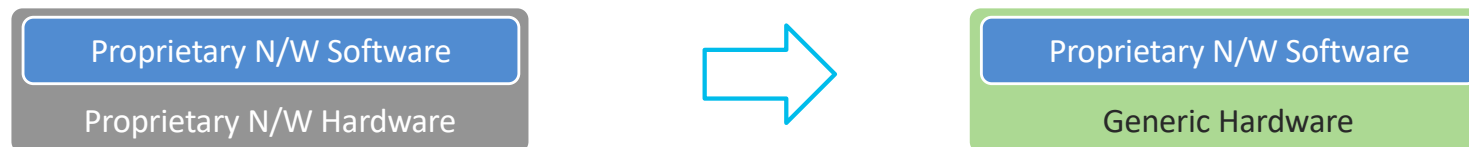# Agenda

- Role of NFV in Network

- IOS XRv 9000

- Benefits & Use Cases

- Deployment & Troubleshooting

- Service Orchestration for NFV

- Summary

Network Functions Virtualization (NFV) - Defined

…. NFV decouples the network functions such as NAT, IPS, DNS, RR etc. from proprietary hardware appliances, so they can run in software.

…

| Proprietary N/W Software |
| Proprietary N/W Hardware |

→

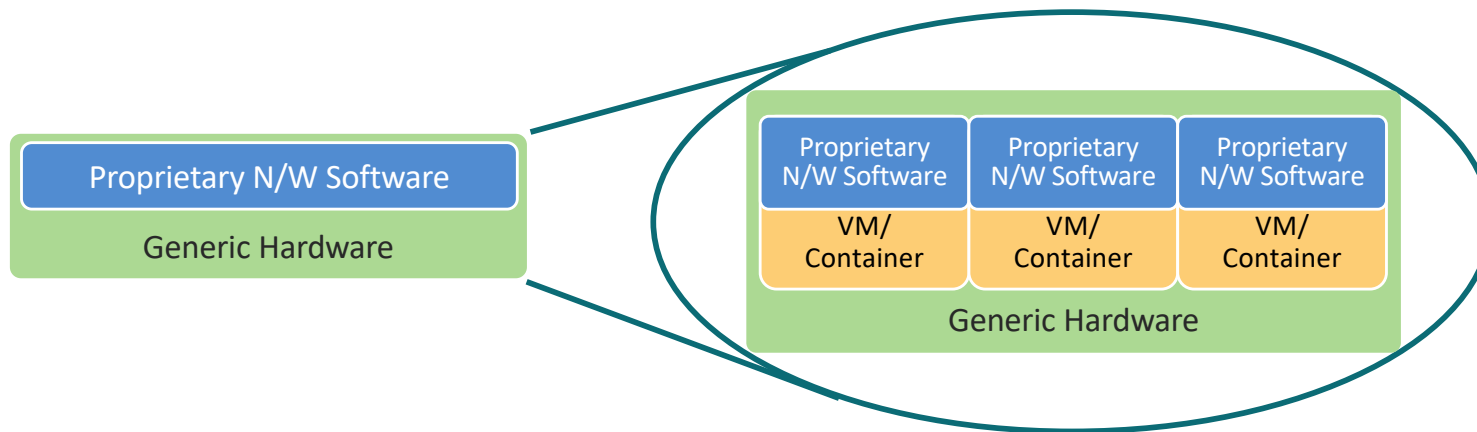| Proprietary N/W Software |
| Generic Hardware |

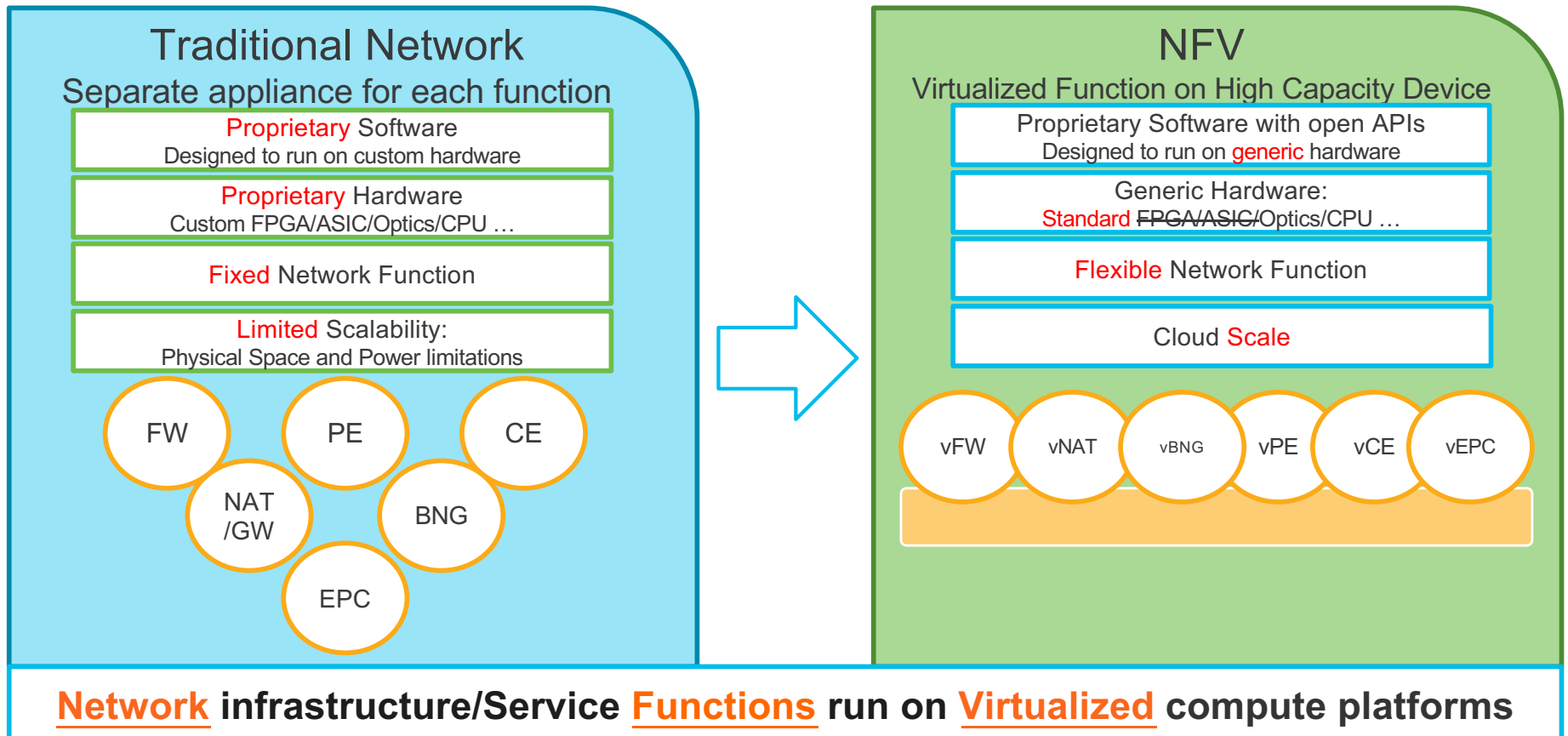https://www.sdxcentral.com/nfv/definitions/whats-network-functions-virtualization-nfv/

