- Combining StackWise Virtual and Layer 2 or Layer 3 MEC builds simplified, scalable and highly resilient campus network
- MEC is an primary network design component to enable –
  - Simplified STP loop-free network topology
  - Consistent L3 control-plane and network design as traditional Standalone mode system
  - Deterministic sub-second network recovery



Stackwise Virtual

Inter Chassis SSO/NSF



1 **Virtual Switch incurs a failure of the (SSO) Active Switch 1**

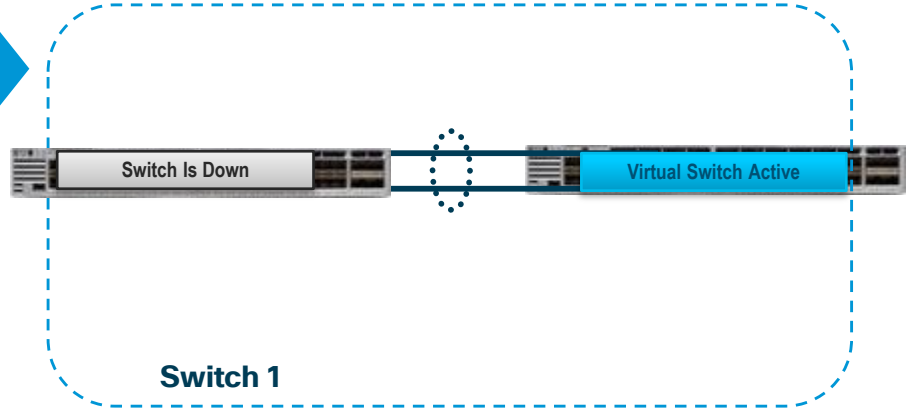
The Standby Switch detects failure by loss of all SVL ports, or no replies to SSO keep-alive packets

2 **The original Standby Switch now takes over as the new Virtual Switch Active**

Virtual Switch initiates Graceful Restart (NSF)

Non Stop Forwarding of packets continues using hardware entries synched to Switch 2

NSF Aware neighbors exchange protocol updates with the new Virtual Switch Active



StackWise Virtual – Non-Stop Forwarding (NSF)

OSPF

```
D6-9500sv-1(config)#router ospf <ID>
D6-9500sv-1(config-router)#nsf cisco | ietf
```

EIGRP

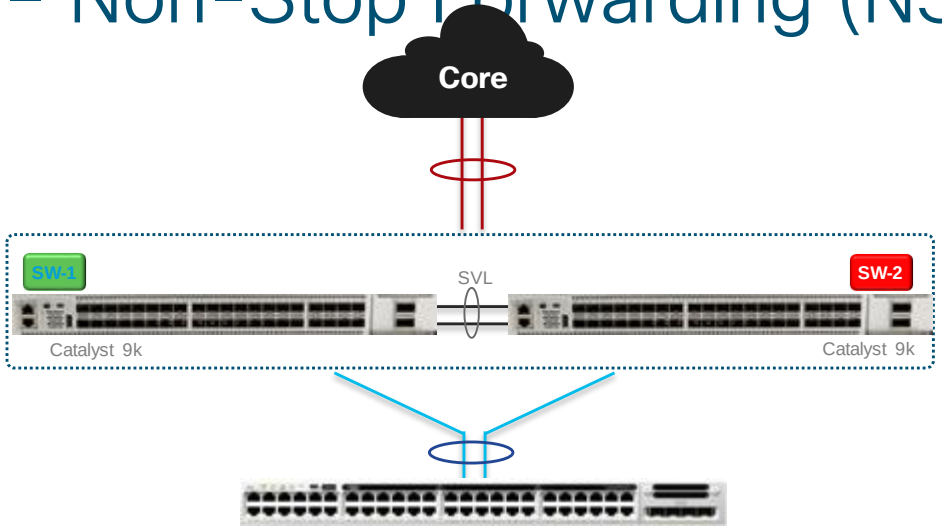
```
D6-9500sv-1(config)#router eigrp <AS ID>
D6-9500sv-1(config-router)#nsf
```

BGP

```
D6-9500sv-1(config)#router bgp <AS ID>
D6-9500sv-1(config-router)#bgp graceful-restart
```

MPLS LDP

```
D6-9500sv-1(config)#mpls ldp graceful-restart
```



- StackWise Virtual is NSF-Capable and NSF-Helper system.
- NSF capabilities for all Layer 2 protocols and several Layer 3 Unicast and Multicast routing protocols. Including VRF and MPLS.
- NSF is mandatory configuration for graceful recovery during switch over conditions. Default on for Multicast protocols, manual configuration required for each Unicast and MPLS LDP protocol.
- Implement IETF based OSPF NSF capability with "**nsf ietf**" CLI if OSPF neighbor is based on Cisco NXOS.

High Availability

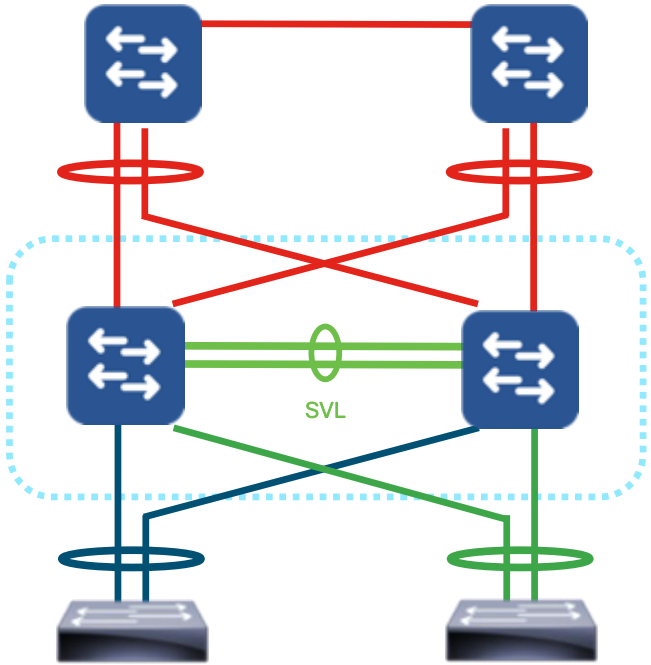
Dual-Active Detection

In a SVL Domain, one switch is elected as Active and the other as Standby

All Neighbors view SVL as a single Entity, single MAC, single IP

Since the SVL is always configured as a Port Channel, the chance of the entire SVL going down is remote…

However… IT IS POSSIBLE! ☹



Recommend to deploy the SVL with **2 or more** links, distributed across ASIC's for highest redundancy

High Availability

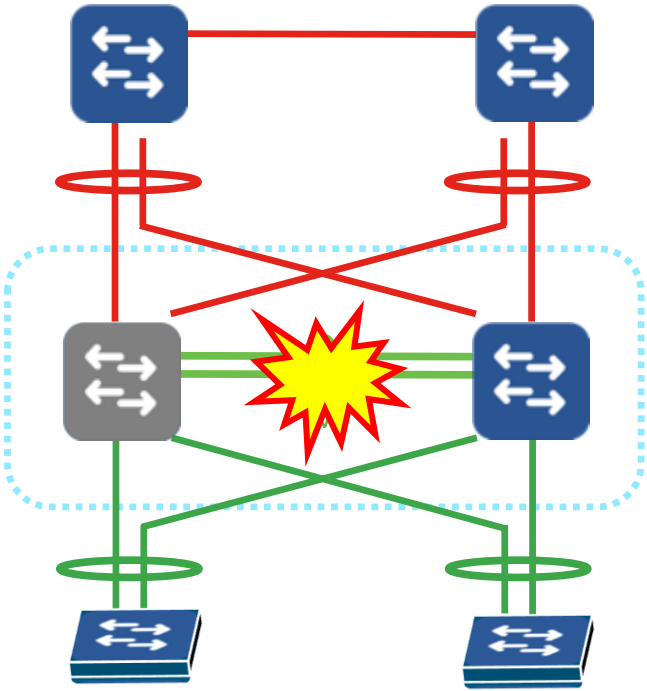
Dual-Active Detection

If the entire SVL bundle fails, the SVL Domain will enter into a "Dual Active" scenario

Both switches transition to SSO Active state, and share the same network configuration

- IP addresses, MAC address, Router IDs, etc.

This can cause communication problems in the network!



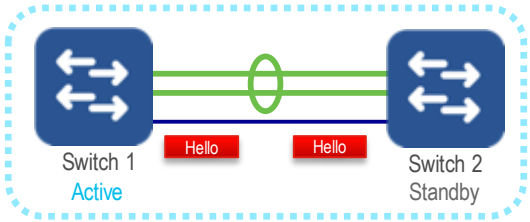
3 Step Process

1. **Dual-Active Detection** - using any detection method enabled in the system.
2. Previous SVL Active shuts down ALL interfaces, and enters "Recovery Mode"... preventing further network disruption
3. **Dual-Active Recovery** - when the SVL recovers, the switch in Recovery Mode will reload to boot into a preferred standby state

High Availability

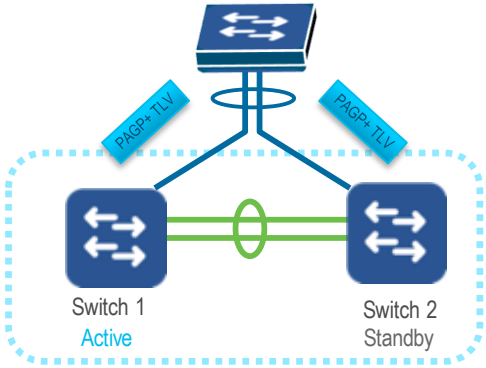
Dual-Active Protocols

Fast Hello



- **Direct L2 Point-to-Point Connection**
- **Sub-Second Convergence**
  - Typically ~50-100ms

Enhanced PAGP



- **Requires ePAGP capable neighbor:**
- **Sub-Second Convergence**
  - Typically ~200-250ms

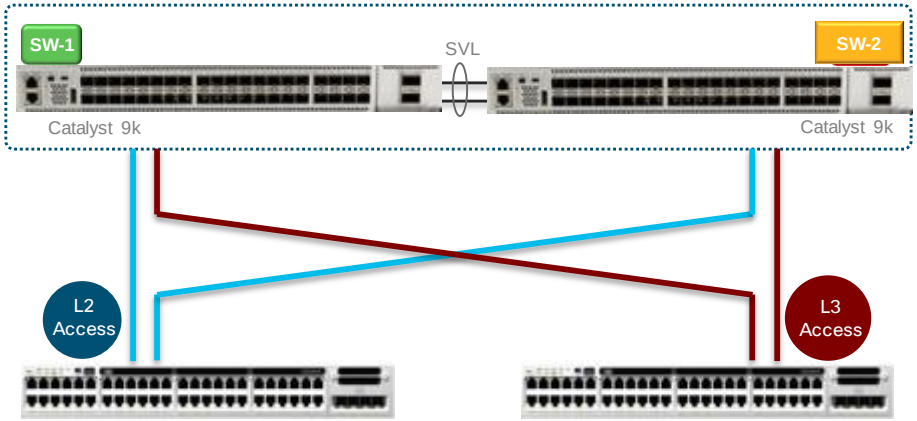
Stackwise Virtual Network Designs

You make security **possible**

Cisco live!

StackWise Virtual – Access Network Design

- Single-home network design is non-recommended
- Cannot leverage any distributed StackWise Virtual architecture benefits.
- Non-congruent L2 or L3 network design with –
  - Centralized network control-plane processing over SVL
  - Asymmetric forwarding plane. Ingress data may traverse over SVL interface and oversubscribe the ports
- Single-point of failure in various faults – Link/SFP/Stack-Member failure, SSO switchover, ISSU etc.
- Cannot be trusted switch for dual active detection purpose using ePAgP.



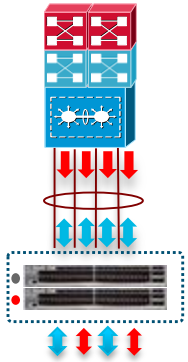
Unicast Forwarding Path

Multicast Forwarding Path

StackWise Virtual – Core Network Design

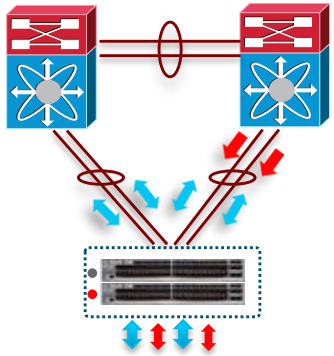
VSS Enabled Core – MEC Design

VSS-Core



SV-Dist

Standalone Core – EtherChannel Design



Standalone-Core

SV-Dist

- Improved System Performance – Single MEC hat reduces 50% control-plane load in Core
- Simple Topology – Abstracts hardware layer with single neighbor and single best forwarding path
- Improved Network Performance – Consistent unicast forwarding design. Increase in multicast switching capacity in core
- Improved App Performance – Increased unicast and multicast load sharing input variables
- Resilient – Protocol and scale-independent network recovery

Stackwise Virtual ISSU

You make security **possible**

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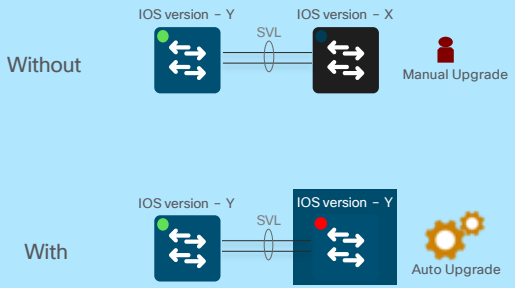
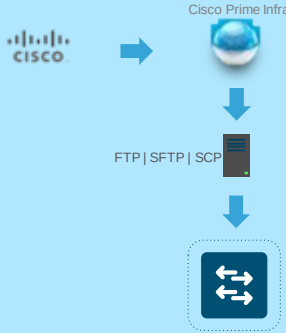
StackWise Virtual – Software Upgrade

Auto Software Upgrade



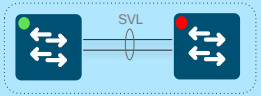
- StackWise Virtual members must have common IOS software version to pair in SSO redundancy state
- Stack member with version mis-match with ACTIVE switch will fail to RPR mode.
- Enable "**software auto-upgrade enable**" command to automate upgrade process.
- System must boot in Install mode (Default and Recommended). Auto Upgrade not supported in Bundle mode.

Cisco Prime Infra SWIM Upgrade



- Cisco IOS software upgrade from centralized Cisco Prime Infrastructure Software Image Management (SWIM)
- Supports internal or external file distribution server with – FTP, SFTP and SCP protocols
- Upgrade single or multiple StackWise Virtual domains based on automated schedule or on-demand.

In-Service Software Upgrade (ISSU)

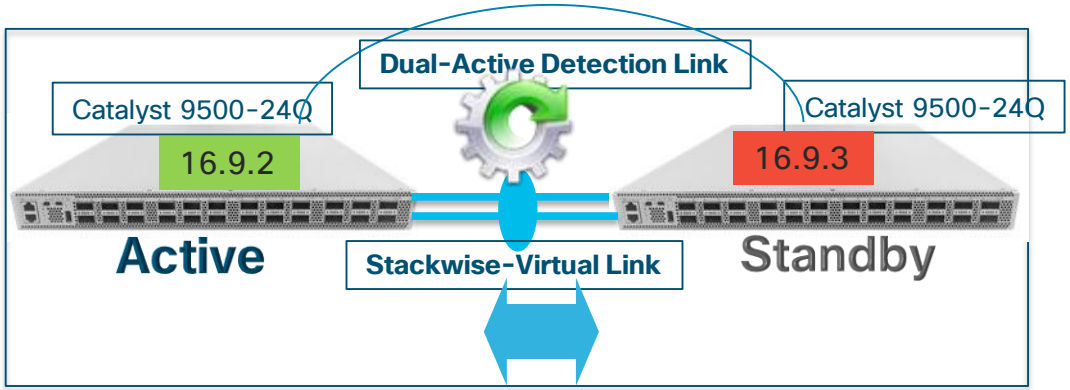


- Cat 9500 series systems deployed in StackWise Virtual mode will support ISSU
- StackWise Virtual ISSU support is currently targeted for 16.7.0
- Plan for network downtime during software upgrade on both StackWise Virtual systems

Stackwise Virtual ISSU

ISSU Overview

- ISSU provides a mechanism to perform software upgrades and downgrades without taking the switch out of service
- Leverages the capabilities of NSF and SSO to allow the switch to forward traffic during Supervisor IOS upgrade (or downgrade)
- Key technology is the ISSU Infrastructure
  - Allows SSO between different versions



C9K ISSU

Stackwise Virtual ISSU and Dual Supervisor ISSU

3 Step Process

- Install add file <tftp/ftp/flash/disk:*.bin>
- Install activate ISSU
- Install commit

Granular Control on the upgrade process with ability to rollback

1 Step Process

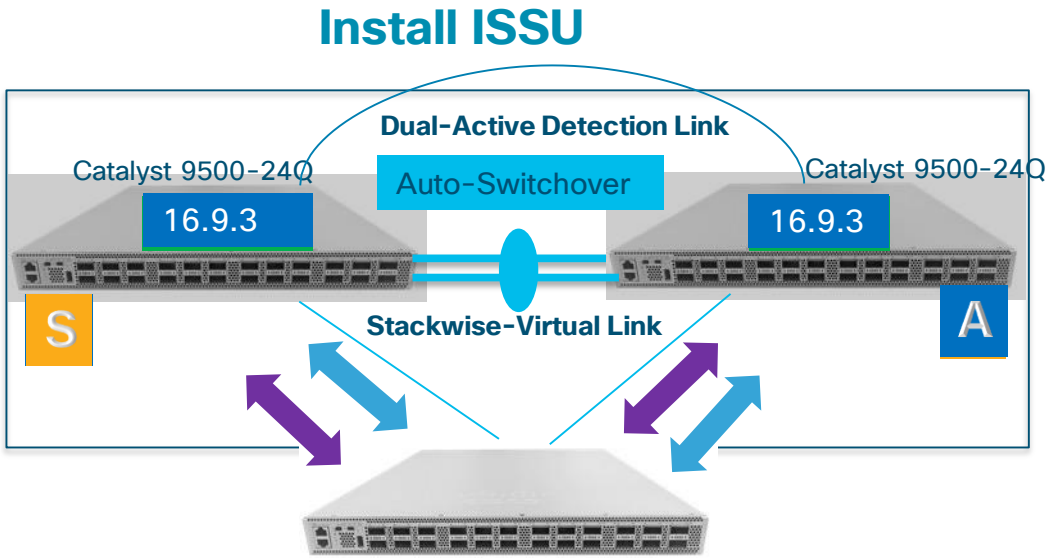
- Install add file <tftp/ftp/flash/disk:*.bin>activate ISSU commit