Network Functions Virtualization (NFV) - Defined

.....

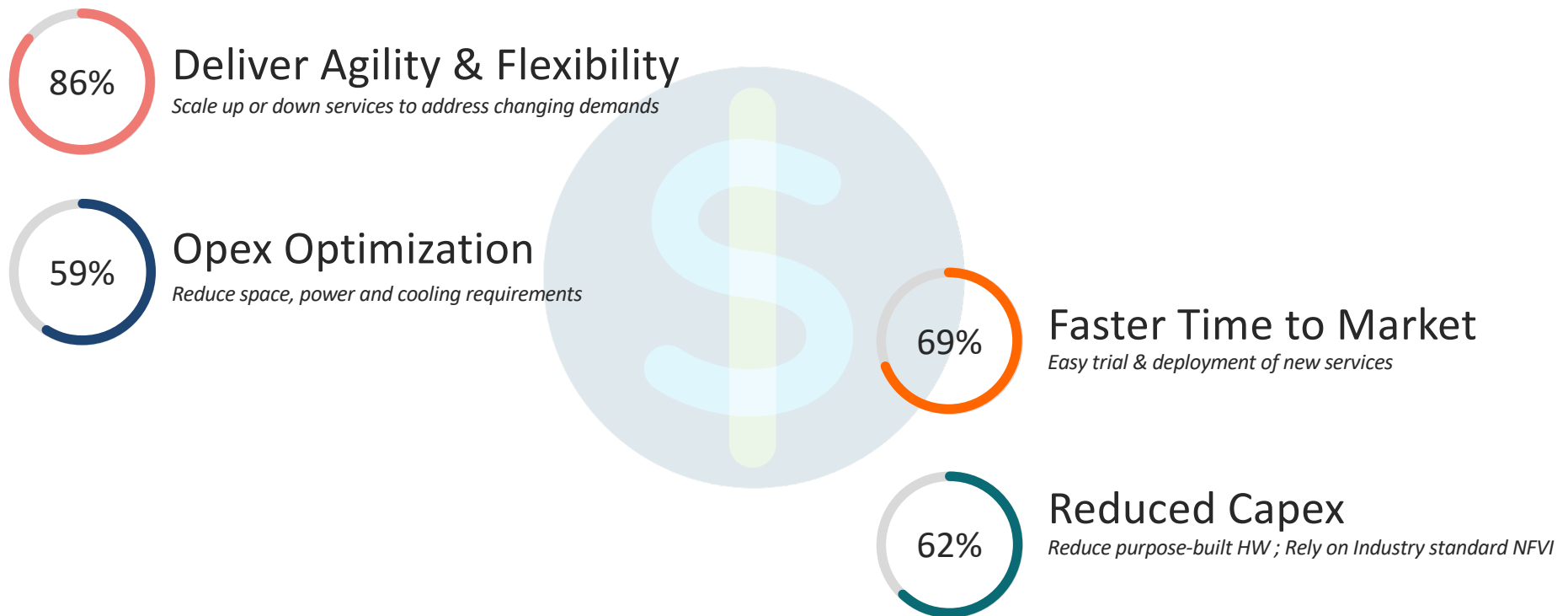It utilizes standard IT virtualization technologies that run on high-volume service, switch and storage hardware to virtualize network functions.

Proprietary N/W Software		
Proprietary N/W Software	Proprietary N/W Software	Proprietary N/W Software
VM/Container	VM/Container	VM/Container

Generic Hardware

Generic Hardware

http://www.sdncentral.com/whats-network-functions-virtualization-nfv/

Network Functions Virtualization (NFV) – Market Drivers

Traditional Network
Separate appliance for each function

Proprietary Software
Designed to run on custom hardware

Proprietary Hardware
Custom FPGA/ASIC/Optics/CPU …

Fixed Network Function

Limited Scalability:
Physical Space and Power limitations

FW   PE   CE
NAT /GW   BNG
EPC

NFV
Virtualized Function on High Capacity Device

Proprietary Software with open APIs
Designed to run on generic hardware

Generic Hardware:
Standard FPGA/ASIC/Optics/CPU …

Flexible Network Function

Cloud Scale

vFW   vNAT   vBNG   vPE   vCE   vEPC

Network infrastructure/Service Functions run on Virtualized compute platforms

Network Functions Virtualization (NFV) – Market Ask

86% **Deliver Agility & Flexibility**
Scale up or down services to address changing demands

59% **Opex Optimization**
Reduce space, power and cooling requirements

69% **Faster Time to Market**
Easy trial & deployment of new services

62% **Reduced Capex**
Reduce purpose-built HW ; Rely on Industry standard NFVI

Based on Survey Results by SDX Central

Enablers of SP Network Transformation

NFV

Agility & Flexibility
Operational Efficiency
Hardware Agnostic

Flexible SW & HW
Improved Life Cycle
Flexibility & Scalability

Network Functions Virtualization (NFV)

Software Defined Networking (SDN)

Application & Service Orchestration

SDN

Automated Provisioning
Traffic Optimization
Service Agility
Reduced Cost

API Driven
Central Control
Central Management

Network Functions Virtualization & SDN

SDN

Software
Software
Software
Software
CP & DP
Hardware

Network Control Plane

Network Data Plane

NFV

Network Function (Software)

Hardware Infrastructure

NFV   SDN

Apps & Orch

- Orthogonal Concepts; Similar Goals
- SDN complementary, but not mandatory

Network Functions Virtualization & SDN
Comparison

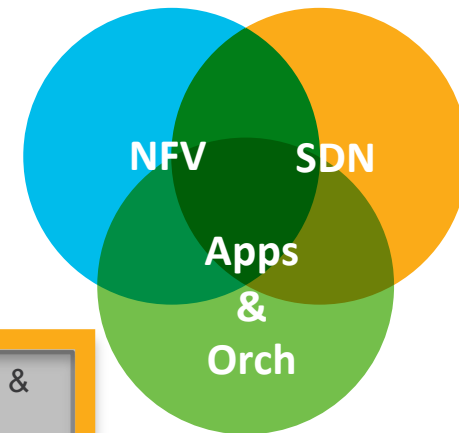|	SDN	NFV	Applications
Deployment	SDN Controller: Application Policy Infrastructure Controller (APIC), APIC-EM, Open Daylight (ODL), SR-PCE, etc.	Virtual network functions : vFW, vRR, vCPE , vPE etc.	Applications & Orchestrators: Network Service Orchestrator (NSO), WAN Automation Engine (WAE), Cisco Crosswork
Connectivity	OpenFlow, NETCONF/Yang , REST, API, gNMI/gRPC	VM to Host (socket, Taps etc.)	REST, API
Scope	Network domain	Single network entity	End to End network
Arch	New network architecture	Virtualization of existing architecture	New network architecture

Achieving Virtualization

HW appliance

Virtual Machine

Linux Container
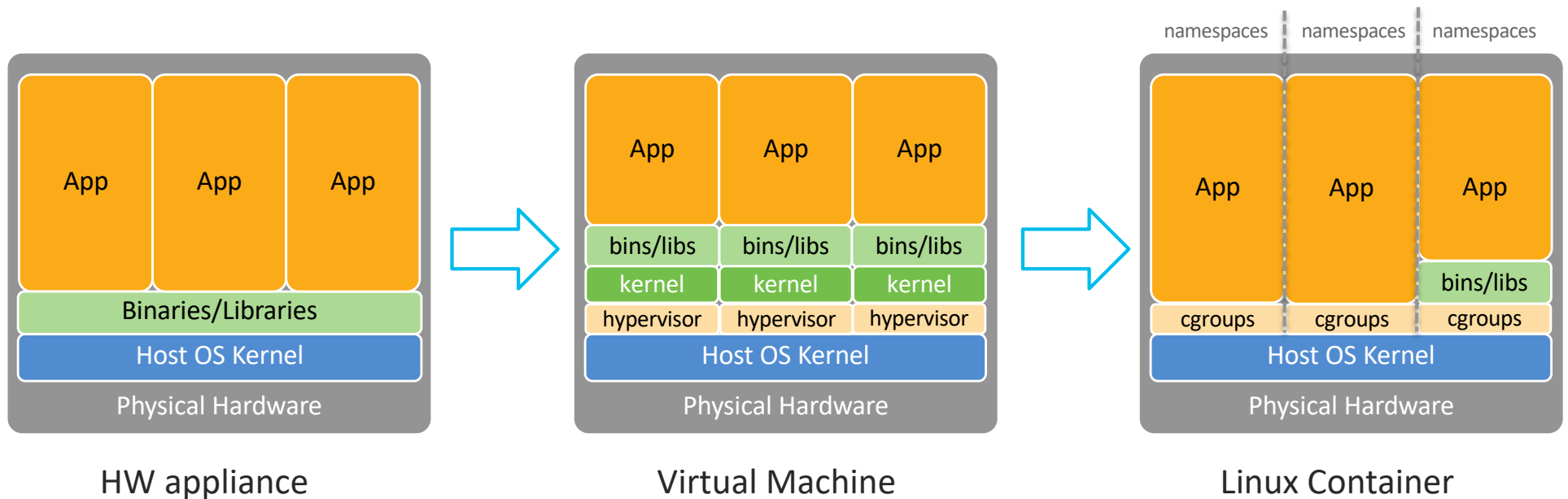
Achieving Network Function Virtualization

Applications running using virtualized Hardware end CPUs	Virtual Machines / Container
Guest O/S running independently in each VM	Guest O/S
HyperVisor - isolated application providing VMs on the Host	HyperVisor
Host operating system	Host O/S
Virtualization capable CPUs	Physical Host
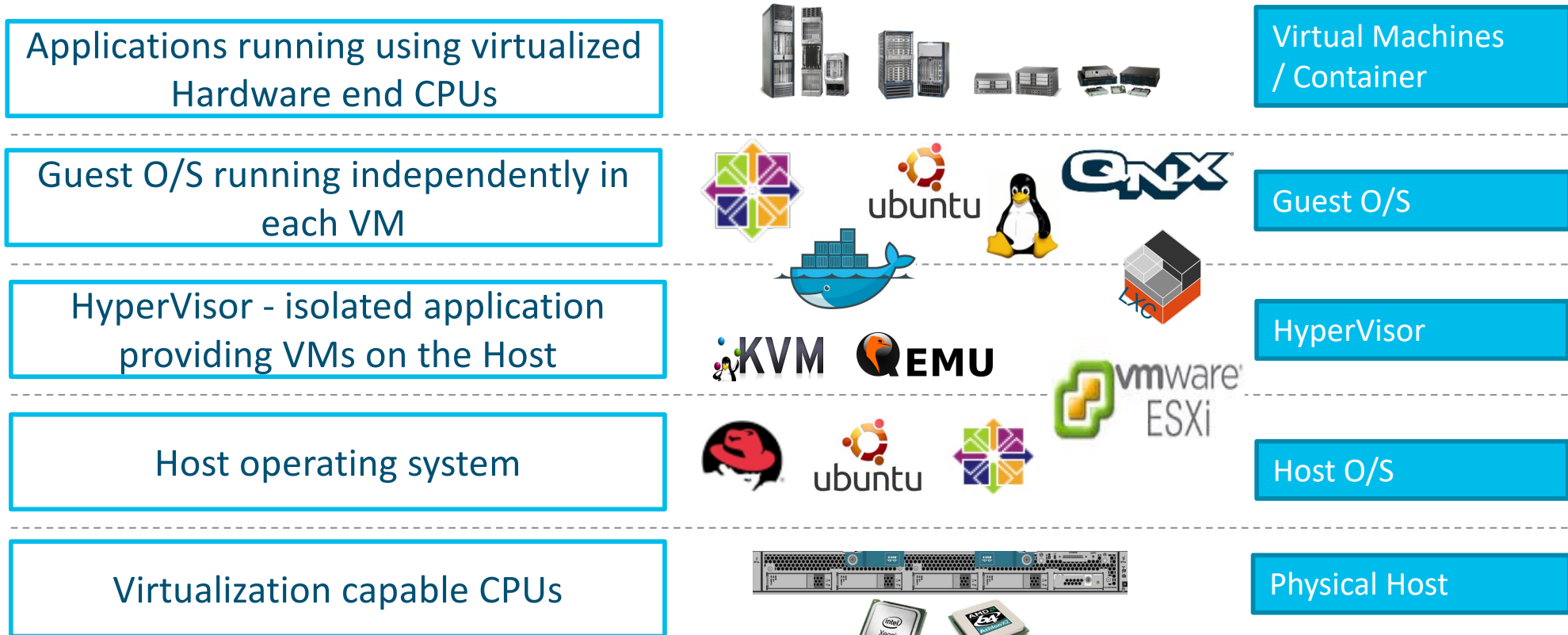
Network Virtualization
ETSI Architecture Framework for NFV