Single Command to perform complete ISSU

Stackwise Virtual ISSU

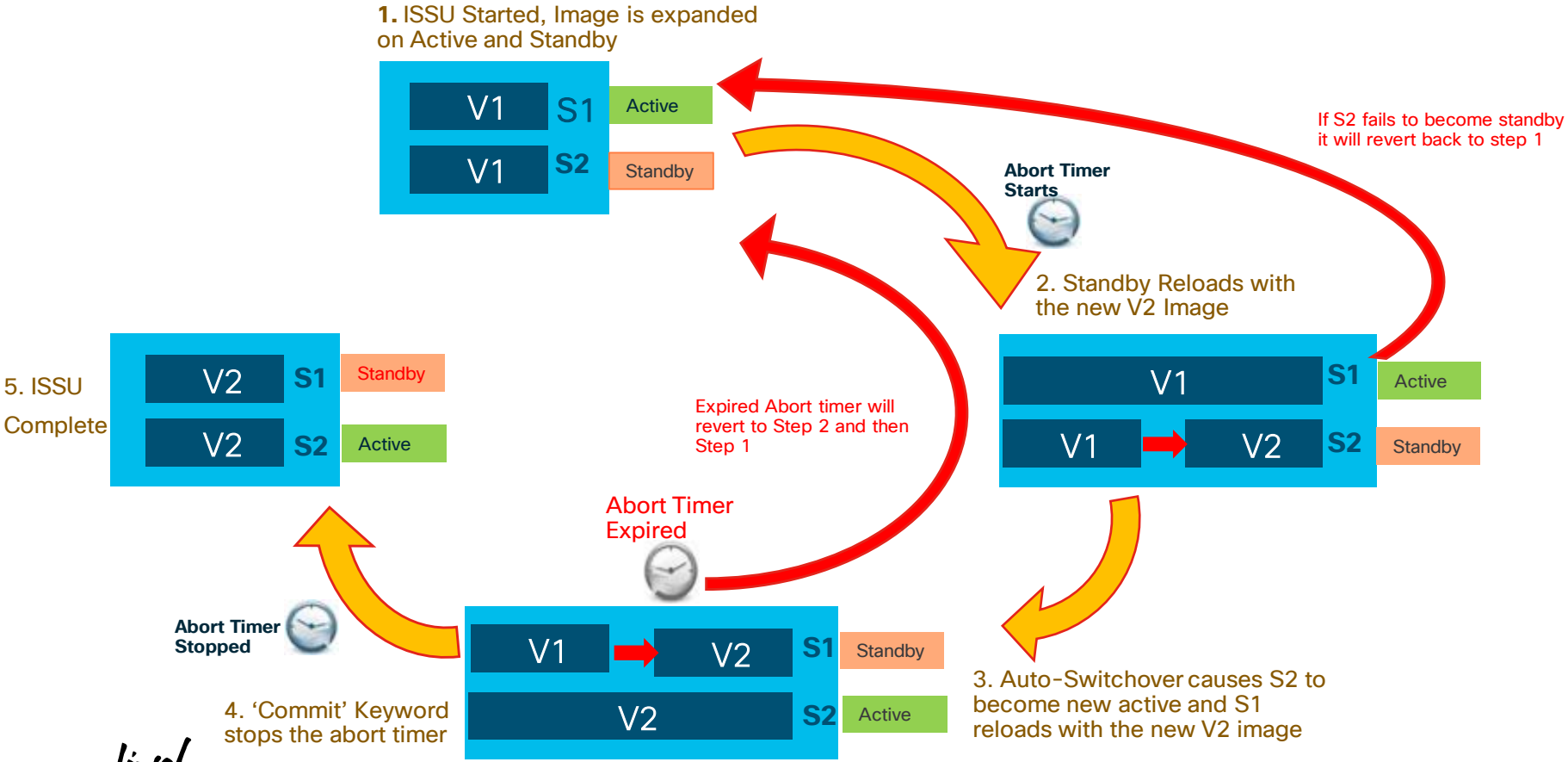
ISSU Process

2nd Sub-second traffic convergence



1st Sub-second traffic convergence

C9K ISSU Workflow

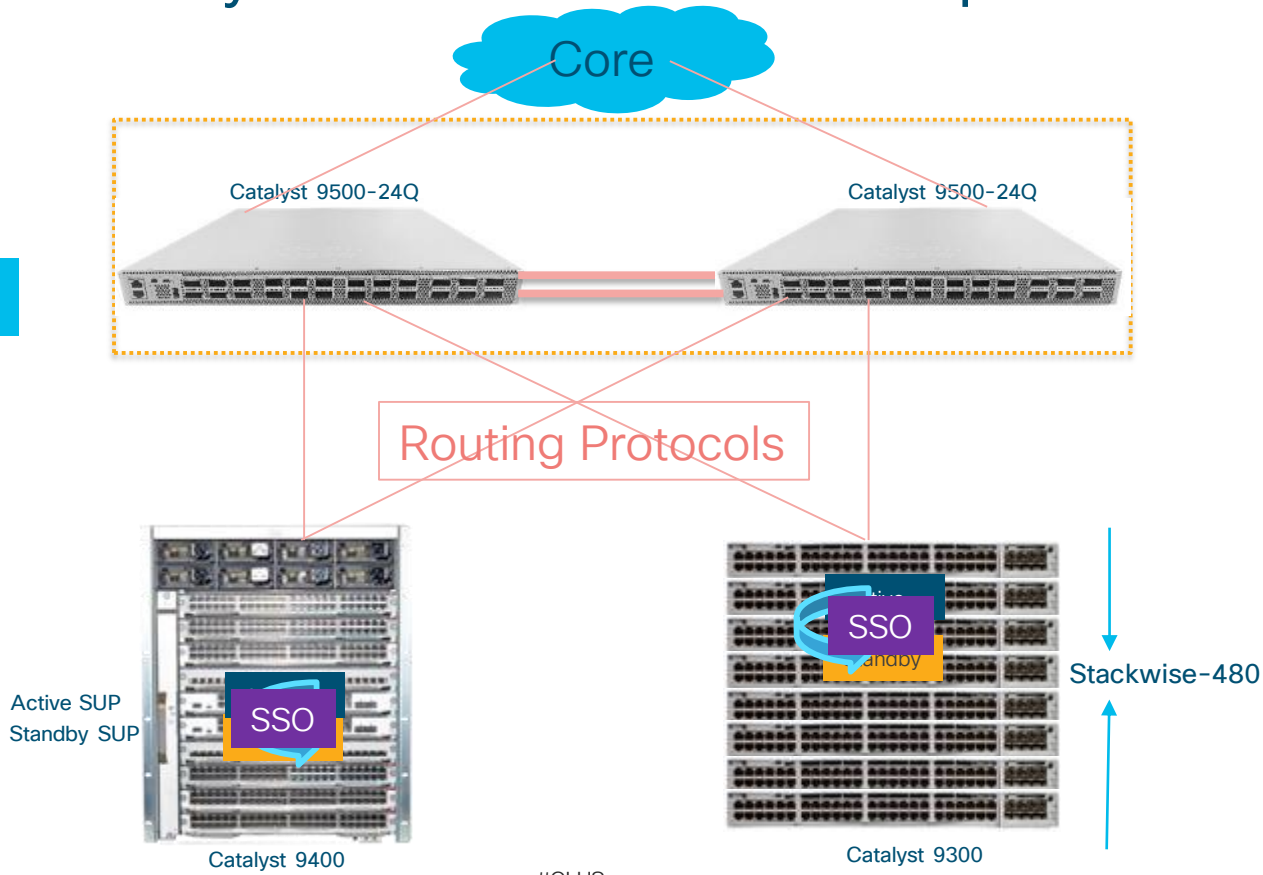


Graceful Insertion and Removal (GIR)

You make security **possible**

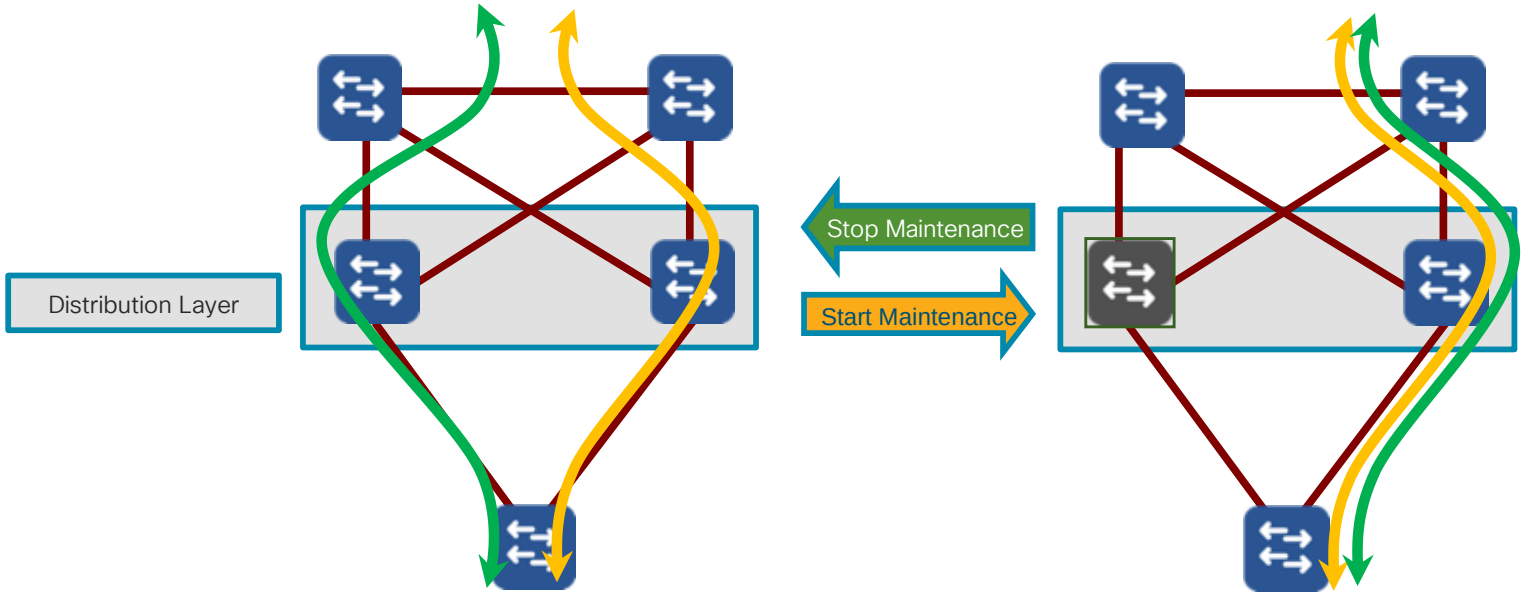
High Availability Architecture in Campus – GIR

Routed Access



Graceful Insertion and Removal on Catalyst 9000

Isolation of Switch from network Gracefully



Graceful Insertion and Removal

Upgrades with no or Minimal Traffic Loss

Comprehensive Node Isolation Framework

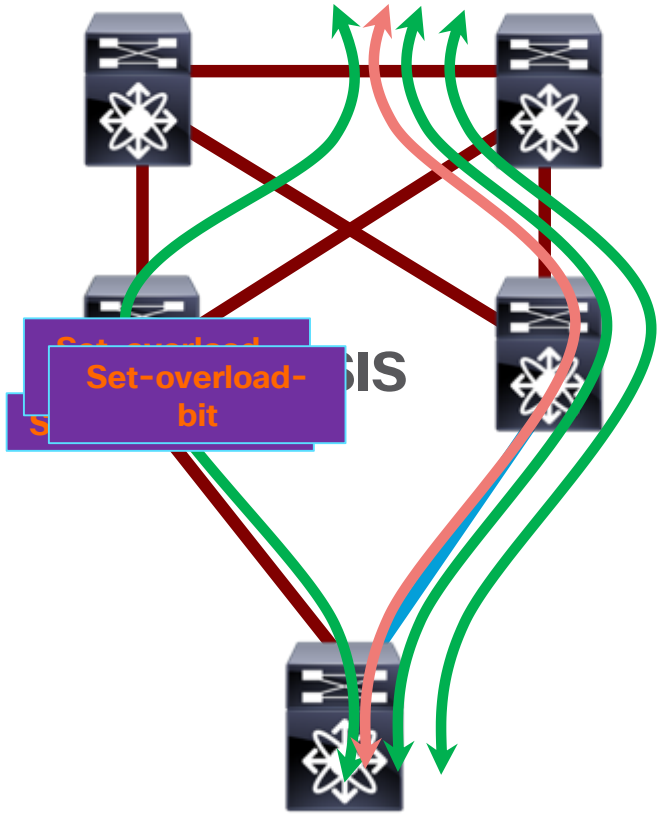
Easy Execution with a single command

Highly Customizable workflow

Simple Customizable Non-Traffic Impacting

L2 and L3 Topology with GIR Isolation

```
9300#start maintenance
Template default will be applied.
Do you want to continue?[confirm]
*Mar 25 17:43:20.162: %MMODE-6-
MMODE_CLIENT_TRANSITION_START: Maintenance Isolate
start  for router isis 1
*Mar 25 17:43:50.213: %MMODE-6-
MMODE_CLIENT_TRANSITION_COMPLETE: Maintenance Isolate
complete  for router isis 1
*Mar 25 17:43:50.213: MMODE-6-
MMODE_CLIENT_TRANSITION%_START: Maintenance Isolate
start  for shutdown l2
*Mar 25 17:44:20.214: %MMODE-6-
MMODE_CLIENT_TRANSITION_COMPLETE: Maintenance Isolate
complete  for shutdown l2
*Mar 25 17:44:20.214: %MMODE-6-MMODE_ISOLATED: System
is in Maintenance
```

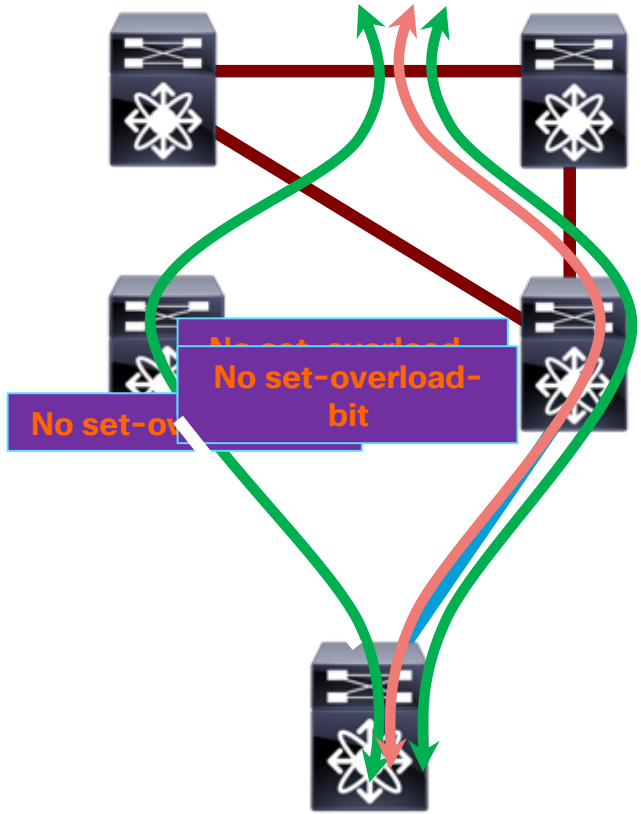


Order for Maintenance:

BGP -> IGPs in parallel (ISIS) -> L2

L2 and L3 Topology with GIR Isolation

```
9300#stop maintenance
*Mar 25 19:15:40.235: %MMODE-6-
MMODE_CLIENT_TRANSITION_START: Maintenance
Insert start  for shutdown l2
*Mar 25 19:16:10.237: %MMODE-6-
MMODE_CLIENT_TRANSITION_COMPLETE: Maintenance
Insert complete  for shutdown l2
*Mar 25 19:16:10.237: %MMODE-6-
MMODE_CLIENT_TRANSITION_START: Maintenance
Insert start  for router isis 1
*Mar 25 19:16:40.288: %MMODE-6-
MMODE_CLIENT_TRANSITION_COMPLETE: Maintenance
Insert complete  for router isis 1
*Mar 25 19:16:40.612: %MMODE-6-MMODE_INSERTED:
System is in Normal Mode
```



Order for Maintenance:

L2 → IGPs in parallel (ISIS) -> BGP

Graceful Insertion and Removal

Default and Customizable Templates

- **Default Template**
  - System Generated Profile based on the switch configuration
- **Customized Template**
  - User Configured Profile based on specific configuration or use case

```
9300L#show system mode maintenance template default
System Mode: Normal
default maintenance-template details:
router isis 1
shutdown l2
9300L#show system mode maintenance template test
System Mode: Normal
Maintenance Template test details:
shutdown l2
```

Graceful Insertion and Removal

- Snapshots

- **Automatic Snapshots**
  - Snapshots are automatically generated when entering and exiting maintenance mode
  - Captures operational data from the running system like Vlan's, Routes etc.

- **User Configured Snapshots**
  - Snapshots can be collected manually for comparing and troubleshooting

```
Switch#show system snapshots compare before_maintenance
after_maintenance
================================================================================
Feature             Tag             .before_maintenance .after_maintenance
================================================================================
[interface]

--------------------------------------------------------------------------------
      [Name:Vlan1]
                    packetsinput                181587          **181589**
      [Name:GigabitEthernet1/0/3]
                    packetsinput                101531          **101550**
                    broadcasts                  80893           **80910**
                    packetsoutput               211568          **211594**
      [Name:GigabitEthernet1/0/8]
                    output                      00:00:00,       **00:00:04,**
                    packetsinput                6915            **6918**
                    packetsoutput               57677           **57706**
      [Name:GigabitEthernet1/0/17]
                    packetsinput                101528          **101550**
                    broadcasts                  80891           **80910**
                    packetsoutput               211570          **211600**
```

Graceful Insertion and Removal

Maintenance Profile Options

- On-Reload
  - If the switch is reloaded in maintenance mode, the switch will come back in maintenance mode
- Failsafe
  - Timeout for Client Acknowledgement
- Duration
  - The Switch will come out of maintenance after the configured duration

```
9300(config)#system mode maintenance
9300(config-maintenance)#?
maintenance mode submode configuration commands:  default
Set a command to its defaults
exit        Exit from maintenance configuration mode
failsafe    Client ack timeout
no          Negate a command or set its defaults
on-reload   On reload maintenance mode configuration
template    use maintenance-template
timeout     maintenance duration
```

Configuration Profiles

- Maintenance-mode profile is applied when entering GIR mode,
- Normal-mode profile is applied when GIR mode is exited.

Automatic Profiles	Custom Profiles
• Generated by default • GIR is applied to all protocols running on the system • GIR state machine uses Registry mechanism to interface with client protocols • Use: Maintenance Windows	• User created profile for maintenance-mode and normal-mode using “templates” • Flexible selection of protocols for isolation • Use: maintenance windows and isolation during troubleshooting using preconfigured templates

Open IOS-XE Patchability

You make security **possible**

Ready for Software Patching

SMU is an emergency point fix positioned for expedited delivery to a customer in case of a network down or revenue affecting scenario.

Cold Patching: Install of a SMU will require a system reload in the first release. It is traffic impacting.

Hot Patching: Install of a SMU does not require a reload.

Why SMUs are needed?

Software Upgrades are Challenging

Cost

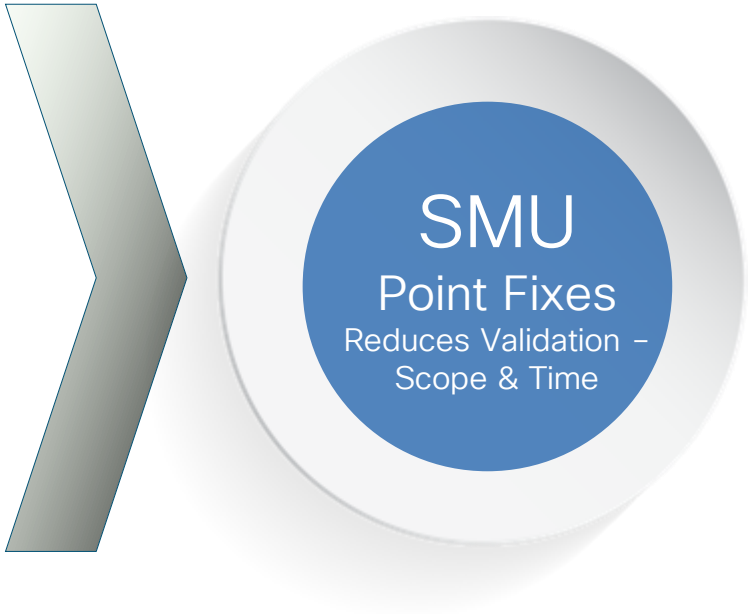
- Expensive Upgrades – Business Loss
- Each device upgrade causes Network outage

Time

- Reduced IT staff slows software roll out
- Physical presence required

Scope

- New Code requires bug analysis, certification



SMU Lifecycle – CLI

Switch# install remove ...

SMU | SMU

SMU Repository

Switch# install add ...

SMU Committed

Memory: Process:

```
show install active
show install committed
show install inactive
show install packages
```

Copy to Device

Memory: Process:

Switch# install commit ...

Switch# install activate ...

SMU Removed

Memory: Process:

SMU Applied

Memory: Process:

Switch# install deactivate ...

SMU Committed

Memory: Process:

Switch# install commit ...

Software Update Creation – Work Flow

TAC/HTTS

DDTS

Fixed ?

NO

Investigate

Service Impacting ?

NO

Commit to next SW release

YES

Request Patch

SMU Council approval

Create SW Update

Documentation

Post on CCO

DE Engineer

DT Engineer

Build Engineer

Create SW update

...

Unit /Dev Test

Integration Test

SMU Management Options

Problem: SMU Life Cycle Mgmt. at Scale is a challenge with (1) Device types (2) SW versions

There are three potential solutions

CLI

- Small Scale Deployments
- Per Device Access
- Full Control

Controller (Cisco DNA-C)

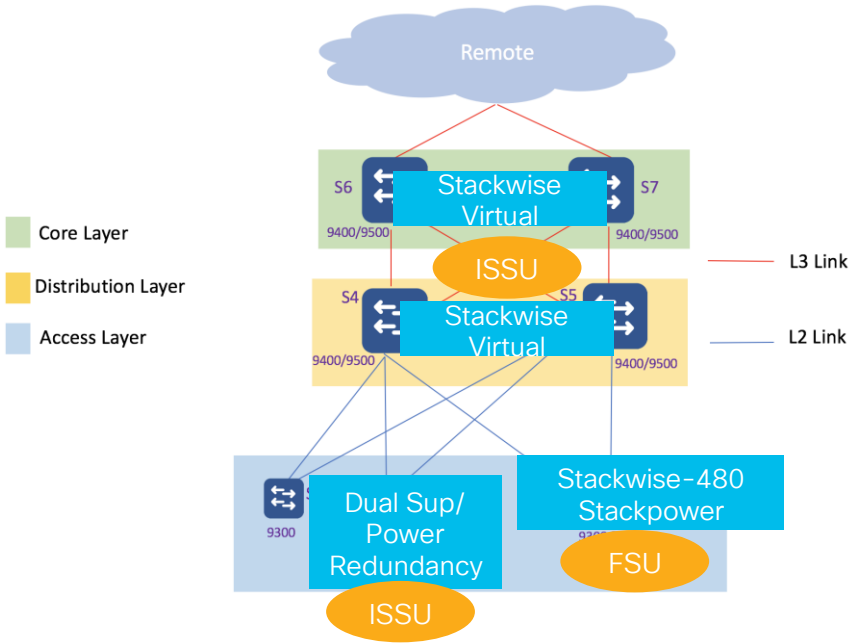
- Mass Scale Deployments
- SMU Analysis
- SMU Life Cycle Mgmt
- SMU Alerts and Notification
- SMU Orchestration across Geo's

Programmable APIs
(3rd Party tools - Chef/Puppet/Ansible)

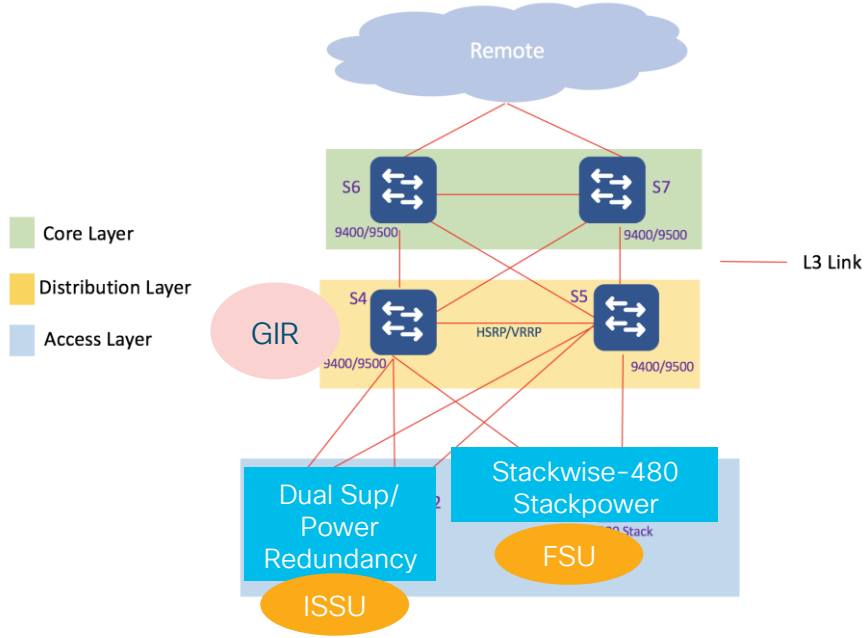
- Mass Scale Deployments
- Standard Programmatic Interfaces
  - Open Standards APIs
  - Consistent across multiple platforms
- Script Support (Shell, Perl, Python)

Enterprise Campus Network Designs

Multi-Tier **Layer2/3** Topology



Multi-Tier **Layer3** Topology



High Availability on Catalyst 9000

Catalyst 9300	Catalyst 9400	Catalyst 9500/9600

Graceful Insertion & Removal(GIR)

Supported Protocols: ISIS, **OSPF,BGP, HSRP,VRRP**

Software Maintenance Upgrade

- Cold Patching
- Hot Patching

Catalyst 9300	Catalyst 9400	Catalyst 9500/9600
• Stackwise-480 • Stack Power • Fast Software Upgrade • **Enhanced Fast Software Upgrade**	• Stackwise Virtual • ISSU(Stackwise Virtual) • ISSU (Dual Supervisor)	• Stackwise Virtual • ISSU with Stackwise Virtual 16.9.2

Quality of Service (QoS)

You make networking **possible**

Cisco live!