NFV **SDN**

Apps & Orch

Operational & Billing Support System

Virtualized Network Functions (VNFs)

| VNF vRR | VNF vPE | Other VNF |

NFV Management & Orchestration (MANO)

Deployment

Network Function Virtualization Infrastructure (NFVI)

| Virtual Compute | Virtual Storage | Virtual Network |

Virtualization Layer

| Compute & Storage Hardware | Network Hardware |

Management
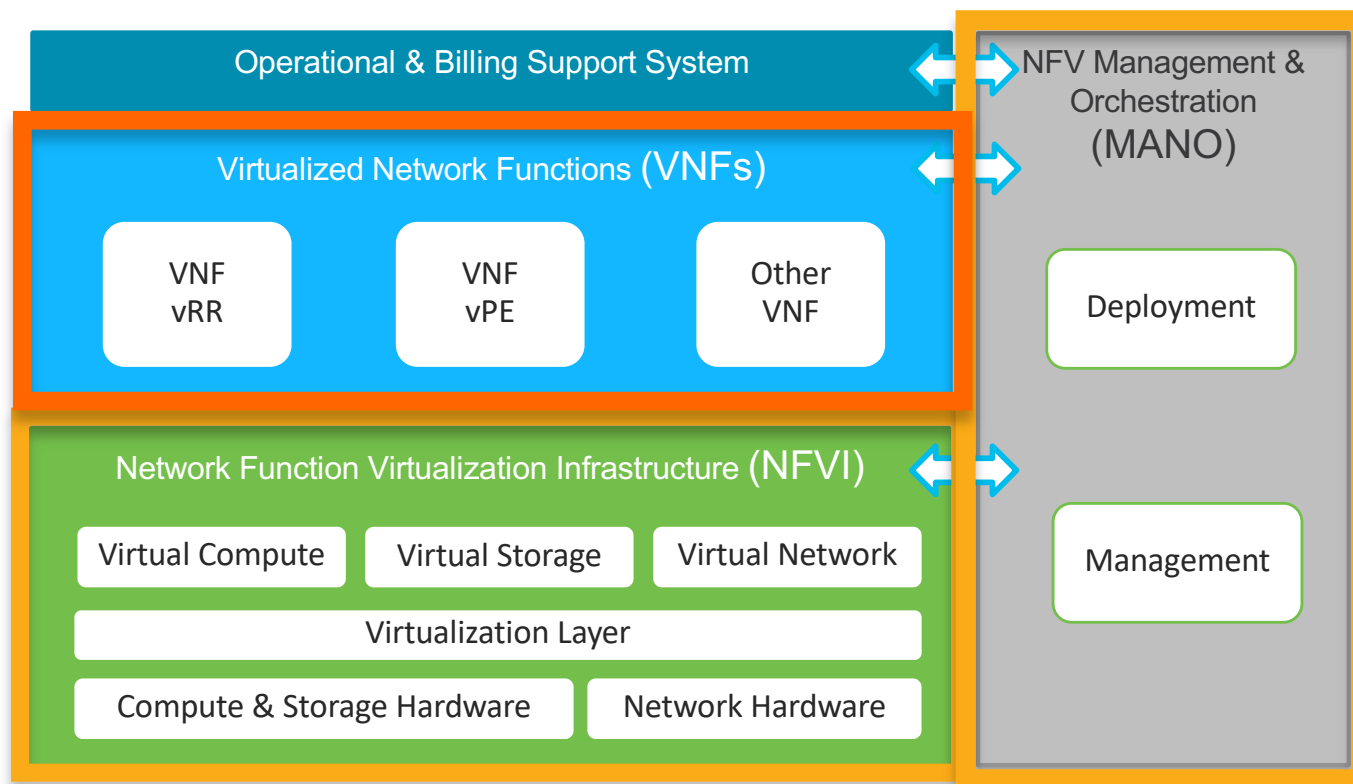
VNF across Cisco portfolio

Some Virtualized Network Operating Systems and Appliances

IOS-XR	NX-OS	IOS-XE	ASA
Virtualized as IOS XRv 9000	Virtualized as Nexus 9000v	Virtualized as CSR1000v	Virtualized as ASAv