Why QoS ?

Guaranteeing voice quality

Video Quality

Bandwidth Savvy Business Applications

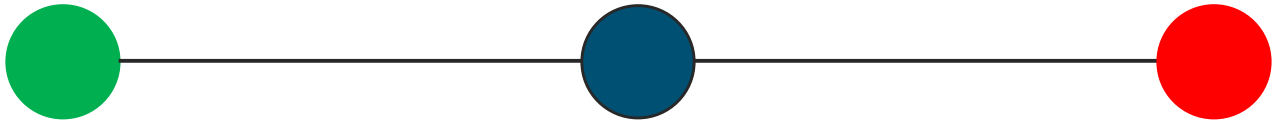
protect network infrastructure to deal with abnormal events

de-prioritizing non-business applications

protecting the control planes

Determining Business Relevance

How Important is an Application to Your Business?



Relevant

- These applications directly support business objectives
- Applications should be classified, marked and treated marked according to industry best-practice recommendations

RFC 4594

Default

- These applications may/may not support business objectives (e.g. HTTP/HTTPS/SSL)
- Applications of this type should be treated with a Default Forwarding service

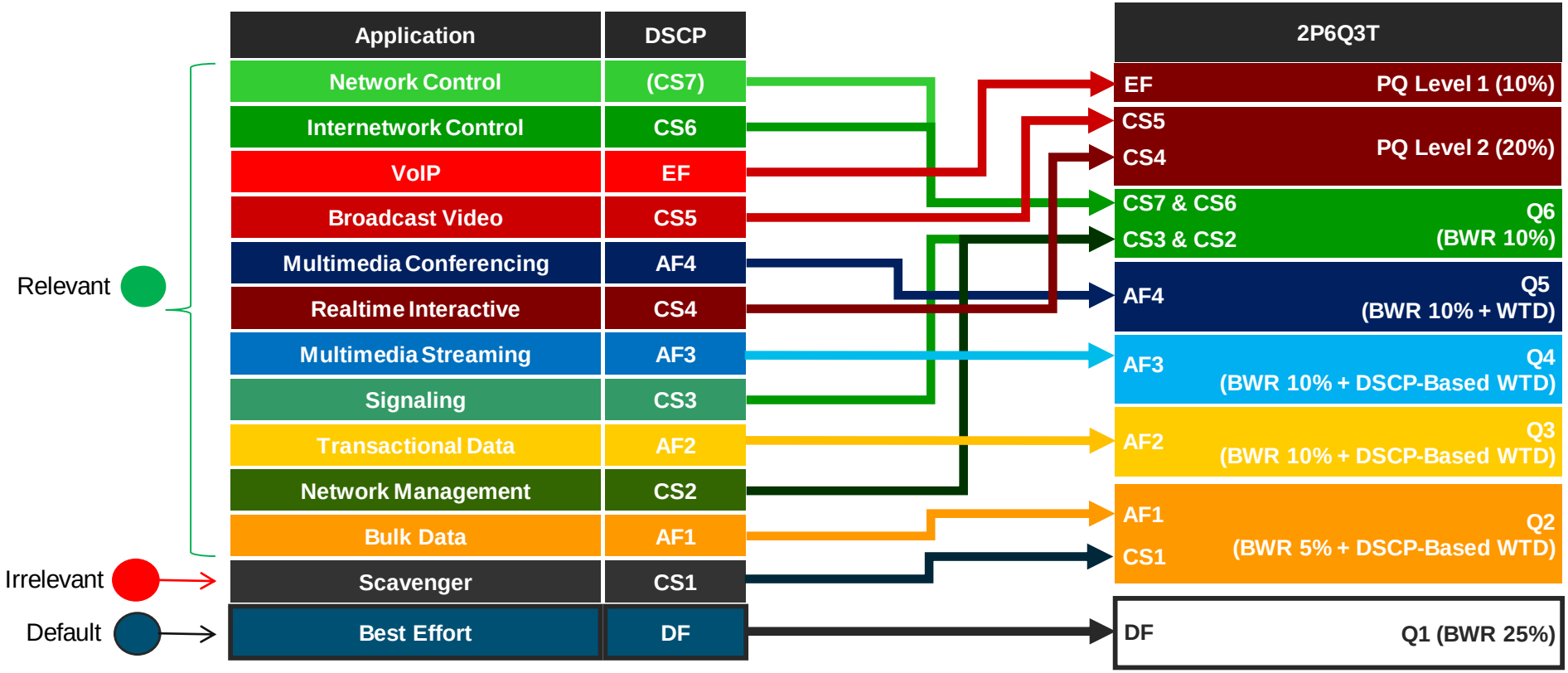
RFC 2474

Irrelevant

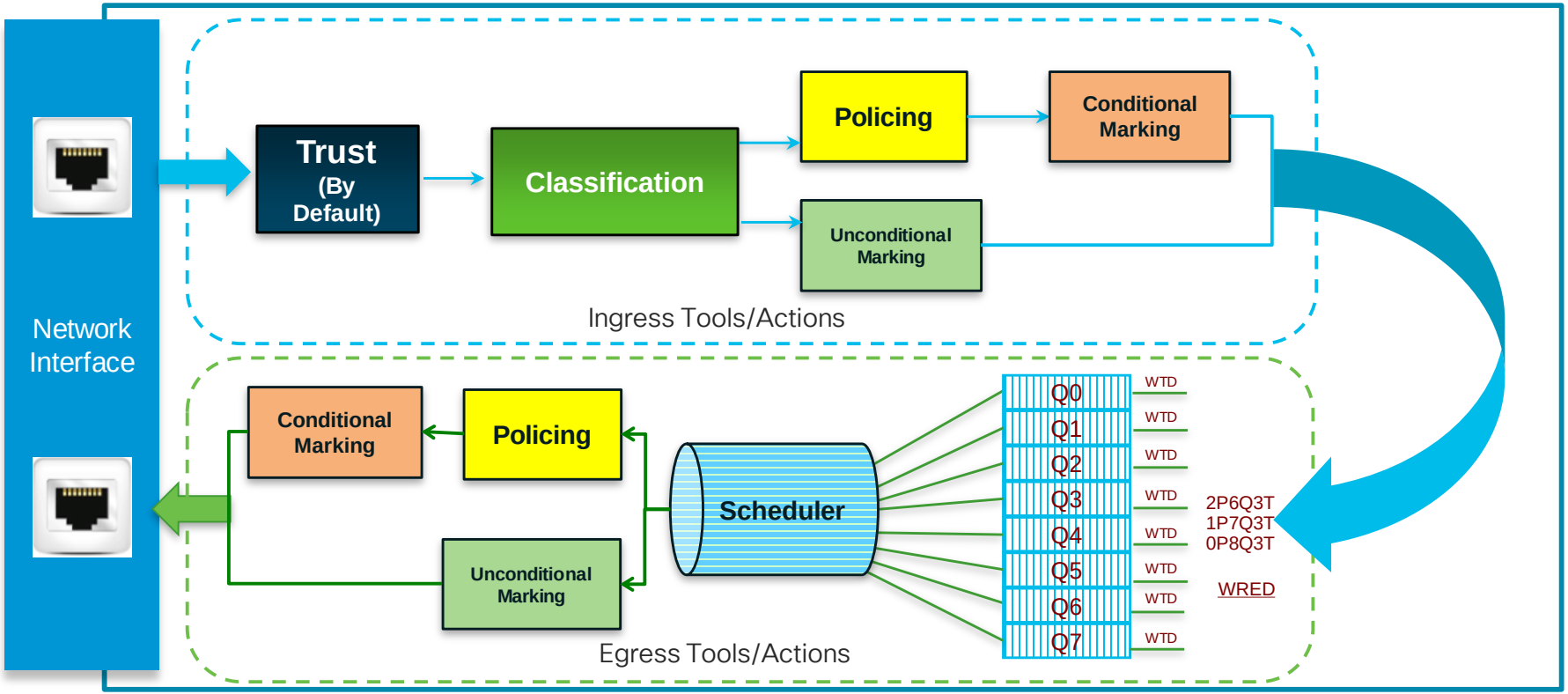
- These applications do not support business objectives and are typically consumer-oriented
- Applications of this type should be treated with a “less-than Best Effort” service

RFC 3662

Catalyst 9000 Campus QoS Design



Catalyst 9000 – QoS Tools



Catalyst 9000 Family – Consistent QoS

Highlights

MQC

1P7Q3T or
2P6Q3T

8 Queues
per Port

8 Queues
per Port

Trust
By Default

HQoS
2-Level

No DBL
WRED

Buffer
8MB – 36MB
Depending on the ASIC

Trust & Conditional Trust

Trust Model

Trusted 

- Catalyst 9000 family trust all ports by Default (DSCP based)

DSCP/Prec/CoS on the incoming packets are retained

Untrust Model

- Trust Specific Devices – Cannot trust multiple devices at the same time

```
interface GigabitEthernet 1/0/1
 trust device cisco-phone      [or]
 trust device cts          [or]
 trust device ip-camera    [or]
 trust device media-player
```

```
interface GigabitEthernet 1/0/1
 trust device cisco-phone
 service-policy input CISCO-IPPHONE
```

Traffic Classification

- A class-map can be defined as a logical OR “match-any”
- And now “match-all” is supported on Catalyst 9000

OR

```
Switch(config-cmap)# class-map match-any VOICE
Switch(config-cmap)# match ?
  access-group    Access group
  class-map       Class map
  cos             IEEE 802.1Q…
  dscp            Match DSCP …
  ip              IP specific values
  non-client-nrt  Match non-client NRT
  precedence      Match Precedence…
  protocol        Protocol
  qos-group       Qos-group
  vlan            VLANs to match
```

AND

```
Switch(config-cmap)# class-map match-all VOICE
Switch(config-cmap)# match ?
  access-group    Access group
  class-map       Class map
  cos             IEEE 802.1Q…
  dscp            Match DSCP …
  ip              IP specific values
  non-client-nrt  Match non-client NRT
  precedence      Match Precedence…
  protocol        Protocol
  qos-group       Qos-group
  vlan            VLANs to match
```

Marking

- Three types of marking policies:
  - Conditional Policer based marking
  - Unconditional Explicit marking
  - Table Map based marking
- Marking with ‘set’
- Marking with Table Maps
- Table-maps can be applied only on class-default

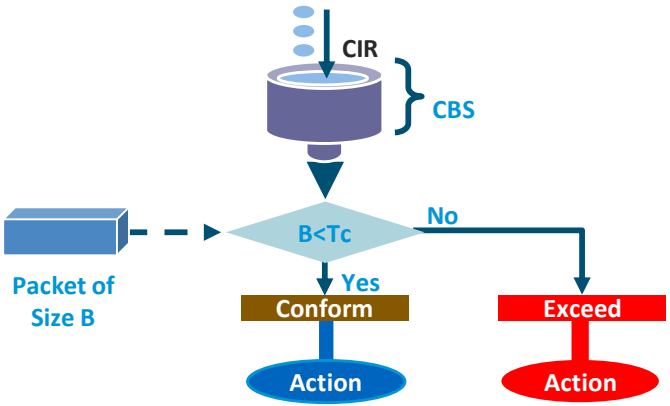
```
Catalyst3650(config-pmap-c)#set ?
  cos          Set IEEE 802.1Q/ISL class…
  dscp         Set DSCP in IP(v4) and IPv6…
  ip           Set IP specific values
  precedence   Set precedence in IP(v4) and IPv6…
  qos-group    Set QoS Group
```

```
[class-maps omitted for brevity]
policy-map MARKING-POLICY
 class VOIP
  set dscp ef
 class MULTIMEDIA-CONFERENCING
  set dscp af41
 class SIGNALING
  set dscp cs3
 class TRANSACTIONAL-DATA
  set dscp af21
 class BULK-DATA
  set dscp af11
 class SCAVENGER
  set dscp cs1
 class default
  set dscp dscp table COS2DSCP
```

```
table-map COS2DSCP
 map from  5 to 46
 default copy
```

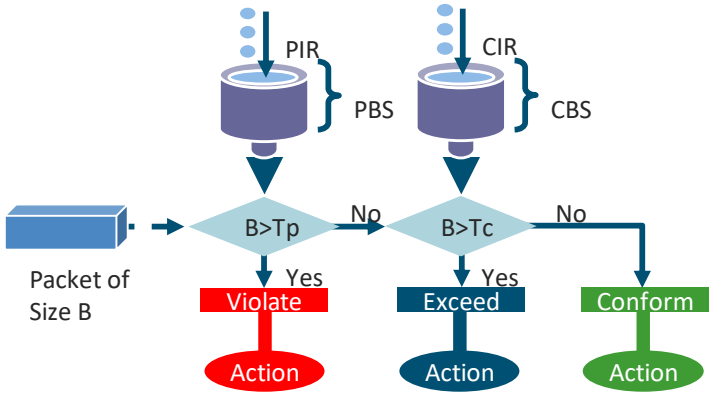
Policing

1 Rate 2 Color




```
police cir 100000000 bc 3125000 conform-
action set-dscp-transmit af41 exceed-action
drop
```

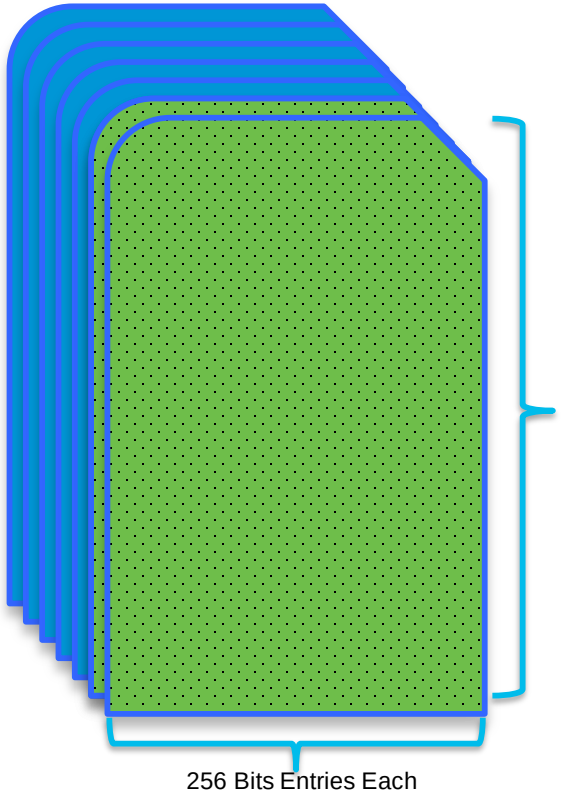
2 Rate 3 Color




```
police cir percent 10 pir percent 50
conform-action transmit exceed-action set-
dscp-transmit af11 violate-action drop
```

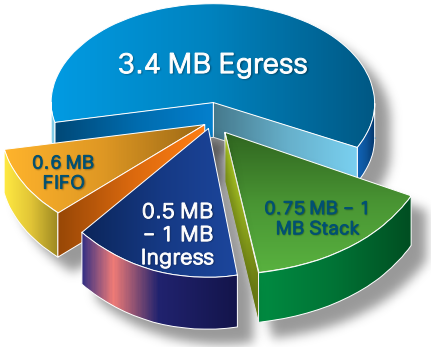
TCAM Resources

QoS TCAM Resources	Cat9300	Cat9400/cat9500
IPv4 Entries	5000 (256 bits) Entries	18000 (256 bits) Entries
IPv6 Entries	Half the IPv4 (512 bits)	Half the IPv4 (512 bits)
Class-maps (Ingress)	255	255
Class-maps (egress)	255	255
Table-maps (ingress)	16	16
Table-maps (egress)	16	16
Aggregate Policers	Per ASIC: 4K (2K per Core) (1R2C), 2K (1K per core) (2R3C) (not shared across cores)	Per ASIC: 4K (2K per Core) (1R2C), 2K (1K per core) (2R3C) (not shared across cores)
Wired Queues/port	8 queues (2 can be priority)	8 queues (2 can be priority)



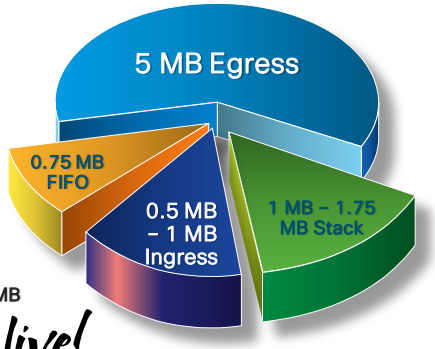
Buffer Size Comparison per Platform

UADP2.0 Mini



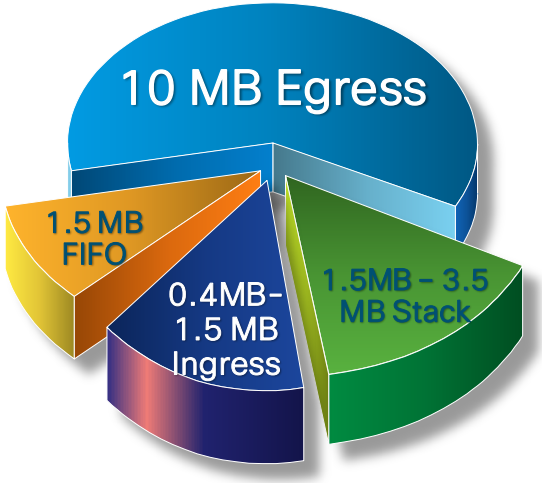
per ASIC 6 MB

UADP2.0



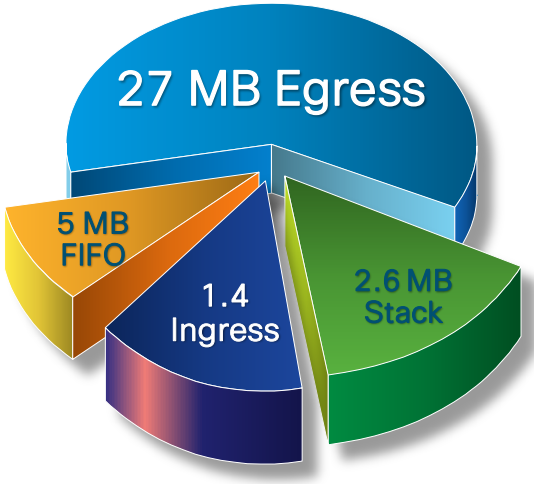
per Core 8 MB
per ASIC 8+8 MB

UADP2.0XL



per Core16 MB
per ASIC 16 + 16 MB

UADP3.0



per Core 36 MB
per ASIC 36 MB

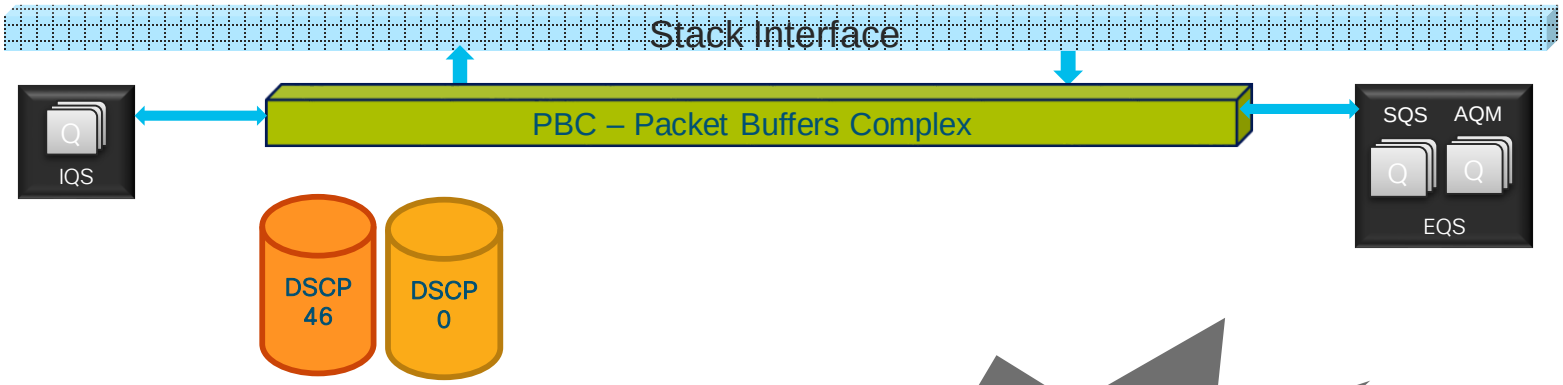
Auto QoS

- Generate templates of Class-maps and Policies based on **best practices** per connected device type
- Different template Versions (Latest: 4.0)

```
auto qos voip {cisco-phone | cisco-softphone | trust}
auto qos video {cts | ip-camera | media-player}
auto qos classify [police]
auto qos trust {cos | dscp}
```