Cisco's VNF Portfolio ….
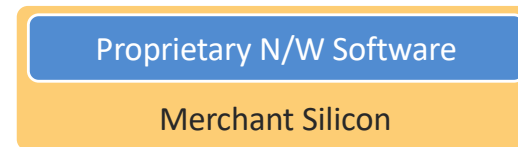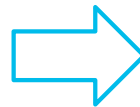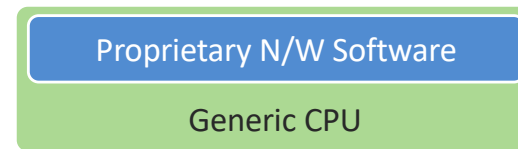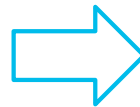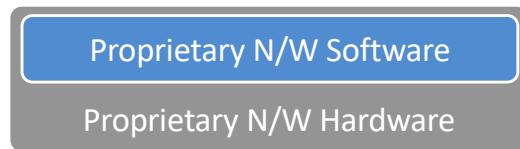
IOS XRv 9000

CSR1000v

ASAv

vWAAS

DDoS Scrubber (w/Arbor)

Nexus 9000v

QvPC

vWLC

vNAM

vWSA

vESA

NFV vs Delayering (NFD)

Disaggregation

Proprietary N/W Software

Proprietary N/W Hardware

→ Proprietary N/W Software

Generic CPU

→ Proprietary N/W Software

Merchant Silicon

OPEN Compute Project

Virtualizing Network Functions

X86 versus Custom Network Processing Unit (NPU)

Network Forwarding (L0-3)	Network Services (L4+)
Mostly predictable traffic	Unpredictable traffic
Stateless functions	Stateful functions
High throughput / BW	Low to Med Throughput
IPv6/v4, MPLS, VPNs, Optical	BGP Route reflector, Firewall, DPI
Better Fit for Custom Hardware	Better Fit for NFV

Compute
Bandwidth

Compute
Bandwidth

Network Transformation with NFV

Legend:
- CE
- Access
- PE / Agg
- Core
- RR
- Contr

Edge

Edge

Edge

Edge

Agg

Agg

Agg

Agg

Core

Network Transformation with NFV

Legend:
- CE
- Access
- PE / Agg
- Core
- RR
- Contr
- VNF

Edge, Edge, Edge, Edge

Agg, Agg, Agg, Agg

Core
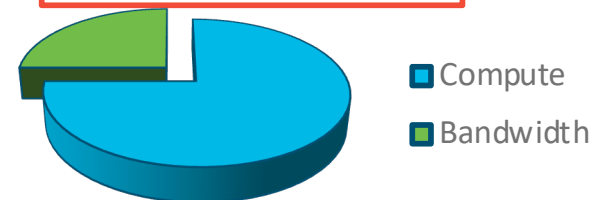
CISCO Live!

Network Transformation with NFV
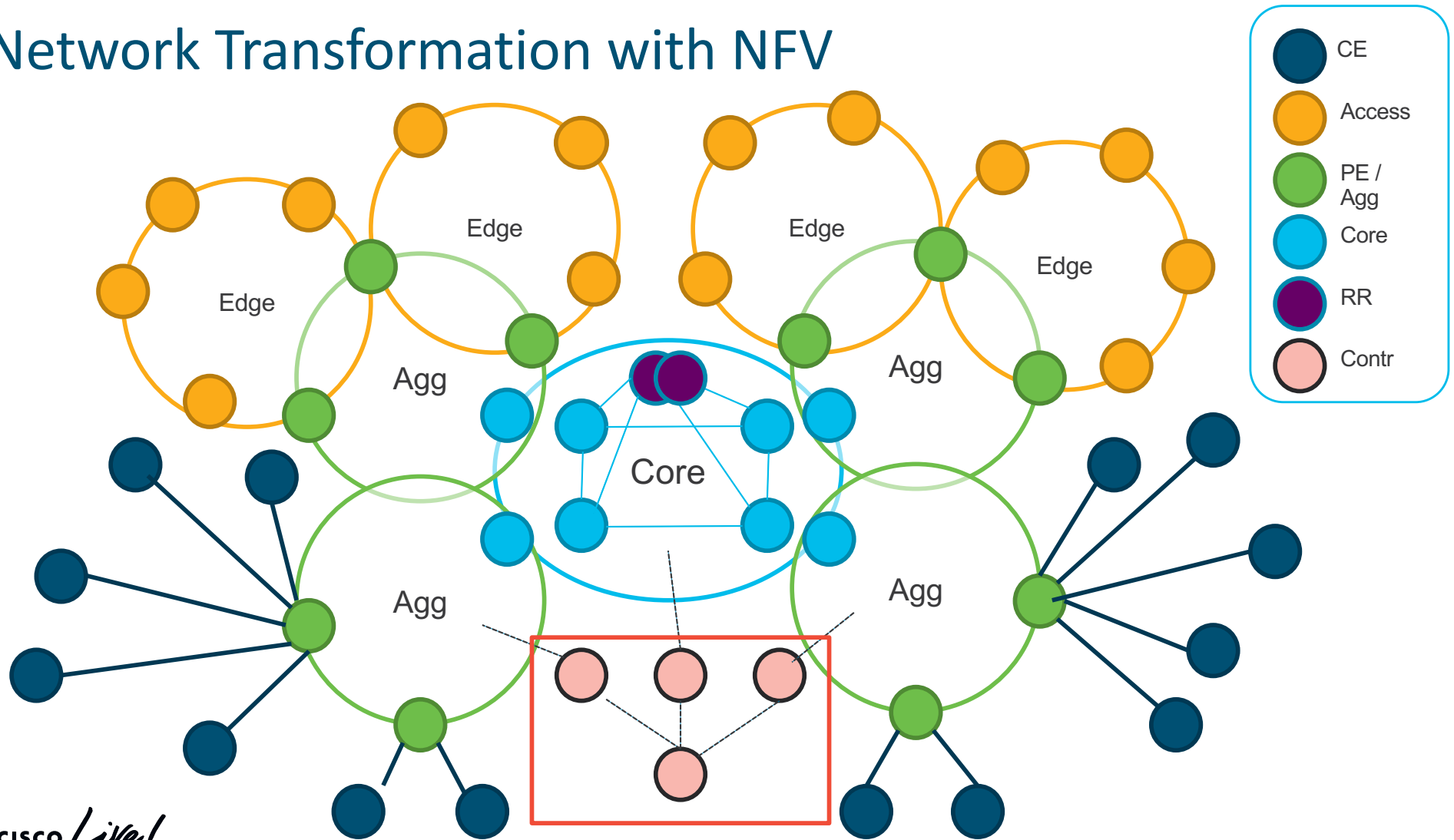
Legend:
- CE
- Access
- PE / Agg
- Core
- RR
- Contr
- VNF