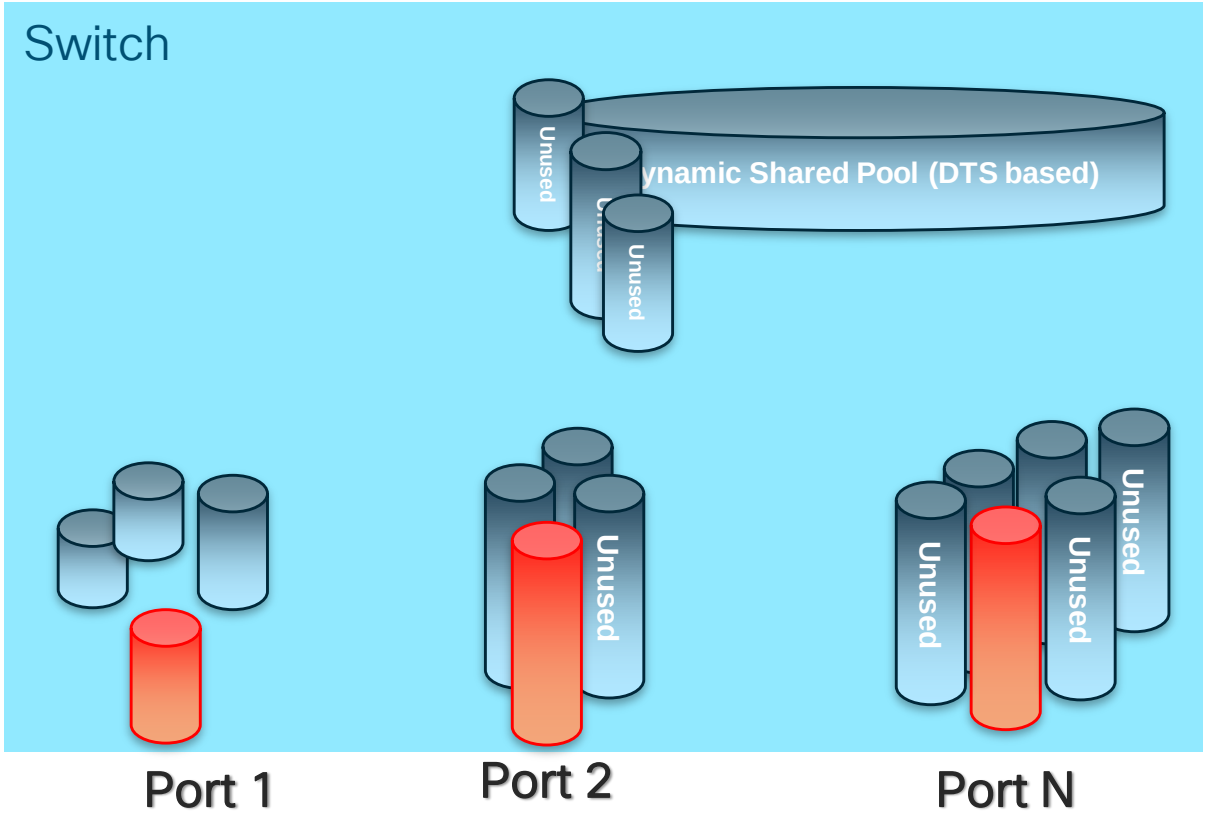
Reference:
www.cisco.com/en/US/docs/solutions/Enterprise/Video/autoqosmediacampus.pdf

IQS Scheduling to Stack Interface



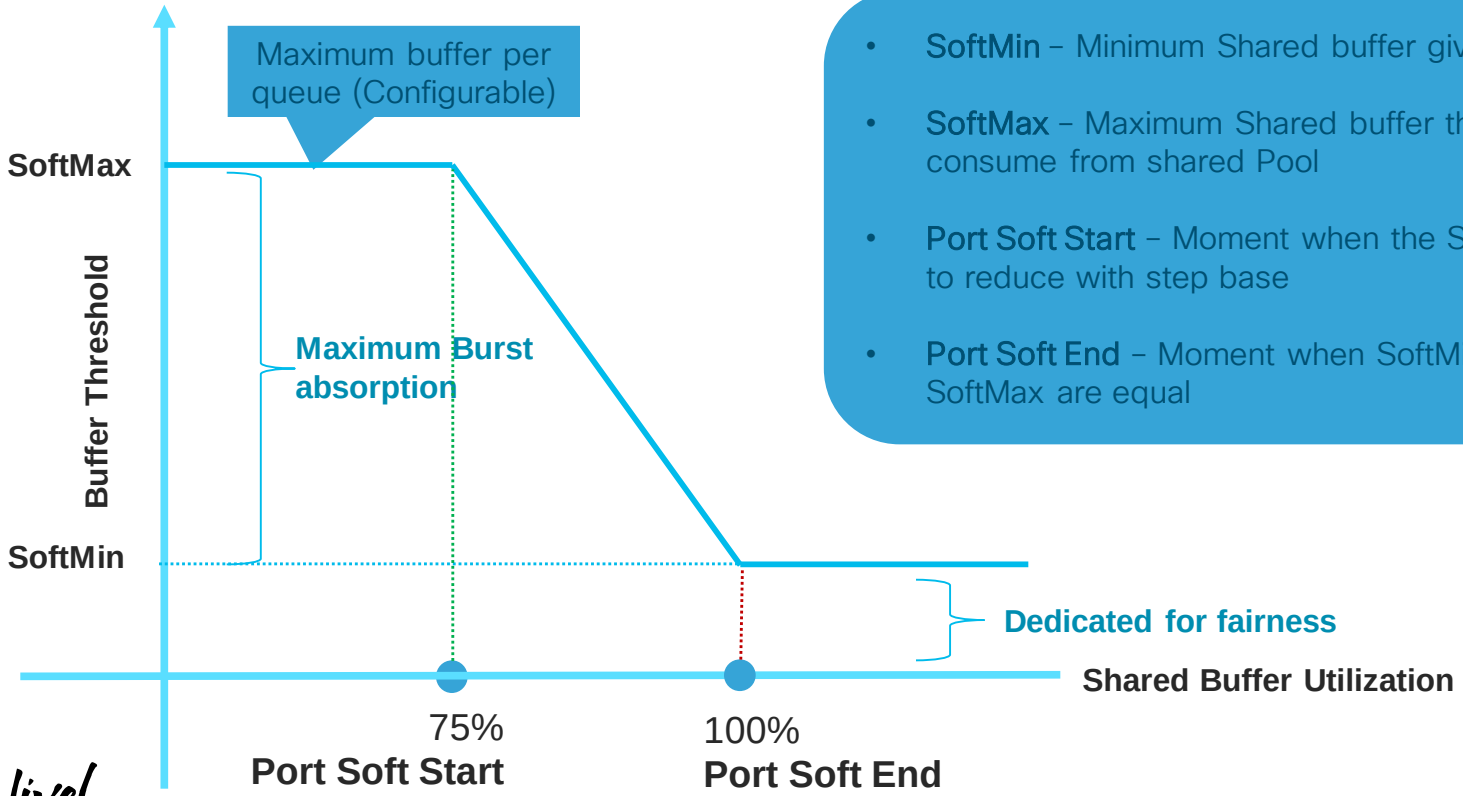
IQS will schedule
High Priority packets
first over stack

Dynamic Threshold Scalability (DTS)



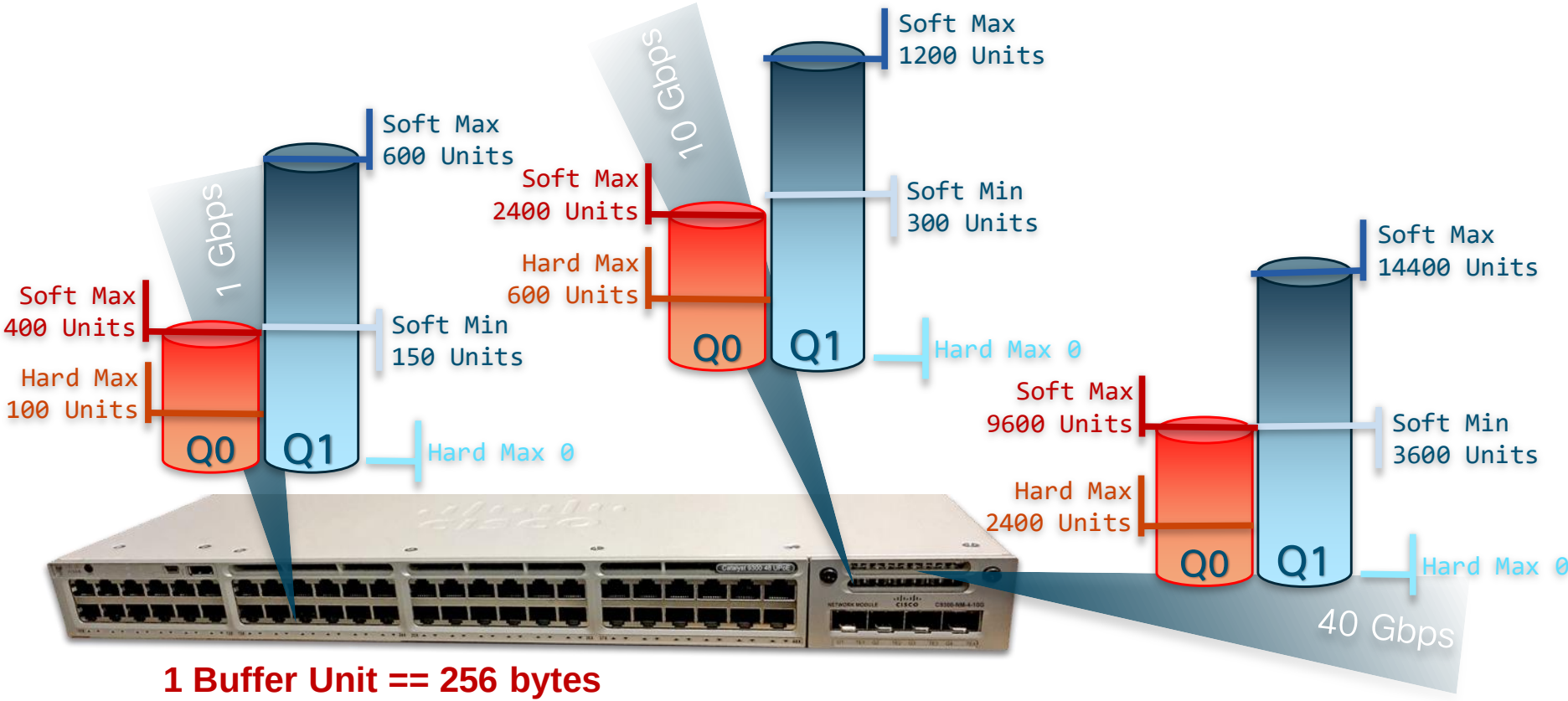
- Shared buffer is good for burst absorption.
- Dedicated buffer is good for predicated performance for each port.
- Buffer management is flexible: Dedicated plus shared.
  - Configurable dedicated threshold per port/queue
  - Configurable global maximum shared threshold
  - Automatically adjusted depends on the available shared pool

DTS – Dynamic Fair Buffer Sharing



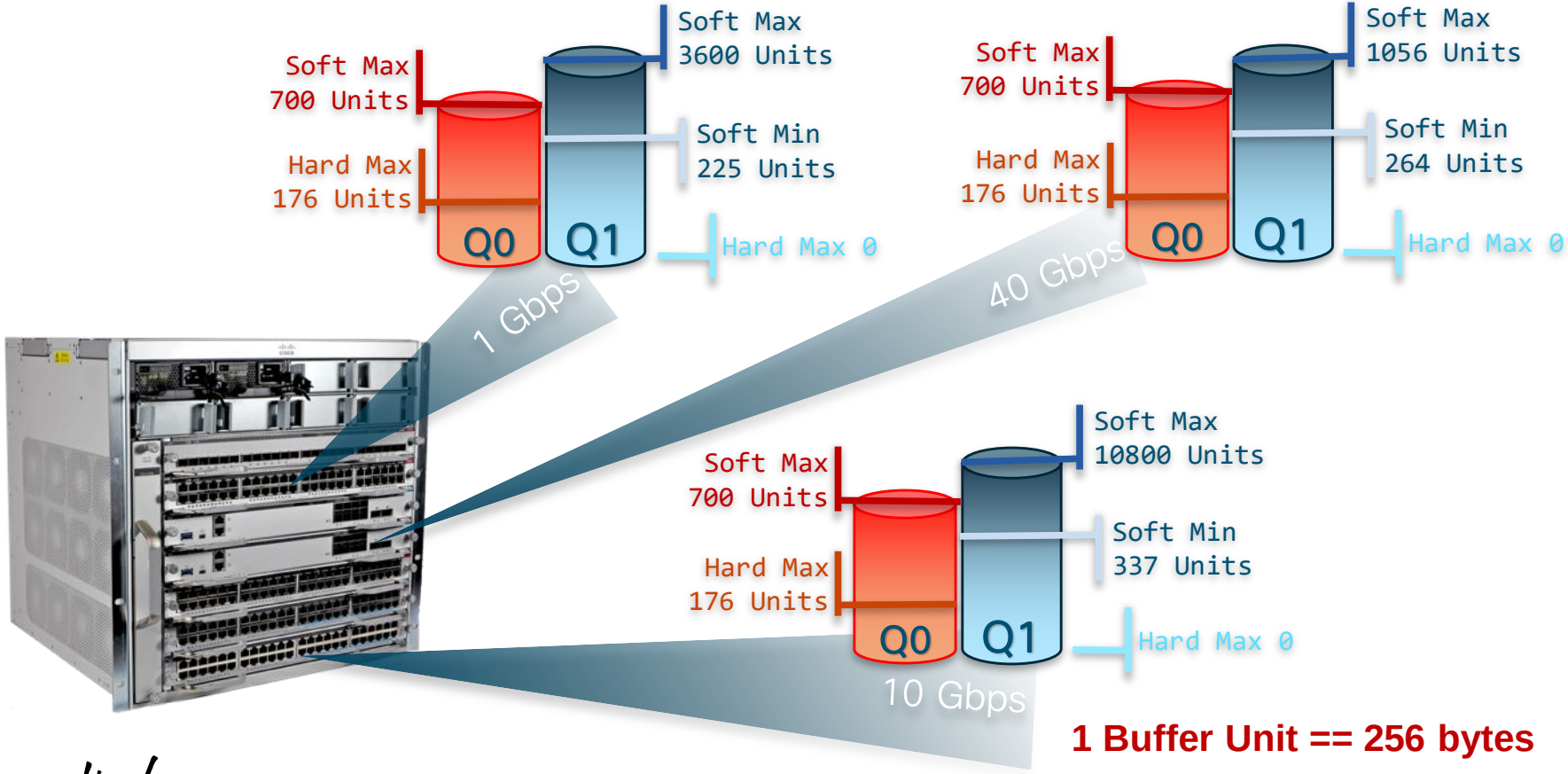
- **SoftMin** – Minimum Shared buffer given to the port
- **SoftMax** – Maximum Shared buffer the port can consume from shared Pool
- **Port Soft Start** – Moment when the Softmax start to reduce with step base
- **Port Soft End** – Moment when SoftMin and SoftMax are equal

Default Buffer Allocation – Cat 9300



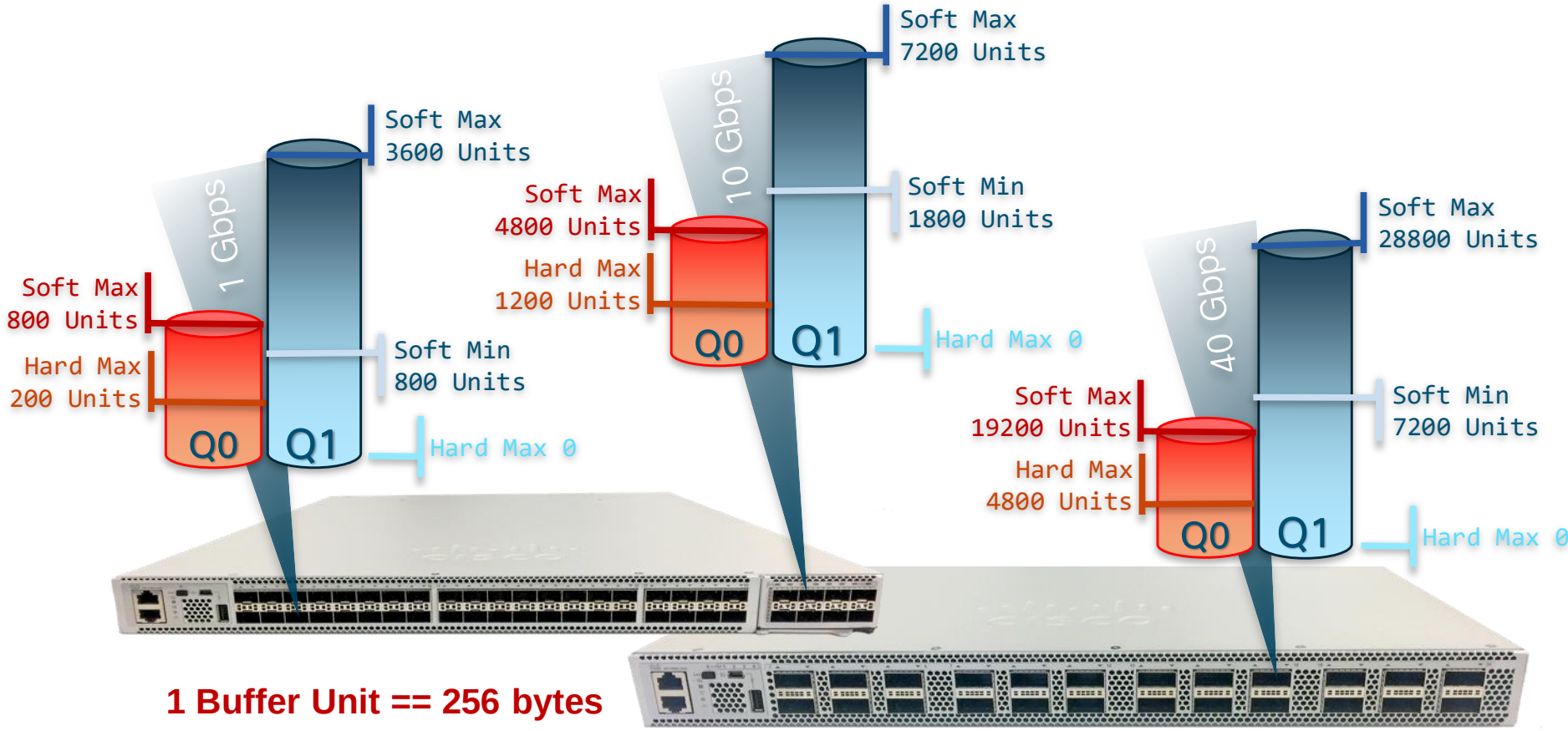
1 Buffer Unit == 256 bytes

Default Buffer Allocation – Cat 9400



1 Buffer Unit == 256 bytes

Default Buffer Allocation – Cat 9500



1 Buffer Unit == 256 bytes

Default Buffer Allocation per port Speed

Platform	Port Speed	100 / 1 / 2.5 / 5 Gbps (if applicable)		10 Gbps		40 Gbps	
	Queue	HardMax	SoftMax	HardMax	SoftMax	HardMax	SoftMax
Cat 9300	Q0	100	400	600	2400	2400	9600
Cat 9400	Q0	176	700	176	700	176	700
Cat 9500	Q0	200	800	1200	4800	4800	19200
		SoftMin	SoftMax	SoftMin	SoftMax	SoftMin	SoftMax
Cat 9300	Q1	150	600	300	1200	3600	14400
Cat 9400	Q1	225	3600	264	1056	337	10800
Cat 9500	Q1	800	3600	1800	7200	7200	28800

Notes: Softmax for Q0 is 4 times Hardmax.
Softmax for Q1 is 4 times “Soft Min”
Q1 doesn’t have Hardmax.

Security

You make security **possible**

Cisco live!

Catalyst 9000 Security Features

Visibility

- Mission-critical application visibility (NBAR)*
- Full NetFlow telemetry

Segmentation

- Highest level of macro and micro segmentation with SD-Access
- Multidomain policy integration

Threat defense

- MACsec 256-bit link encryption
- Encrypted Traffic Analytics*
- Trustworthy solutions

Consistently delivered throughout the Cisco® Catalyst® 9000 family

* Roadmap on Cisco Catalyst 9500 High Performance and Catalyst 9600 Series

Security-Trustworthy Solutions

You make security **possible**

Cisco live!