Core

Edge

Agg

BRKSPG-2724

20
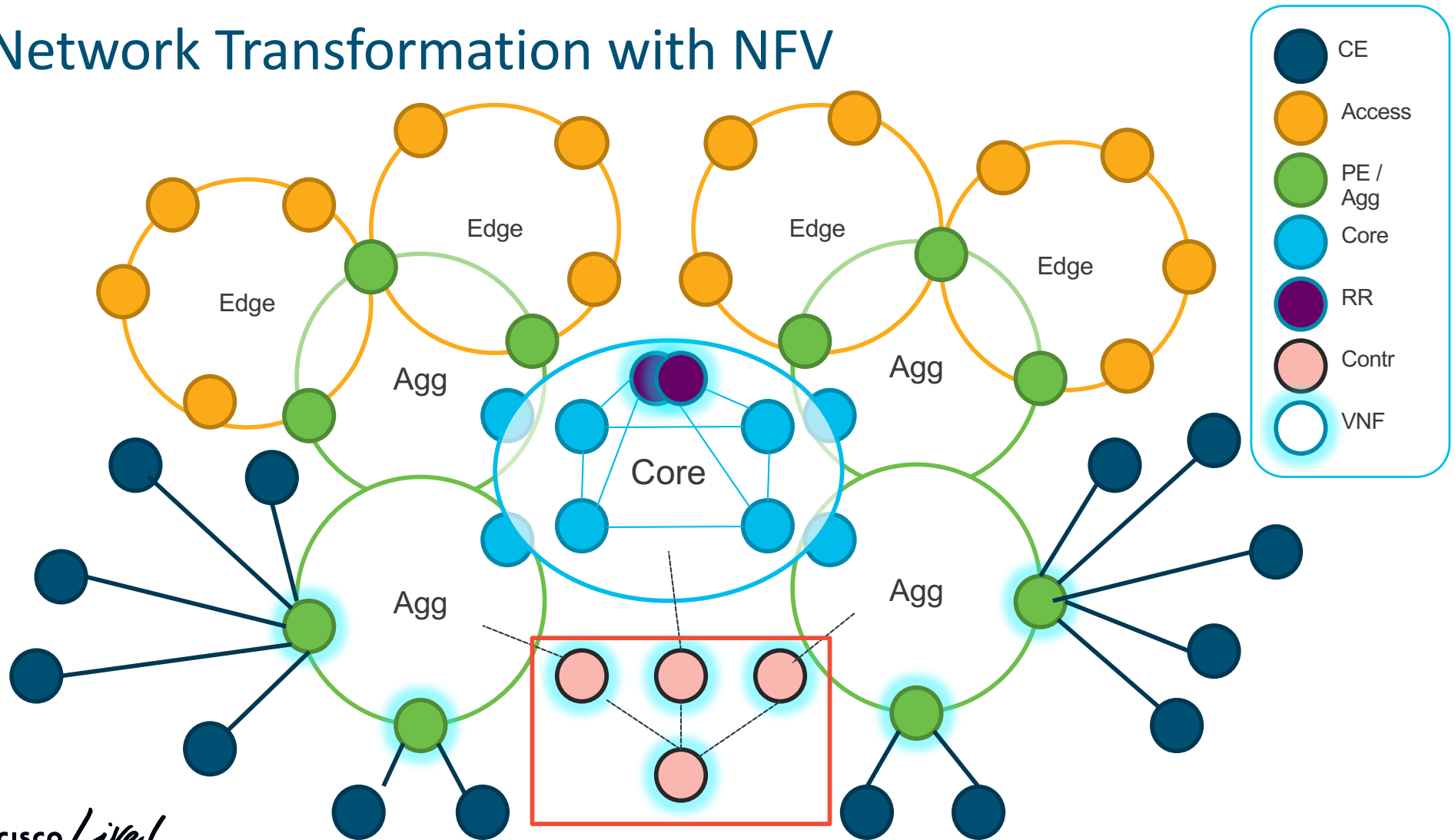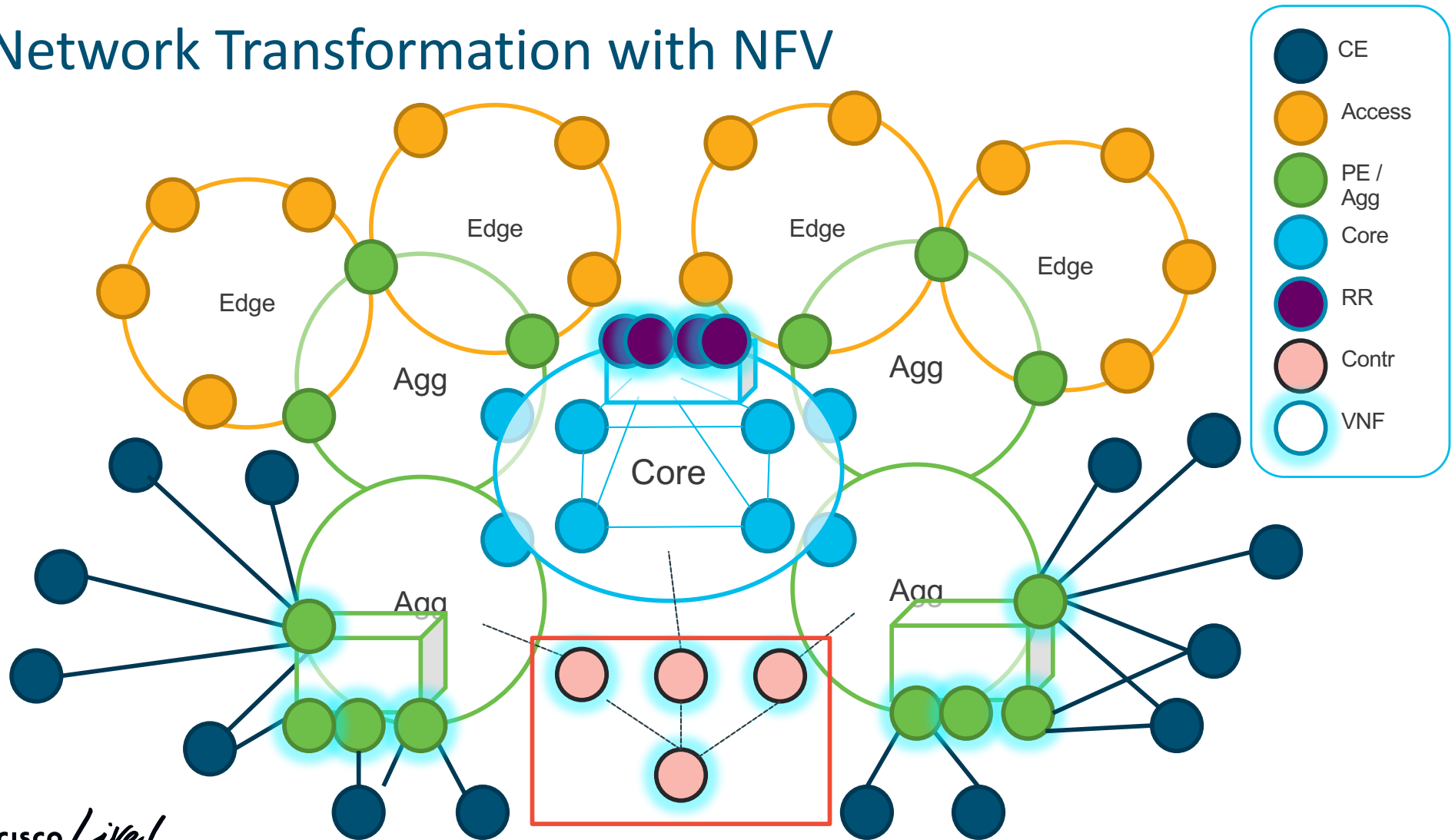
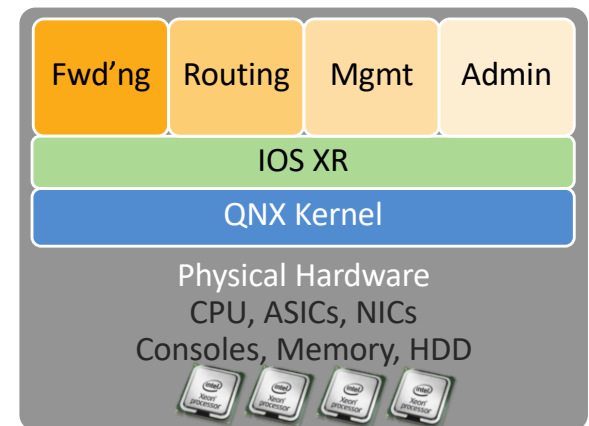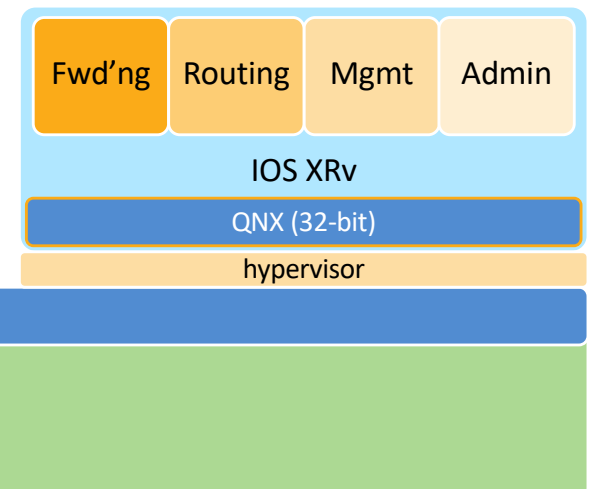# IOS XRv 9000

IOS XR

- Time hardened for years
  - CRS-1, CRS-3, CRS-X, ASR 9000, NCS 6000, NCS5500

- High-scale control plane

- MicroKernel-based

- Modular Software

- Process Restartability & Redundancy

- Remediation through add-on patches

Fwd'ng	Routing	Mgmt	Admin
IOS XR			
QNX Kernel			

Physical Hardware
CPU, ASICs, NICs
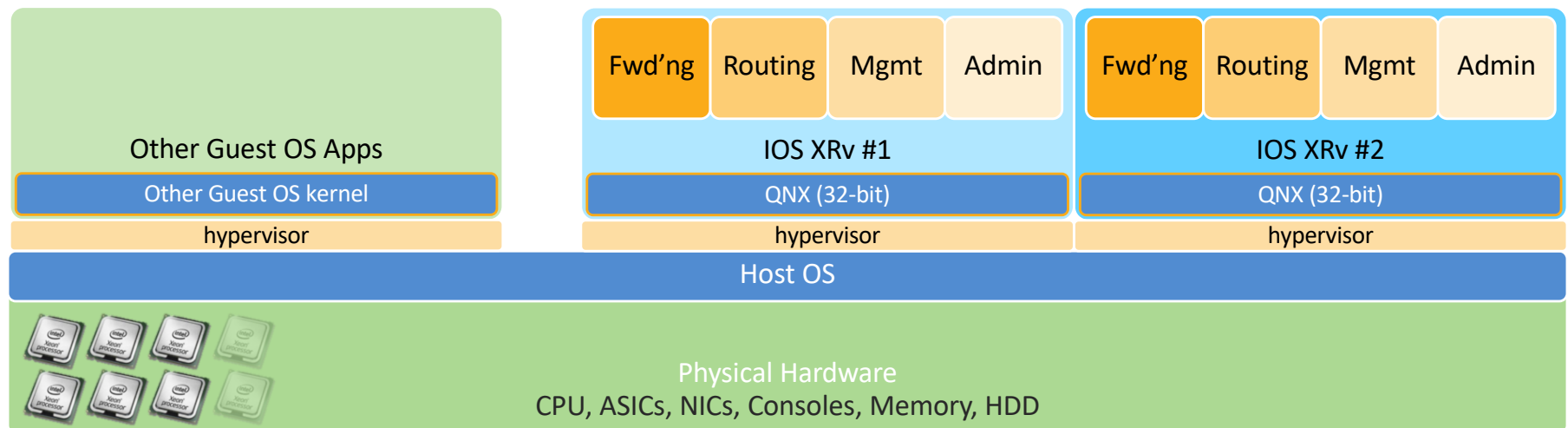Consoles, Memory, HDD