Cisco Catalyst 9000 Platform Trustworthy Solutions

Design/ Develop → Plan/ Order → Source → Make → Quality → Delivery → Service/End of Life (EOL)

Physical security practices + security technology innovations + logical security processes

PnP SUDI support
Two-way trust

Image signing
Authentic OS

Hardware authenticity
Genuine hardware

Secure boot
Boot sequence check

Integrity verification
Malware protection

Runtime defenses
64-bit ASLR

Cisco® trustworthy systems use industry best practices to help ensure full development lifecycle integrity and end-to-end security

Cisco Trust Anchor Module (TAm)

Integrity Applications

TAM Services Libraries

- HW Based Entropy
- HW Authenticity Check
- Secure PnP
- Integrity Verification

Crypto Functions

Tamper-Proof Storage

Boot Measurements

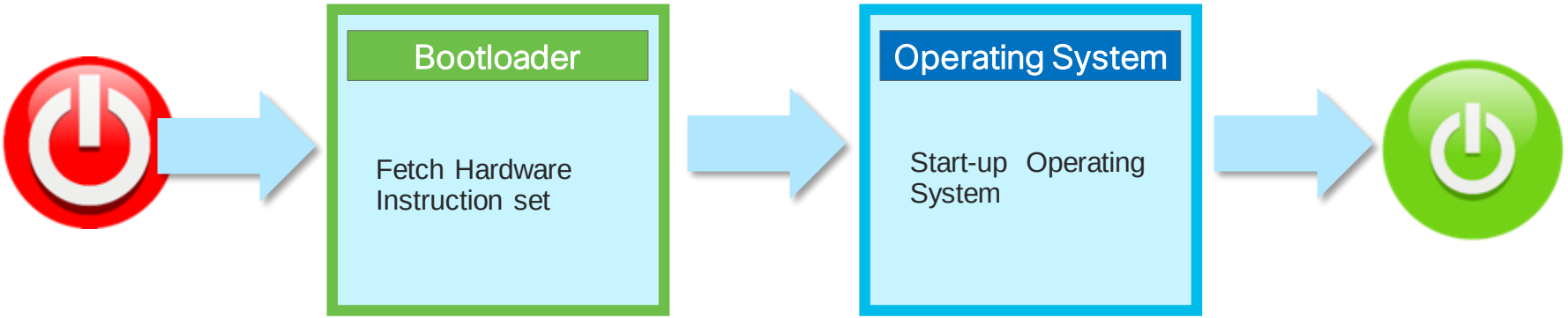
SUDI

- Anti-Tamper Chip Design
- Built-In Crypto Functions
- Secure Storage

Secure Unique Device Identification (SUDI)

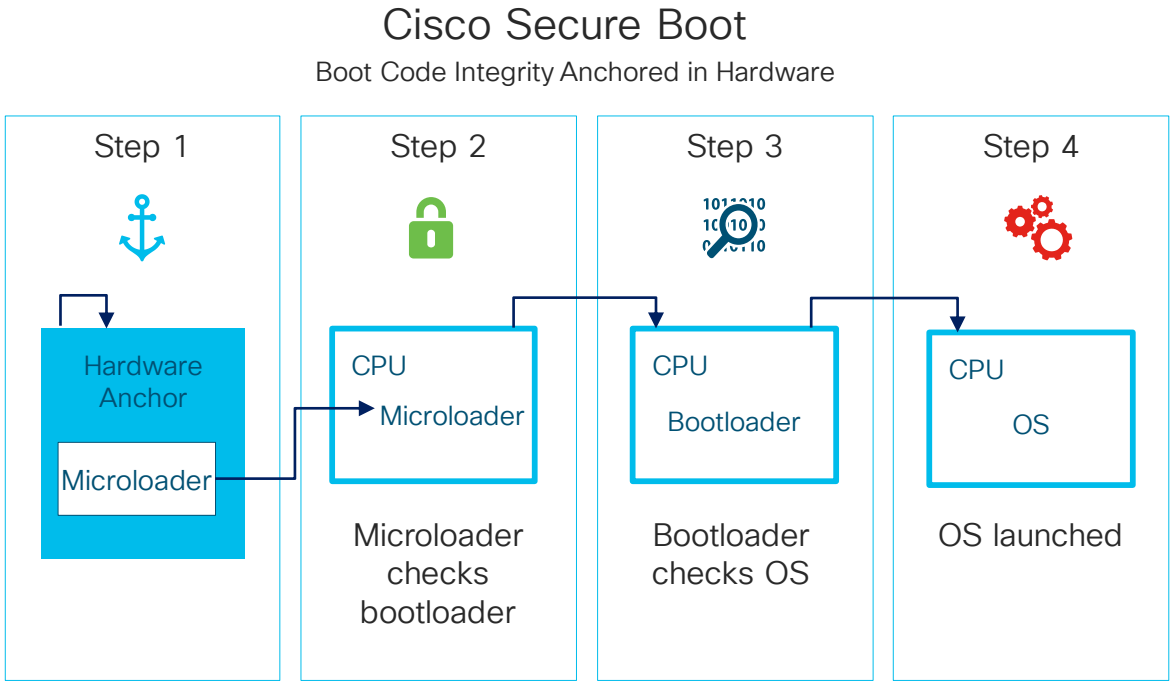
- Tamperproof ID for the device
- Binds the hardware identity to a key pair in a cryptographically secure X.509 certificate PID during manufacturing
- Connections with the device can be authenticated by the SUDI credential
- IEEE 802.1AR Compliant

Boot Sequence



Cisco Secure Boot

Anchors Secure Boot in Hardware to Create a Chain of Trust



- Only authentic signed Cisco software boots up on a Cisco platform
- The boot process stops if any step fails to authenticate
- IOS “show software authenticity” command illustrates the results

Secure Boot Verification during boot up

Microloader doesn't display verification, if verification fails then the box doesn't boot at all.

```
Initializing Hardware ...

System integrity status: 00000610
Rom image verified correctly


System Bootstrap, Version 15.4(3r)S, RELEASE SOFTWARE (fc1)
Copyright (c) 1994-2014  by cisco Systems, Inc.
<snip>
```

1 2

ROMMON Secure boot verification

IOS Secure boot verification

```
<snip>
############################################################
Boot image size = 425853700 (0x19620304) bytes

Package header rev 1 structure detected
Calculating SHA-1 hash...done
validate_package: SHA-1 hash:
        calculated 334207fa:464503d3:2e7abd5f:160919d0:b425523b
        expected   334207fa:464503d3:2e7abd5f:160919d0:b425523b

RSA Signed RELEASE Image Signature Verification Successful.
Package Load Test Latency : 6511 msec
Image validated
<snip>
```

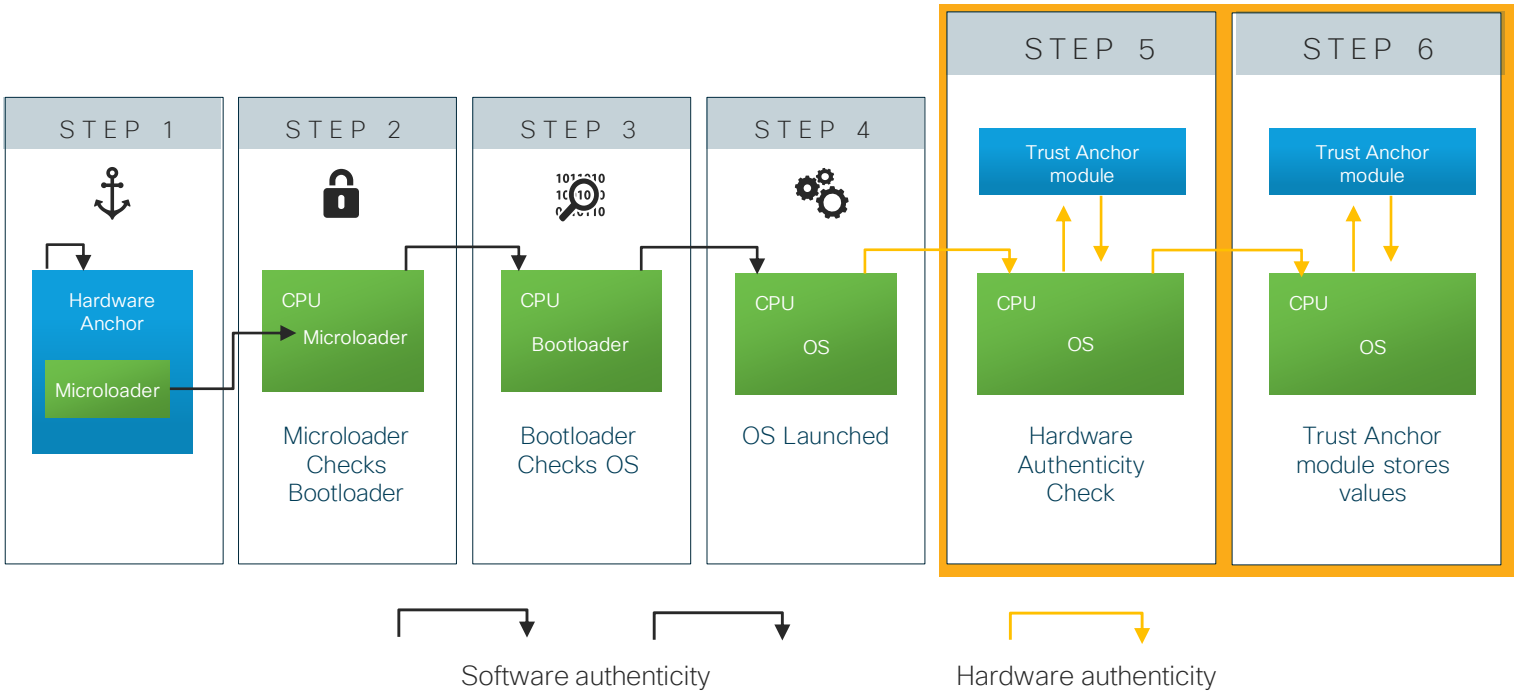
3 4

Secure Boot Verification after bootup

```
Switch#show software authenticity running
<snip> (other packages not displayed)

PACKAGE cat3k--universalk9.16.03.05..SPA.pkg
------------------------------------------------------------------
Image type                    : Production
    Signer Information
        Common Name           : CiscoSystems
        Organization Unit     : IOS-XE
        Organization Name     : CiscoSystems
    Certificate Serial Number : 54F33A2E
    Hash Algorithm            : SHA512
    Signature Algorithm       : 2048-bit RSA
    Key Version               : A

    Verifier Information
        Verifier Name         : mono
        Verifier Version      : 16.03.05

SYSTEM IMAGE
------------
Image type                    : Production
    Signer Information
        Common Name           : CiscoSystems
        Organization Unit     : IOS-XE
        Organization Name     : CiscoSystems
    Certificate Serial Number : 54F33B36
    Hash Algorithm            : SHA512
    Signature Algorithm       : 2048-bit RSA
    Key Version               : A

    Verifier Information
        Verifier Name         : ROMMON
        Verifier Version      : System Bootstrap, Version 15.4(3r
```

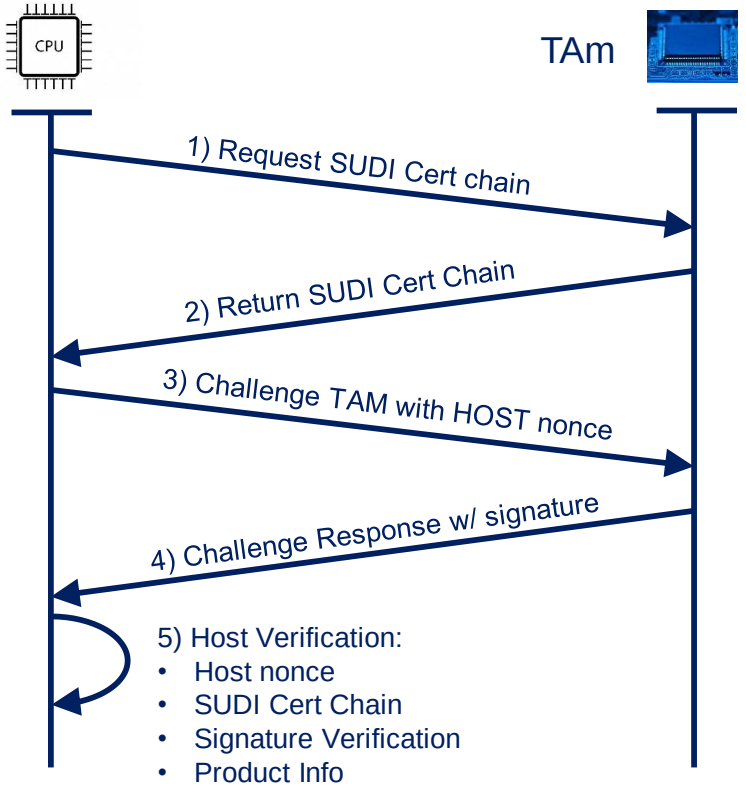
```
ROMMON
------
Image type                    : Production
    Signer Information
        Common Name           : CiscoSystems
        Organization Unit     : IOS-XE
        Organization Name     : CiscoSystems
    Certificate Serial Number : 53A3B3D2
    Hash Algorithm            : SHA512
    Signature Algorithm       : 2048-bit RSA
    Key Version               : A

    Verifier Information
        Verifier Name         : ROMMON
        Verifier Version      : System Bootstrap, Version 15.4(3r

Microloader
-----------
Image type                    : Release
    Signer Information
        Common Name           : CiscoSystems
        Organization Name     : CiscoSystems
    Certificate Serial Number : f01632135f43ae4bc1c4ca63a289b727
    Hash Algorithm            : HMAC-SHA256
    Verifier Information
        Verifier Name         : Hardware Anchor
        Verifier Version      : F01023R12.1817bb4af2014-05-23
```

After Secure Boot, IOS Software Verifies that Hardware is Authentic



HW Authenticity Check

- Trust Anchor Module (TAm) securely stores HW Identity (SUDI)
- After the operating system is up and running…
- IOS-XE automatically verifies that the HW is genuine



Cisco Runtime Defenses

Address Space Layout Randomization (ASLR)

Object-Size Checking

X-Space

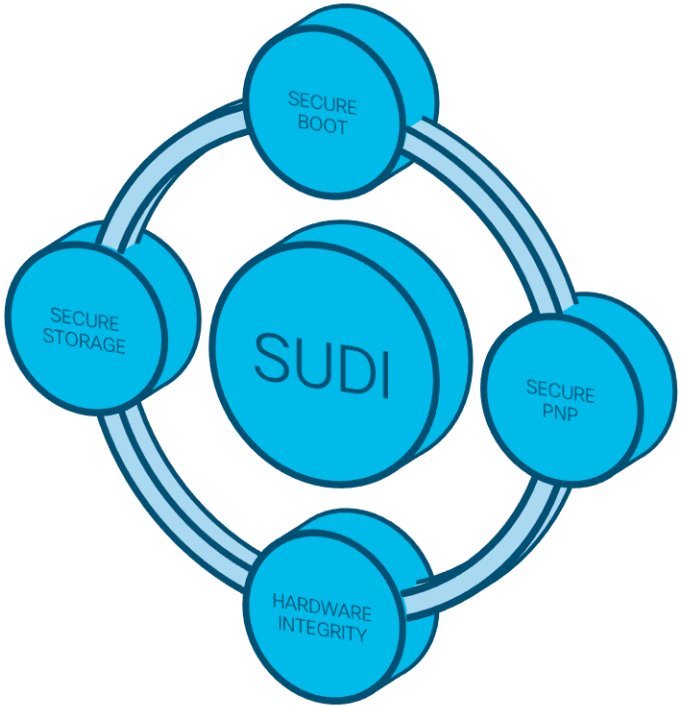
Safe-C Libraries

Hardware, Operating System, Compiler, and Development Best Practices

To protect against Buffer-Overflow and Return-Oriented Programming Attacks

Trustworthy Features on Cat 9000 Family

Features	Catalyst 9000 Family (Open IOS-XE)
Image Signing	Yes
Secure Boot	Yes
Anti-Counterfeit Check	Yes
Trust Anchor Module	Yes
PnP SUDI Support	Yes
Run Time Defenses	Yes
X.509v3 SSH Authentication	Yes



Automation and Programmability

You make networking **possible**

Cisco live!

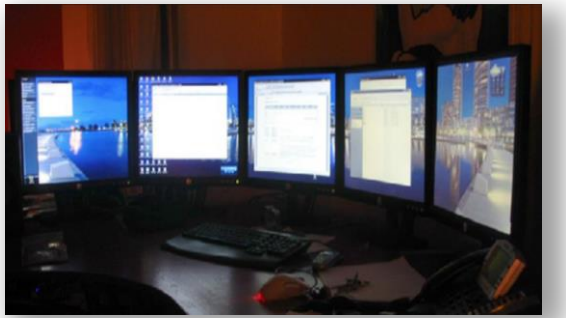
Automation and Programmability

You make networking **possible**

Cisco live!

Why Programmability?

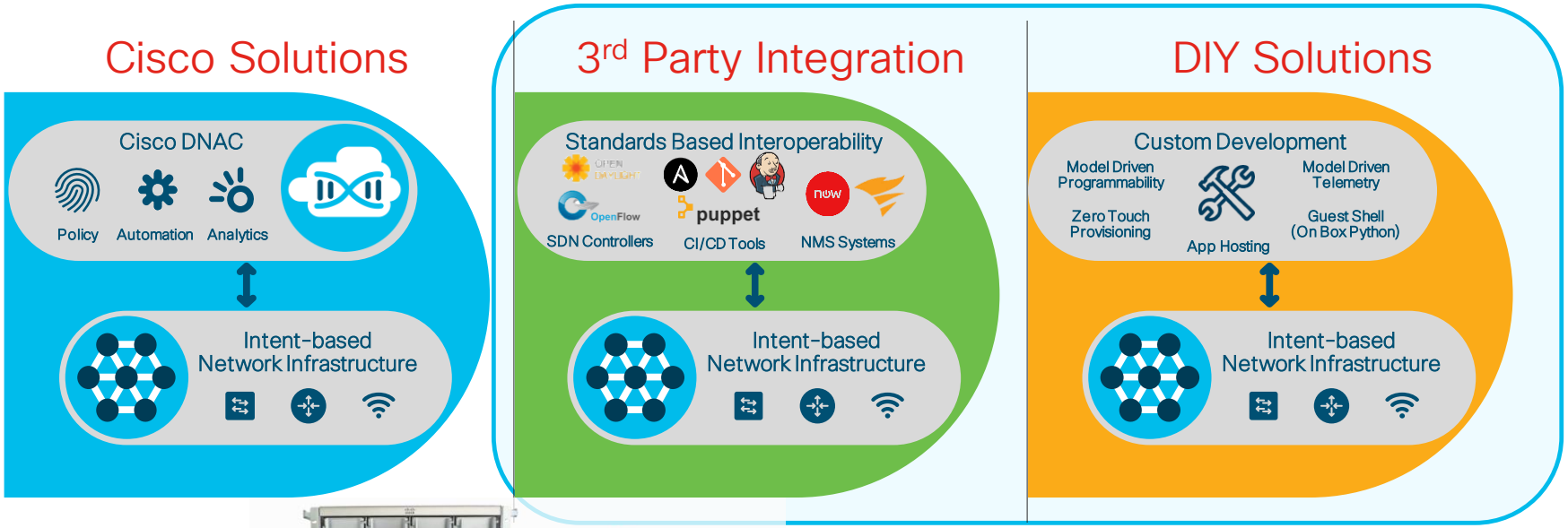
Reduction of human error

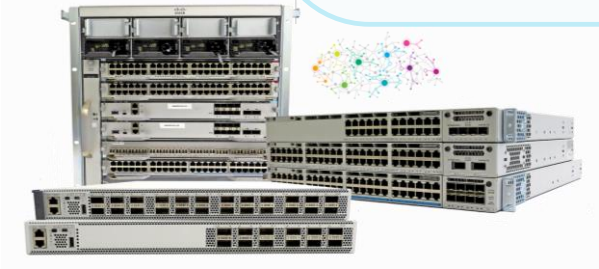


Easier Troubleshooting

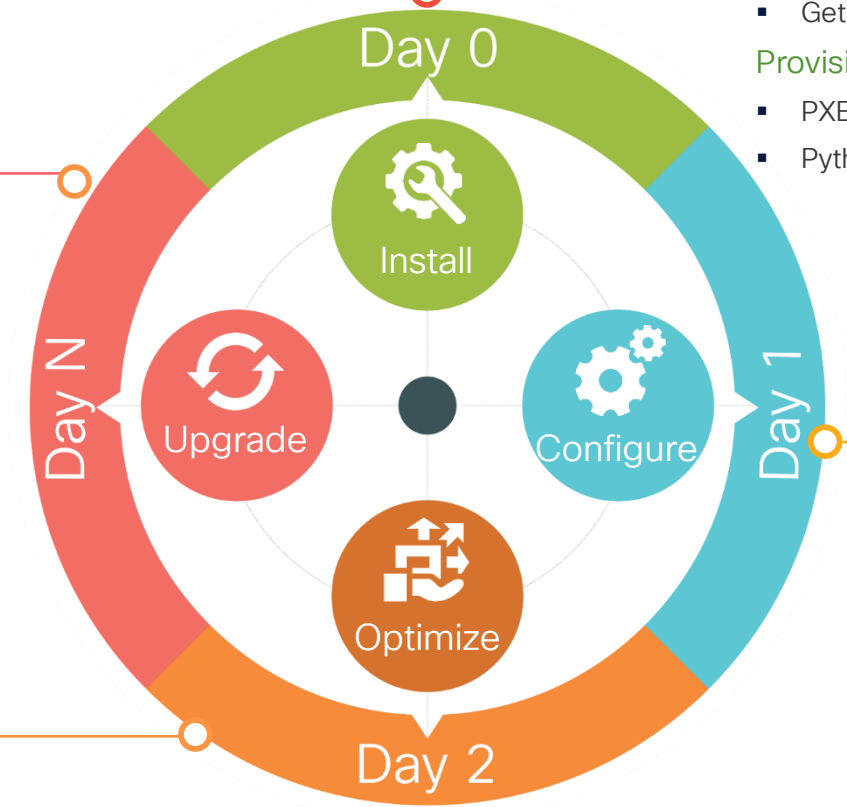
Time and money cost savings

IOS XE 16.X enables...





IOS XE: Automating Network Device Lifecycle



Goal:

- Get devices into an operational state

Provisioning Automation Tools:

- PXE, ZTP, PnP
- Python Scripting

Goal:

- Continuously upgrade network, incrementally and safely

Tools:

- Patching
- Config/Replace

Goal:

- Apply configuration to the device

Tools:

- Data Models
- Programmable Interfaces
- Python Scripting

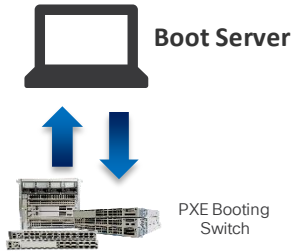
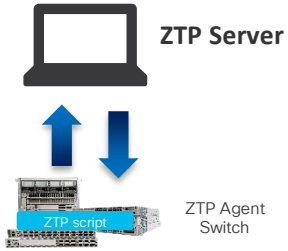
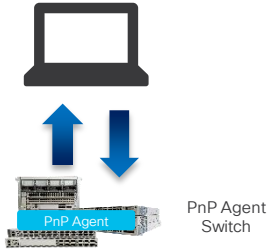
Goal:

- Add dynamic services, optimize behavior and trouble shooting

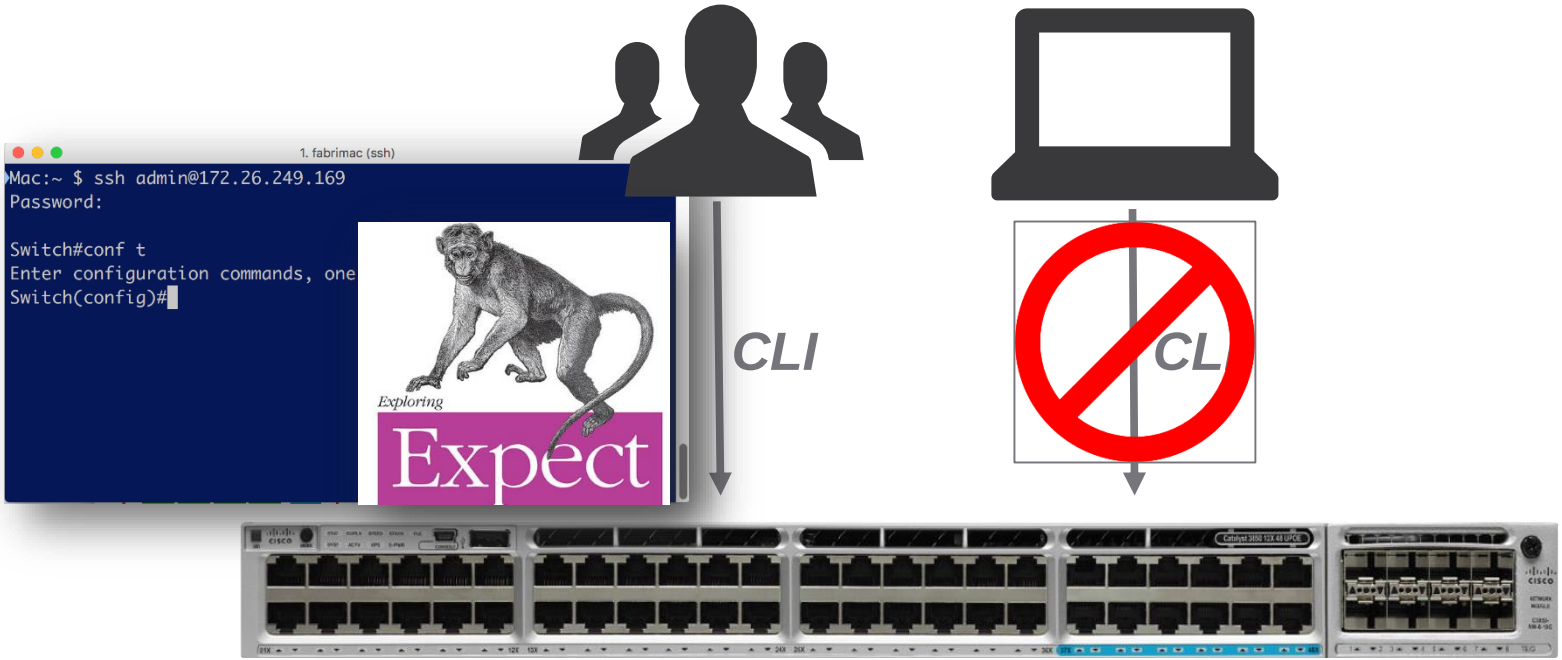
Tools:

- Operating Data Models
- Telemetry

Day 0 Provisioning Automation

	Pre-boot Execution Environment (PXE) Client	Zero Touch Provisioning	Cisco Network Plug and Play
			
Boot Image Source	Network	Device	Device
Programmable Interfaces	Open	Open	Open (via DNAC)
	Ideal for heterogeneous / multi-vendor network environments		*Optimized for Cisco networks (highly secure and scalable)*

Configuration Management Today



CLI

```
router bgp 100
 bgp log-neighbor-changes
 neighbor 13.13.13.1 remote-as 100
 neighbor 13.13.13.1 update-source Loopback10
 neighbor 14.14.14.1 remote-as 100
 neighbor 14.14.14.1 update-source Loopback11
 neighbor 15.15.15.1 remote-as 100
 neighbor 101.1.1.1 remote-as 4200123003
 neighbor 172.26.244.141 remote-as 100
!
iox
ip forward-protocol nd
ip http server
ip http secure-server
!
ip route 10.10.1.0 255.255.255.0 Loopback12
ip route 13.13.13.0 255.255.255.0 172.26.244.141
ip route 14.14.14.0 255.255.255.0 172.26.244.141
ip route 15.15.15.0 255.255.255.0 172.26.244.141
ip route 16.16.16.0 255.255.255.0 172.26.244.141
ip route 21.21.21.0 255.255.255.0 Loopback12
ip route 100.101.102.0 255.255.255.0 Loopback12
ip route 123.22.11.0 255.255.255.0 Loopback12
ip route vrf Mgmt-vrf 0.0.0.0 0.0.0.0 172.26.244.1
ip tacacs source-interface GigabitEthernet1/0/24
ip ssh server algorithm encryption aes128-ctr aes192-ctr aes256-ctr
ip ssh client algorithm encryption aes128-ctr aes192-ctr aes256-ctr
```

Human *Oriented Interface*

YANG Models

```
list interface {
        key "name";
        unique "type location";

        leaf name {
          type string;
          reference
            "RFC 2863: The Interfaces Group MIB - ifName";
        }

        leaf description {
          type string;

...

  container statistics {
          config false;
          leaf discontinuity-time {
            type yang:date-and-time;
          }

          leaf in-octets {
            type yang:counter64;
            reference
              "RFC 2863: The Interfaces Group MIB - ifHCInOctets";
          }
```

Machine *Oriented Interface*

What is YANG

- Data modeling language

- Yet Another Next Generation
- Text-based, readable
- Hierarchical, modular, and extensible
- Can represent operations or capabilities (RPC's)
- Describes: configuration – operational state/parameters – actions – notifications
- Separate operation and configuration modules (trees)
- Vendor neutral [IETF, OpenConfig] and vendor/device specific models
- Each node may contain different combination of models and versions
- SNMP MIB's can be translated to YANG modules
- IETF https://datatracker.ietf.org/wg/netmod/documents/

Structured vs Unstructured Data

Un-structured

John Smith 42 14155551212

What is this?

- His age?
- The year he graduated college?
- Employee number?

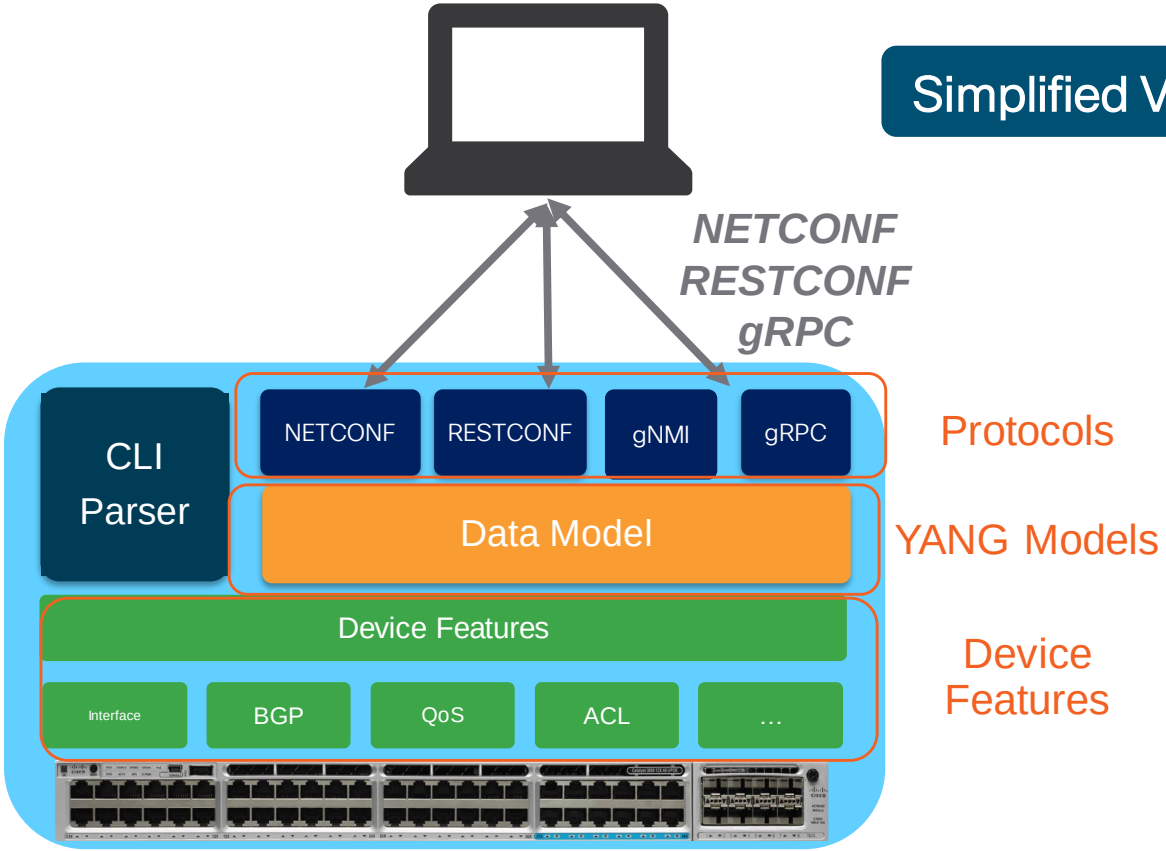
Structured

Name: John Smith
Age: 42
Phone: +1-415-555-1212

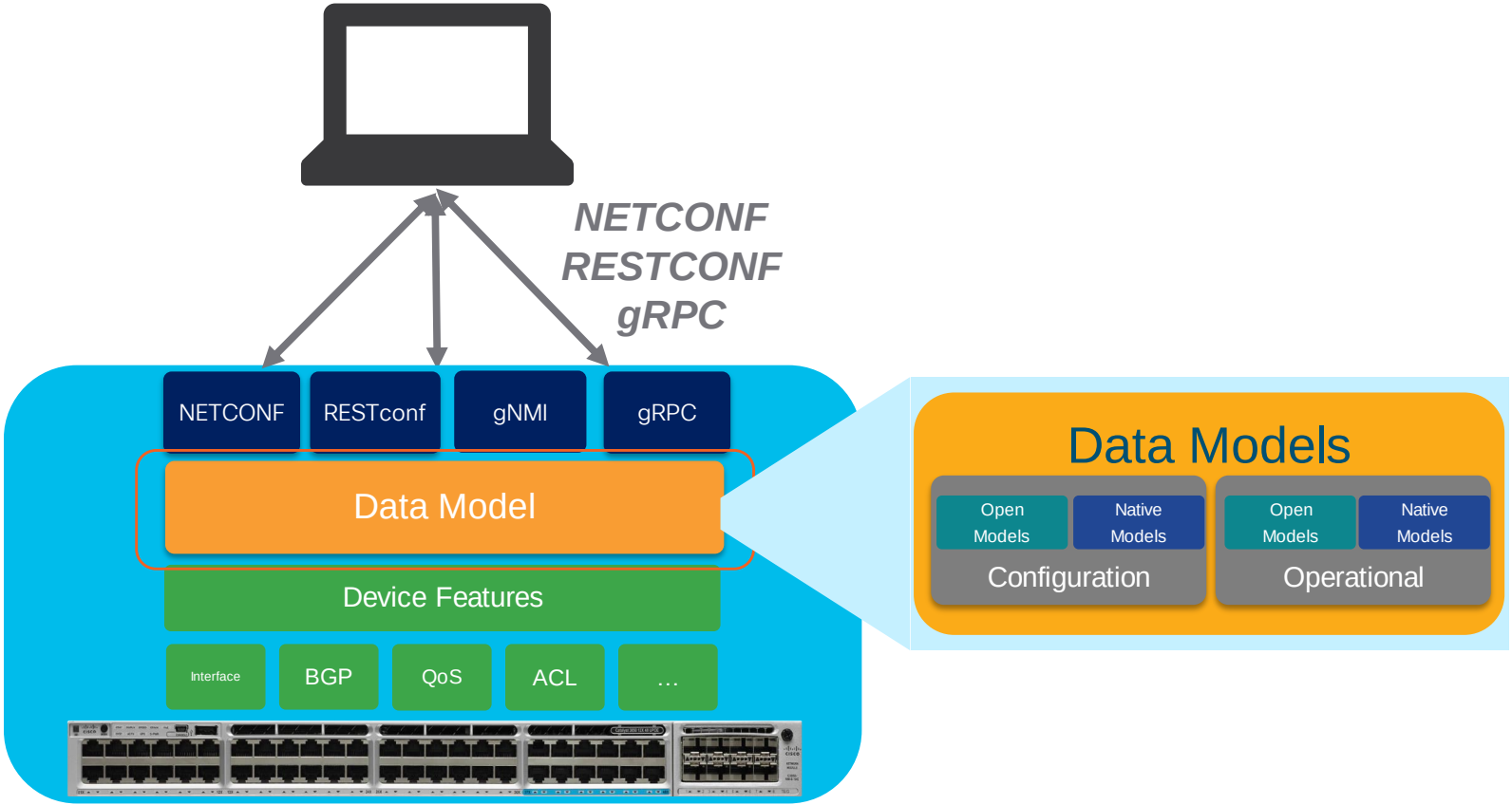
Keys

Values

Open Programmable APIs



Data Models



Configuration vs. Operational data

Config-data

- Tells the device what to do
- Can **write** configuration data
- Can **read** configuration data

Examples:
switch> show run interface Loopback0
switch(config)# interface Loopback0

Operational-data

- How the device is operating
- Output form show command (other than show run)
- This is **read-only**

Examples:
switch> show interface Loopback0

Data Models: Open vs Native

Open Models

Industry definition

Compliant with standard (IETF, ITU, OpenConfig, etc)

Example: *ietf-diffserv-policy.yang*
(IETF Diffserv data model)

Native Models

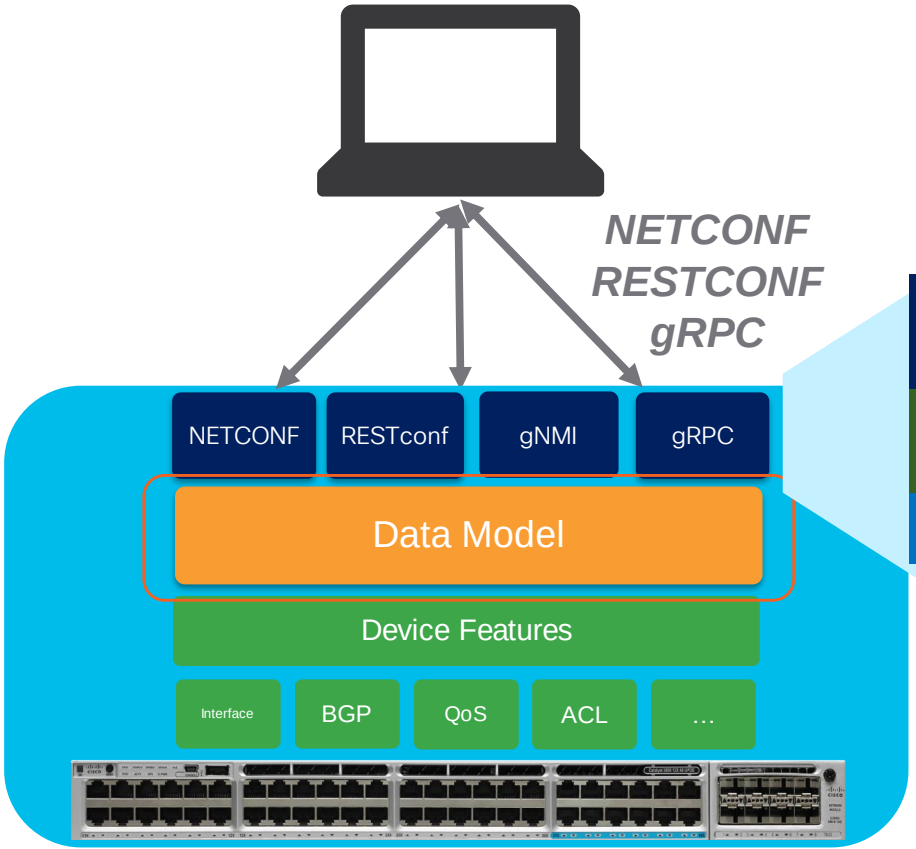
Cisco definition

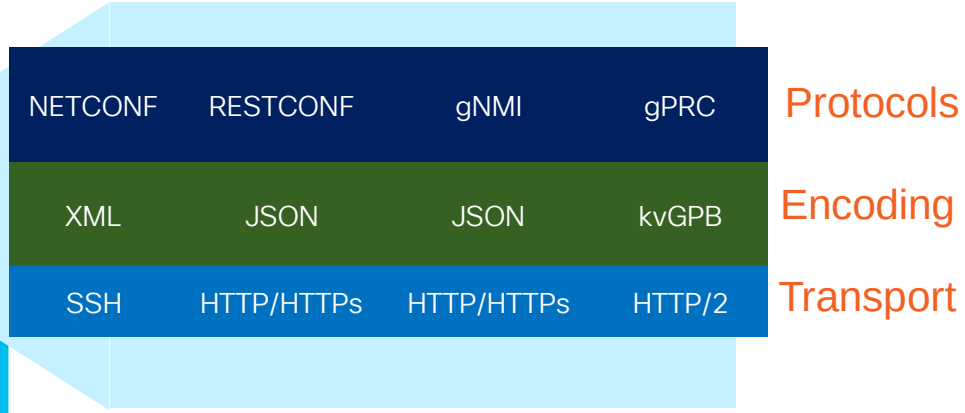
Unique to a Cisco operating system

Example: *Cisco-IOS-XR-ipv4-bgp-cfg.yang*
(IOS-XR BGP data model)

Open Models are **a subset** of the Native Models

Data Models





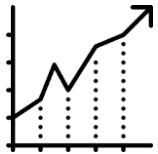
Streaming Telemetry

Export enriched, consistent and concise data with context from network devices for a better user and operator experience

Periodic or On-Change

Structured Data

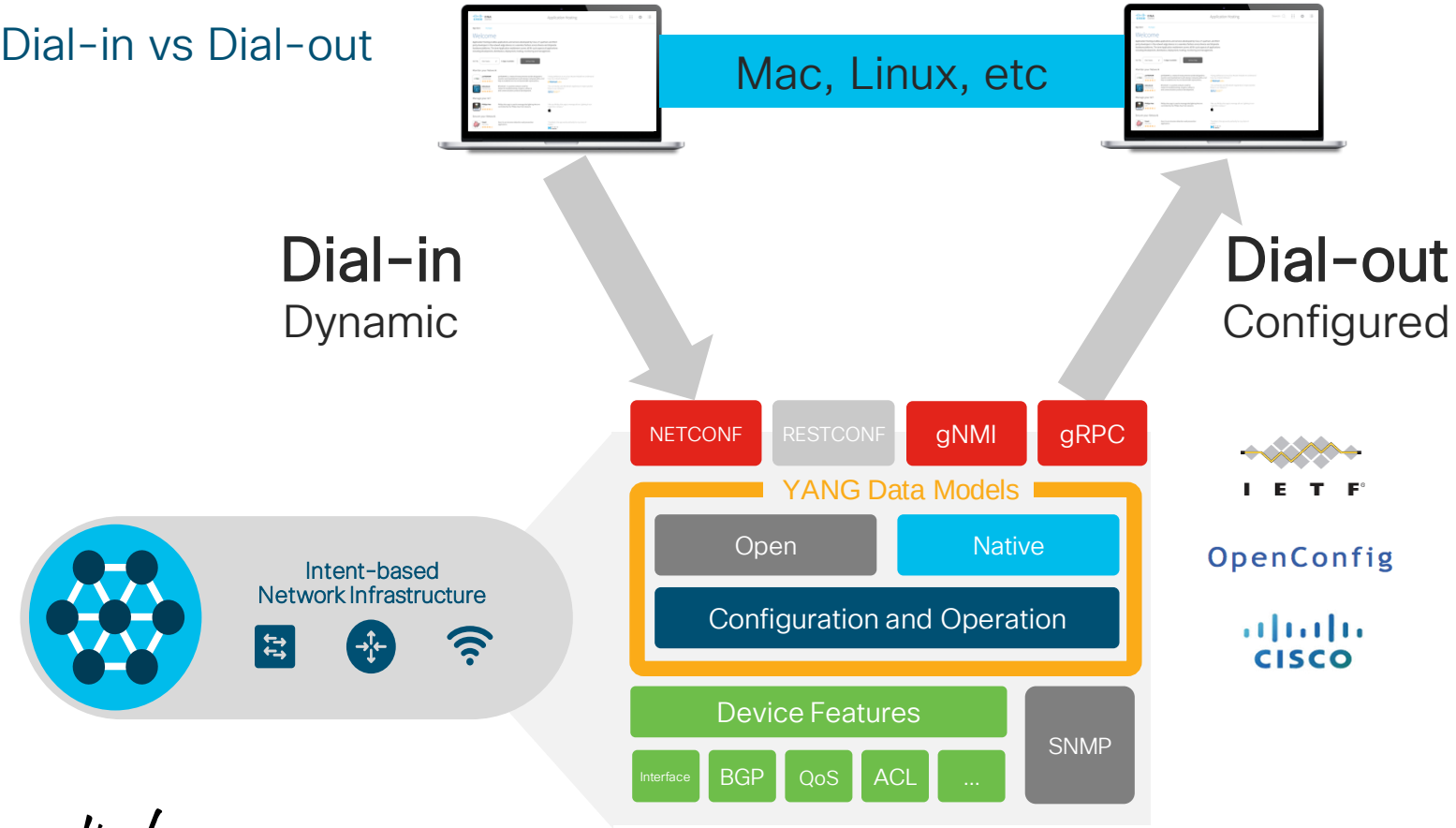
Scalable



Reduced CPU Load

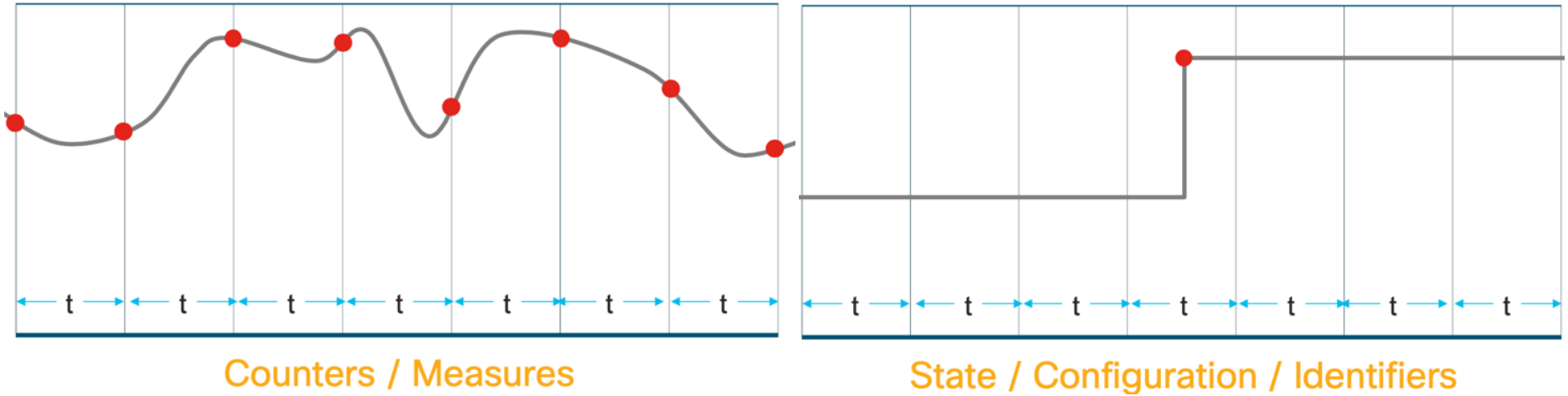
Publication and Subscriptions

Dial-in vs Dial-out



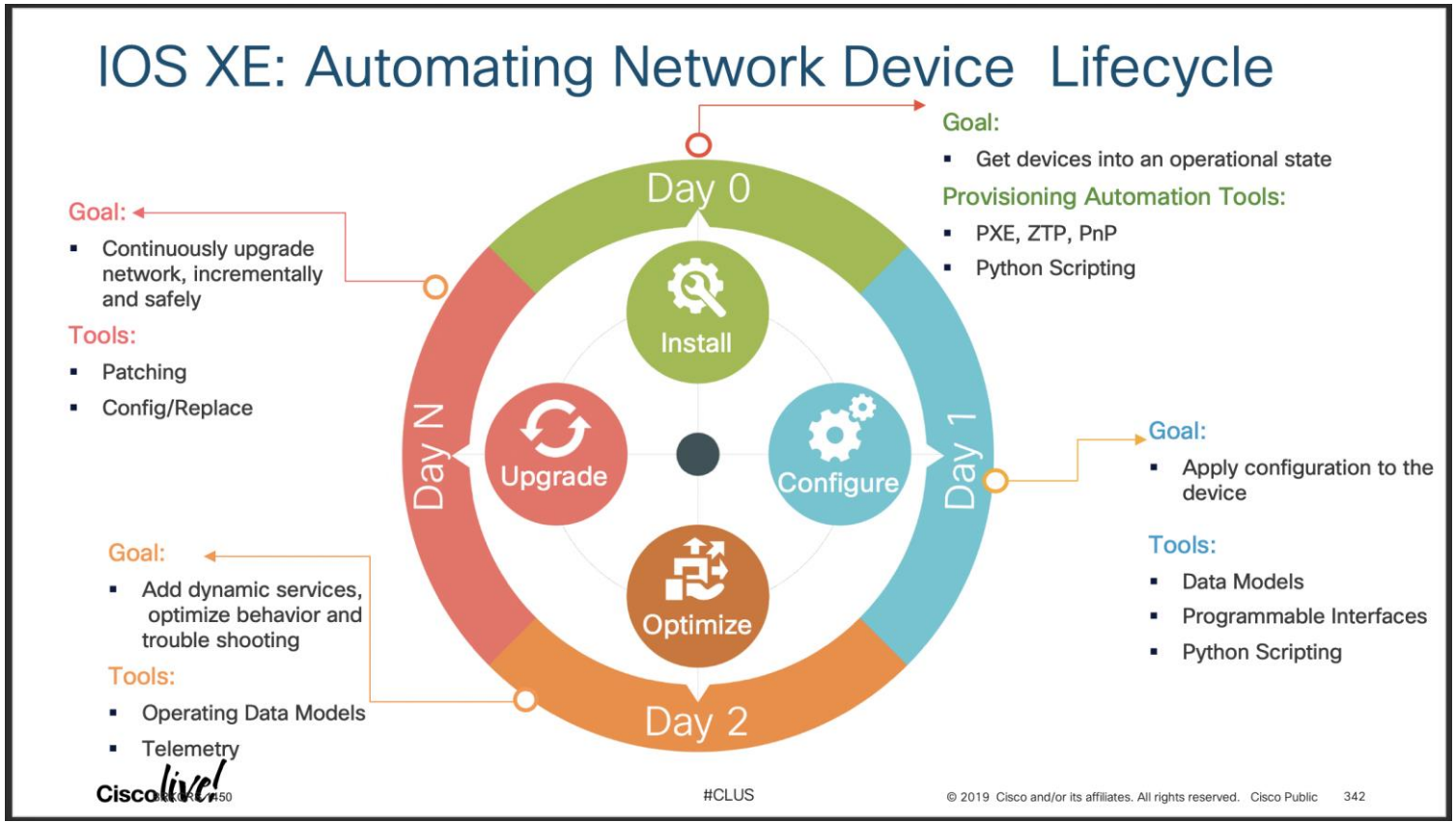
Telemetry Publication Options

Time, or event based



Q. What is the minimum publication interval?
A. On IOS XE 16.10: 1 second

Recap


IOS XE: Automating Network Device Lifecycle
Day 0
Goal:
Get devices into an operational state
Provisioning Automation Tools:
PXE, ZTP, PnP
Python Scripting
Install
Day 1
Goal:
Apply configuration to the device
Tools:
Data Models
Programmable Interfaces
Python Scripting
Configure
Day 2
Goal:
Add dynamic services, optimize behavior and trouble shooting
Tools:
Operating Data Models
Telemetry
Optimize
Day N
Goal:
Continuously upgrade network, incrementally and safely
Tools:
Patching
Config/Replace
Upgrade
#CLUS
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Application Hosting

You make networking **possible**

Cisco live!

Application Hosting in the Enterprise

IT Operations & Monitoring Tools

Consolidate Physical Infrastructure

Security Agents & Functions

Enhance Visibility & Security Enforcement

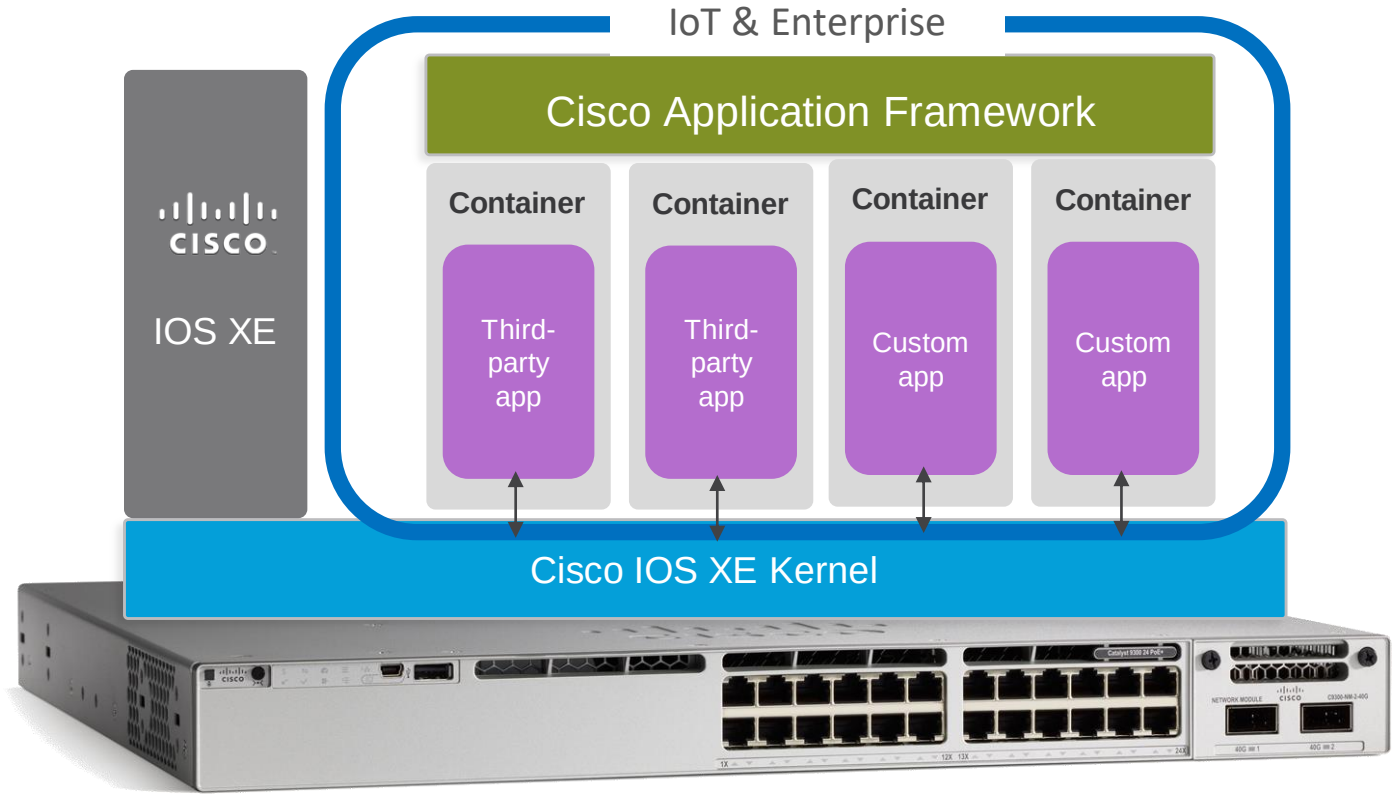
Cloud Gateways with Serverless Edge Compute

Reduce App Latency & Optimize App Traffic

Customer Specific Applications

Derive New Insights and Respond

Application Hosting in Catalyst 9K Platforms

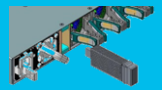


Catalyst 9000 switch storage and compute

	Resource type	Catalyst 9200	Catalyst 9300	Catalyst 9400	Catalyst 9500*	Catalyst 9500 High Perf*	Catalyst 9600*
Networking	Front panel ports (1G)	No	Yes	Yes*	No	No	No
Resources	Memory	No	2GB	up to 8GB	up to 8GB	up to 8GB	up to 8GB
	CPU	No	1 core (25%)	1 core (25%)	1 core (25%)	1 core (25%)	2 core (25%)
	Storage	No	120GB (USB3.0/SSD)	240-960GB (SATA)	120GB (USB3.0/SSD)	240-960GB (SATA)	240-960GB (SATA)

Catalyst 9300/9500

USB 3.0
120GB



Back panel

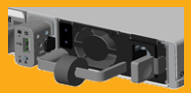
Catalyst 9400

M2 SATA
240/480/960GB

Plug into removable SUP

Catalyst 9500 high-performance

M2 SATA
240/480/960GB



Back panel

For local storage and app hosting production

- 3rd party USB drives in front panel are not supported
- Applications can be hosted via CLI too

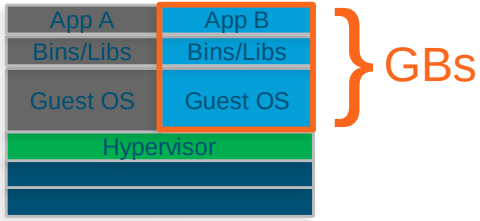
* Roadmap

IOS XE performance and security protection

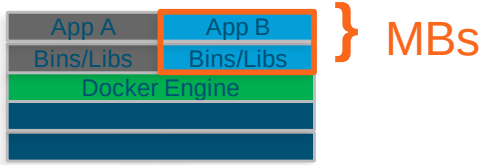
- Memory and CPU usage for Apps are bounded using Control groups (cgroups).
- Process and files access for Apps are isolated and restricted (using user namespace)
- Disk usage is isolated using separate storage.

Docker Container

- **Virtual Machine**
  Includes application, binaries & libraries, an **entire guest OS**.



- **Docker Container**
  format for Linux containers that makes the process of creating and maintaining containers easier.



C9K supports native Docker container starting from IOS XE 16.12 release.

Docker Workflow

1 Dockerfile

```
FROM perfsonar/testpoint

# Copy IOx Scripts
COPY iox_start.sh /etc/init.d/iox_start.sh

# Append IOx bootup daemons
COPY iox.conf /etc/iox.conf
RUN cat /etc/iox.conf >> /etc/supervisord.conf

# Setup app-hosting console login
RUN echo "cisco" | passwd root --stdin
```

2 Build Docker Image

```
docker build -t <app> .
```

or

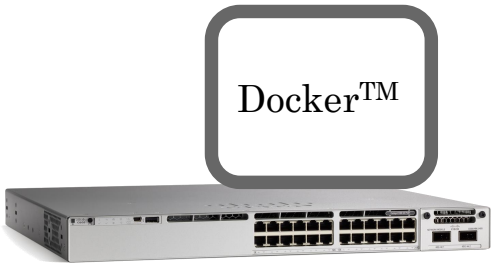
```
docker pull <app>
```

3 App Descriptor (Optional)

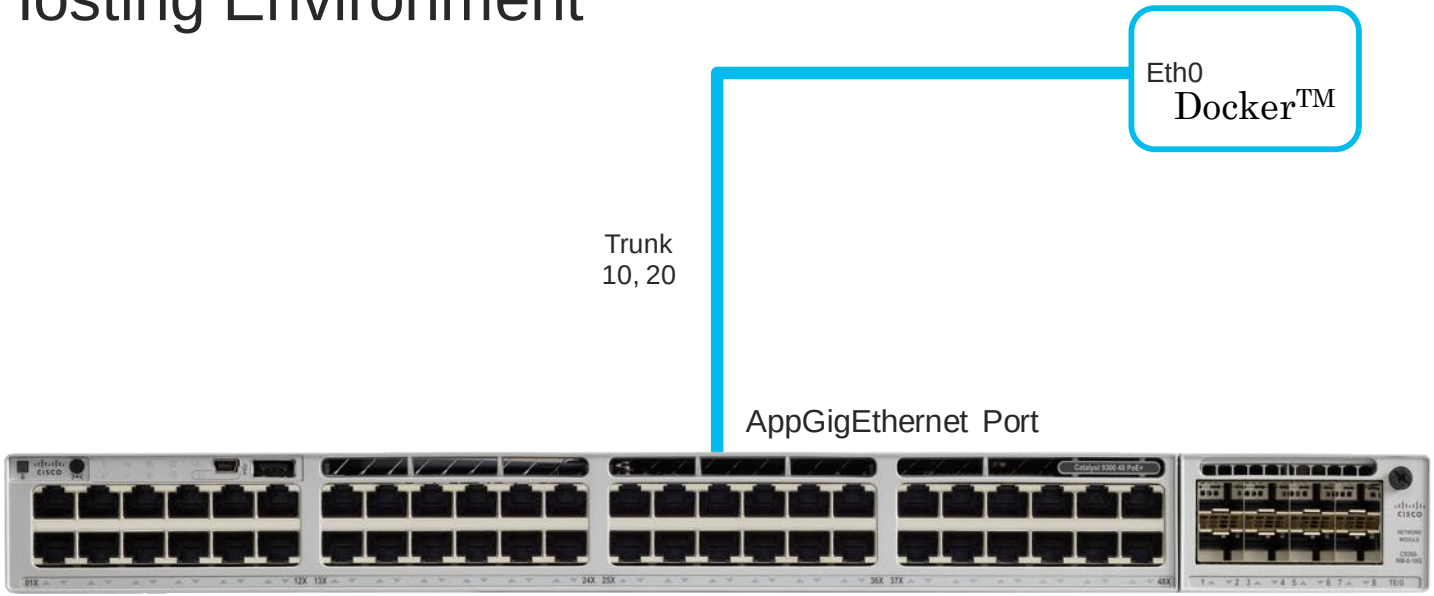
```
descriptor-schema-version: "2.6"

info:
  name: perfsonar
  description: PerfSONAR 4.0
  version: "1.0.0"
  author-link: "http://www.cisco.com"
  author-name: Cisco

app:
  # Indicate app type (vm, paas, lxc etc.,)
  cpuarch: x86_64
  type:
  kernel-version: 4.4.51

  resources:
    profile: custom
    vcpu: 2
    cpu: 7400
    disk: 10
    memory: 2048

    network:
    - interface-name: eth0

# Specify runtime and startup
  startup:
    rootfs: rootfs.img
    target: /etc/init.d/iox_start.sh
```

4 Deploy App

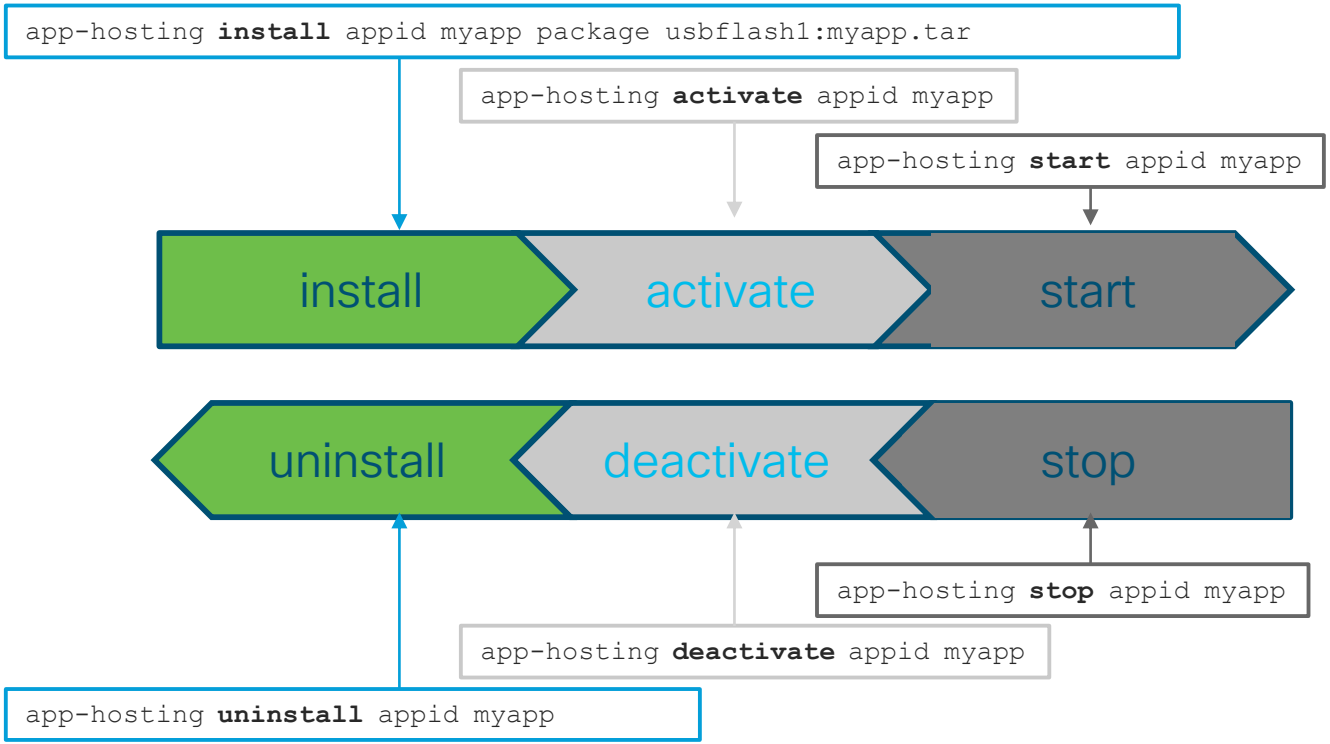
```
docker save myapp > myapp.tar
```



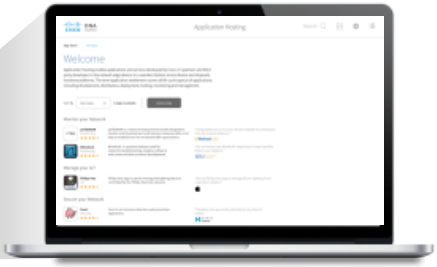
Layer 2 Connectivity to App Hosting Environment



App Lifecycle Management – State Transitions



Application Management



Cisco DNA Center

REST

CLI

REST

Cisco Application Framework

Docker	Docker	Docker	Docker	Docker
3rd Party App	3rd Party App	3rd Party App	Custom App	Custom App

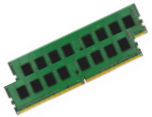
Host OS (IOS XE Kernel)

App Hosting Recap

Catalyst 9000

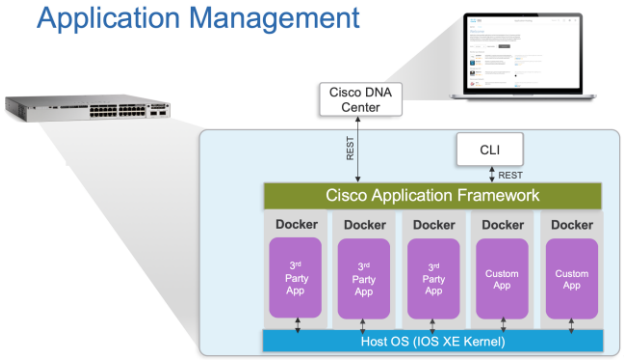
x86 CPU

Linux-based OS



Memory/Storage

Docker™

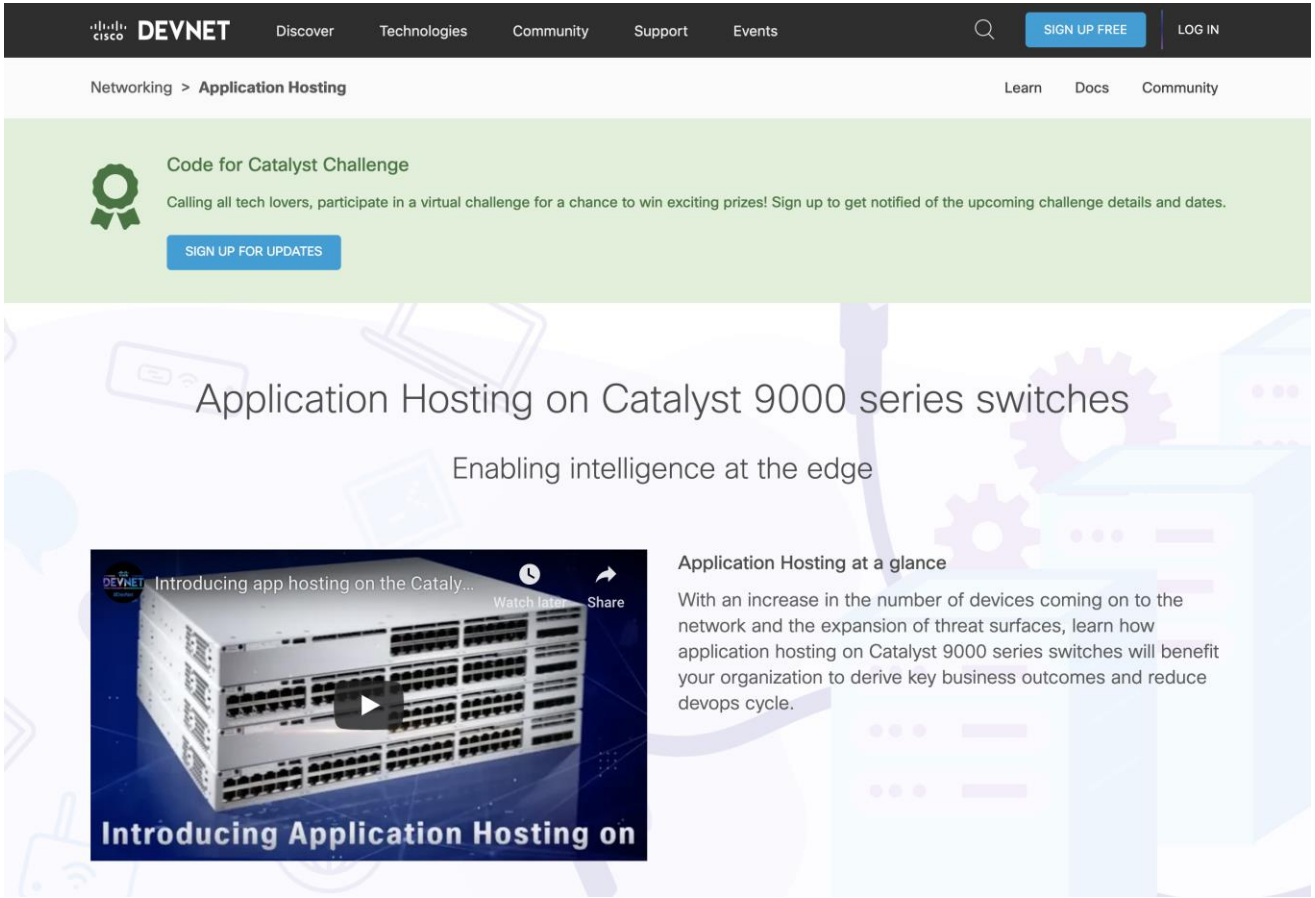


install → activate → start

uninstall → deactivate → stop

Cisco live!

Cisco Catalyst 9000 switching application ecosystem



Sandbox

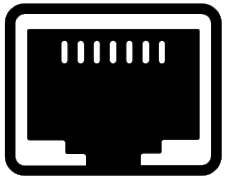
Eco System Exchange

https://developer.cisco.com/

Closing & Wrap up...

You make networking **possible**

Catalyst 9K has fundamentally changed the Networks



Multigigabit

UPoE

100G

40G

25G

10G

5G

2.5G

1G

100M

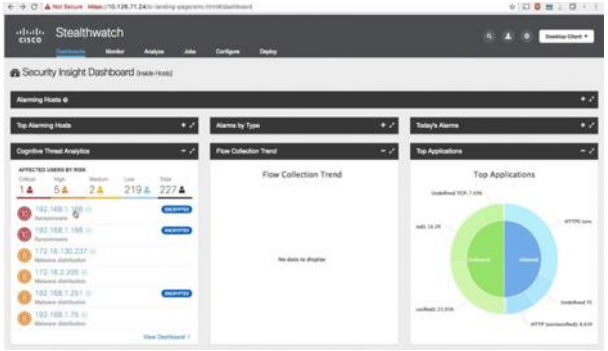
10M

Fabric Enabled Wireless

Embedded Wireless LAN Controller

With Catalyst 9K Or Networks are Ready for 11ax and New Speeds

Security



Encrypted Traffic Analytics

Traffic Analytics

Malware Detection

Compliance

Secure Infrastructure

Trustworthy Systems

Hardware Authenticity

Two Way Trust

Run-time Defense

Secure Transport

MACSEC

Man-in-the-Middle

Wire-tapping

Impersonation

With Catalyst 9K **Our Networks** are more **Secure** than ever

Platform Resilience
Sub Second
Convergence

1+1 Redundancy
Active and Standby
SSO/NSF

ISSU
eFSU
Hot Patching

Highly Available
Networks

Software Upgrade
Instant Fix

Stackwise Virtual
GIR
HSRP/VRRP

With Catalyst 9K **Our Networks** are **Highly Available** most **Resilient**

Full PoE+/UPoE

802.3bt Type 3 (60W)

LED Lights

Building Management Systems

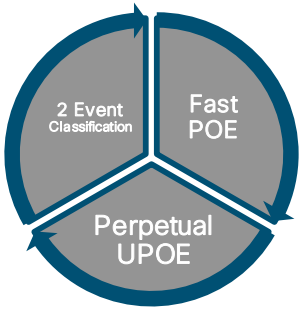
AVB & PTP

Digitized Audio & Video

Digital Court Rooms

Media Rooms

IoT Readiness



PoE Innovations

IoT Devices

IP Based End Points

With Catalyst 9K Our Networks are Ready for IoT

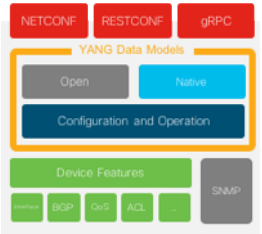
Application Hosting & Containers

Flexibility and Control

Network Analytics Tools

Monitoring Tools

Model Based API & Programmability



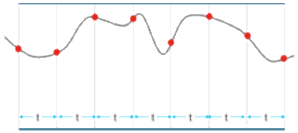
Network Automation

Build Your Own

Consistent Models

Candidate Datastore

Streaming Telemetry

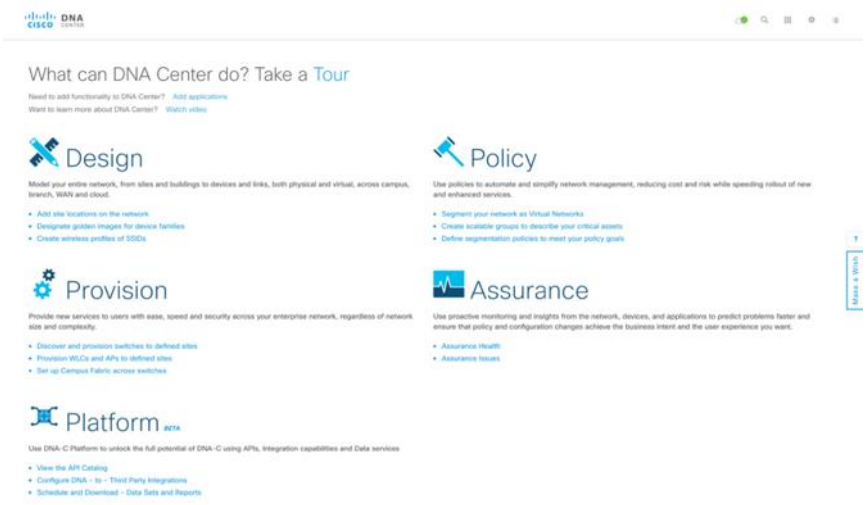


Monitoring the Network

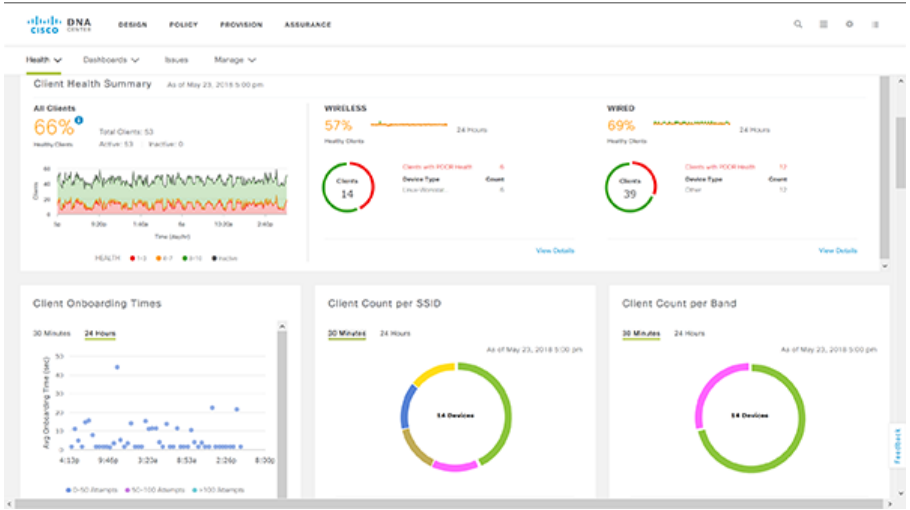
Real Time Monitoring e.g. Kibana

On-change & Periodic Telemetry

With Catalyst 9K Our Networks are Programmable



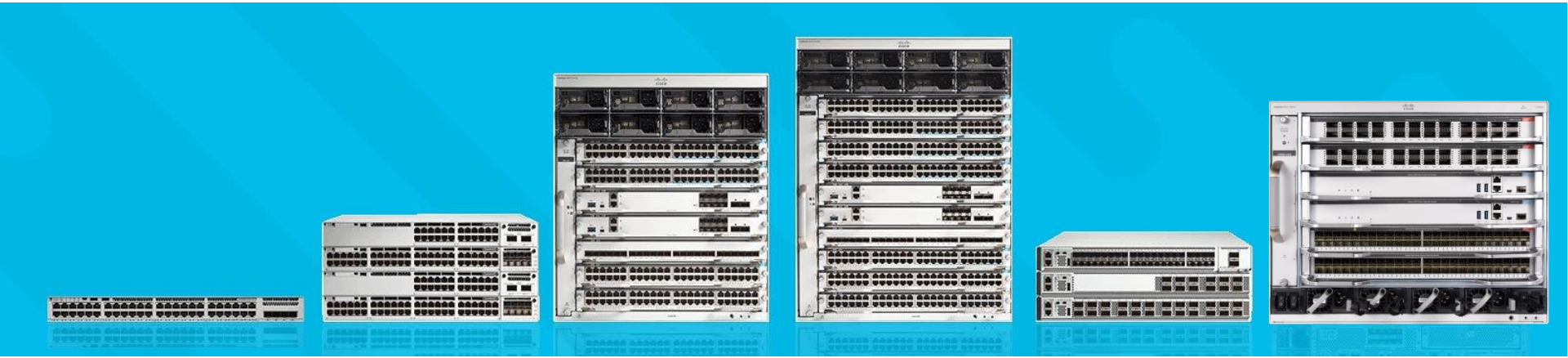
Software Defined Access



DNA Assurance

With Catalyst 9K **Our Networks** are **Software Defined**

The Catalyst 9000 Family of Switches

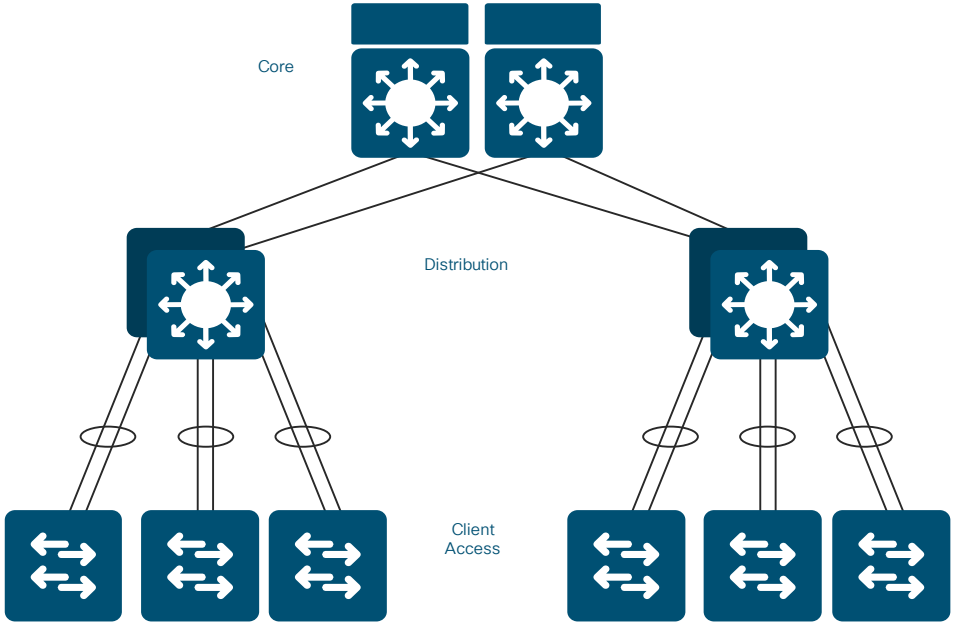


Catalyst 9200 | Catalyst 9300 | Catalyst 9400 | Catalyst 9500 | Catalyst 9600

Fixed Access Switches | Modular Access & Distribution Switches | Fixed Core & Distribution Switches | Modular Core & Distribution

Enabling Campus of the Future

L2 / L3 (IPv4, IPv6)
Multicast
ACL Scale
Netflow
First Hop Security
MACSEC
Etc.



Catalyst 9500/9600

Fixed & Modular Form Factors

Catalyst 9400/9500

Fixed & Modular Form Factors

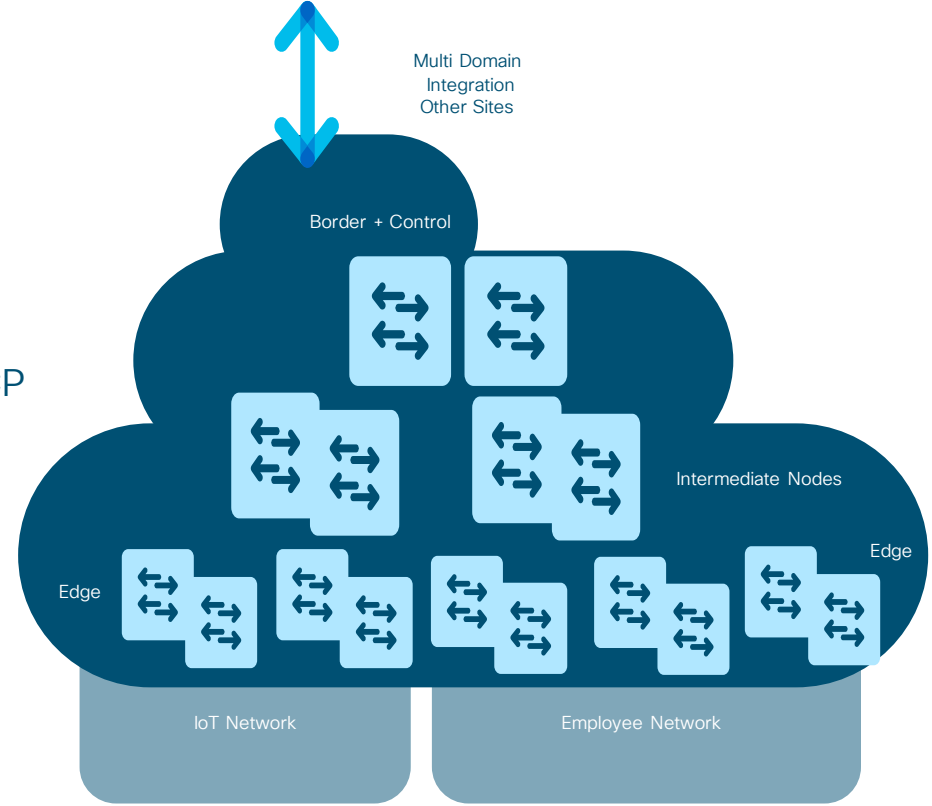
Catalyst 9300/9400

Fixed & Modular Form Factors

Catalyst 9200
for
Small & Medium Size

End to End Catalyst 9000 for Traditional Campus Networks

Any Fabric
SD-Access: Border, CP
BGP/EVPN, VXLAN,
Group based Policy
Segmentation
Unified Policy
Security



Catalyst 9500/9600

Fixed & Modular Form Factors

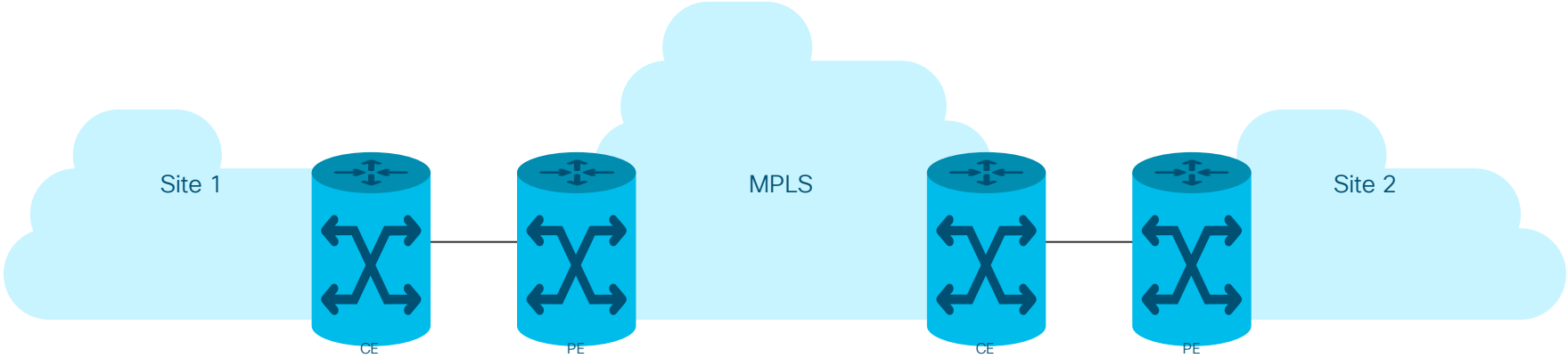
Catalyst 9400/9500

Fixed & Modular Form Factors

Catalyst 9300/9400

Fixed & Modular Form Factors

End to End Catalyst 9000 for Fabric Based Networks



Catalyst 9300/9400/9500/9600

MPLS L2 / L3 VPN
mVPN
QoS/HQoS
NAT

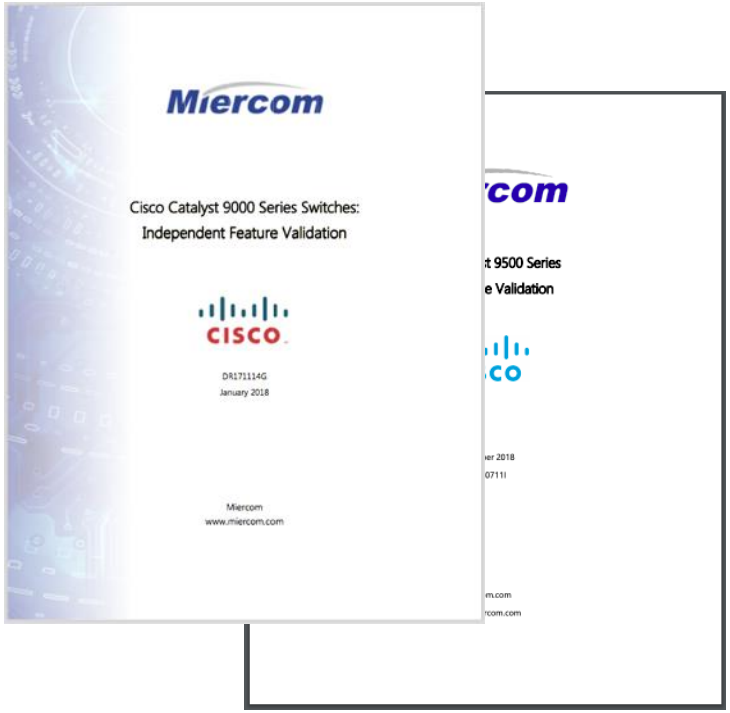
Catalyst 9300/9400/9500/9600

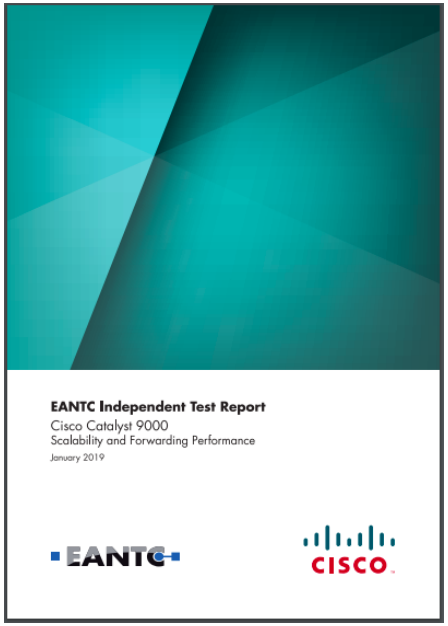
Comprehensive MPLS Features for Core + MPLS PE Deployments

Recognitions & References

You make customer experience **possible**

Industry Recognitions…

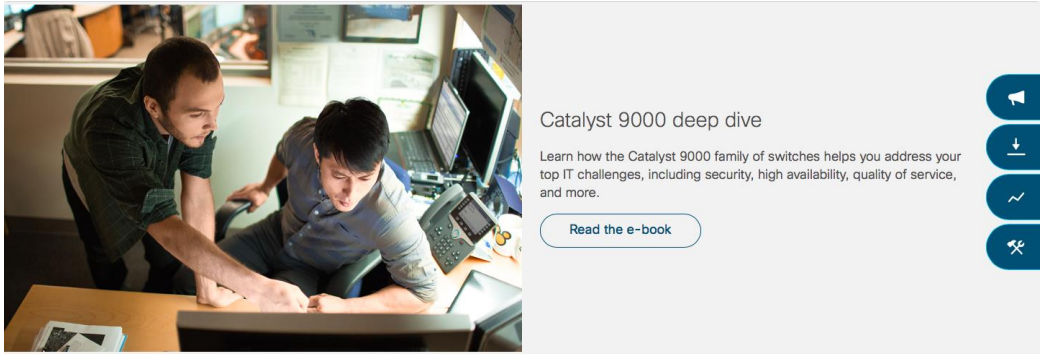




Catalyst 9K Book

Cisco Catalyst 9000
A New Era of Networking

eBook Available on Cisco.com



Visit World of Solutions...

Catalyst 9300/9500

Catalyst 9400

Catalyst 9K Demos

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- Please complete your session survey after each session. Your feedback is very important.
- Complete a minimum of 4 session surveys and the Overall Conference survey (starting on Thursday) to receive your Cisco Live water bottle.
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Thank you

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