IOS XR**v**

- IOS XR on x86 Virtualized environment

- Full *Platform Independent* IOS XR
  - Same IOS XR software feature set
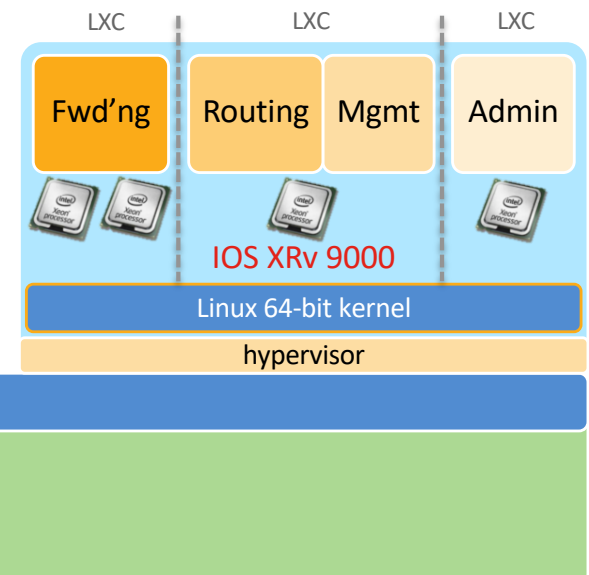 - Manageability
  - Control Plane
  - Routing

Fwd'ng	Routing	Mgmt	Admin

IOS XRv

QNX (32-bit)

hypervisor

Host OS

Physical Hardware
CPU, ASICs, NICs, Consoles, Memory, HDD

IOS XRv

One Physical hardware -- Multiple Instances

| Other Guest OS Apps | | | | Fwd'ng | Routing | Mgmt | Admin | Fwd'ng | Routing | Mgmt | Admin |

Other Guest OS Apps

Other Guest OS kernel

hypervisor

| Fwd'ng | Routing | Mgmt | Admin |

IOS XRv #1

QNX (32-bit)

hypervisor

| Fwd'ng | Routing | Mgmt | Admin |

IOS XRv #2

QNX (32-bit)

hypervisor

Host OS

Physical Hardware
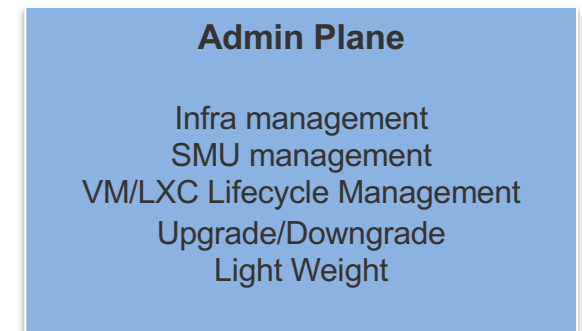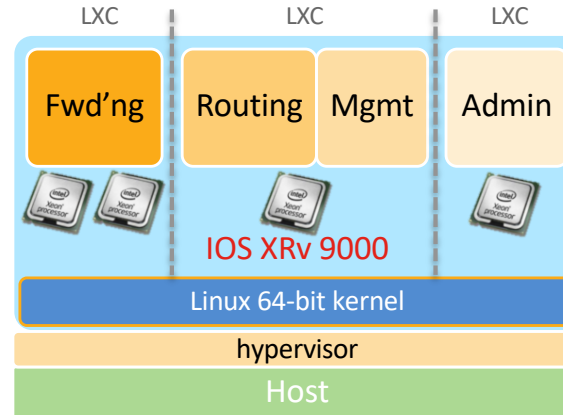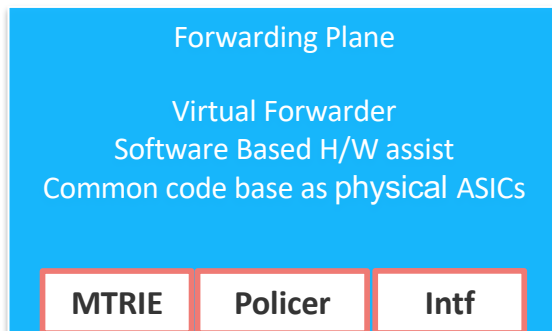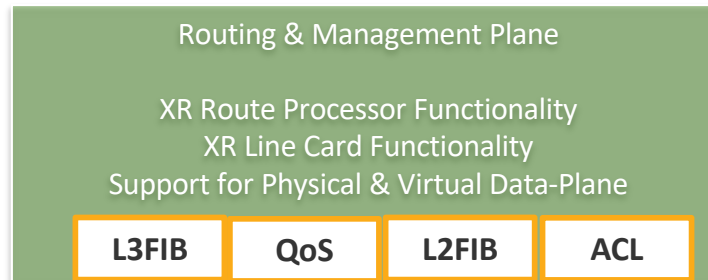CPU, ASICs, NICs, Consoles, Memory, HDD

IOS XRv 9000

- Virtualized IOS XR with Control and Data plane Separation
  - Linux Containers for Admin, Control and Data Planes
  - 64 Bit Kernel

- Scalability through Flexible resource Allocation
  - Data plane scalability.
  - Control Plane scalability

IOS XRv 9000

Routing & Management Plane

XR Route Processor Functionality
XR Line Card Functionality
Support for Physical & Virtual Data-Plane

L3FIB	QoS	L2FIB	ACL

Forwarding Plane

Virtual Forwarder
Software Based H/W assist
Common code base as physical ASICs

MTRIE	Policer	Intf

LXC   LXC   LXC

Fwd'ng	Routing	Mgmt	Admin

IOS XRv 9000

Linux 64-bit kernel

hypervisor

Host

Admin Plane

Infra management
SMU management
VM/LXC Lifecycle Management
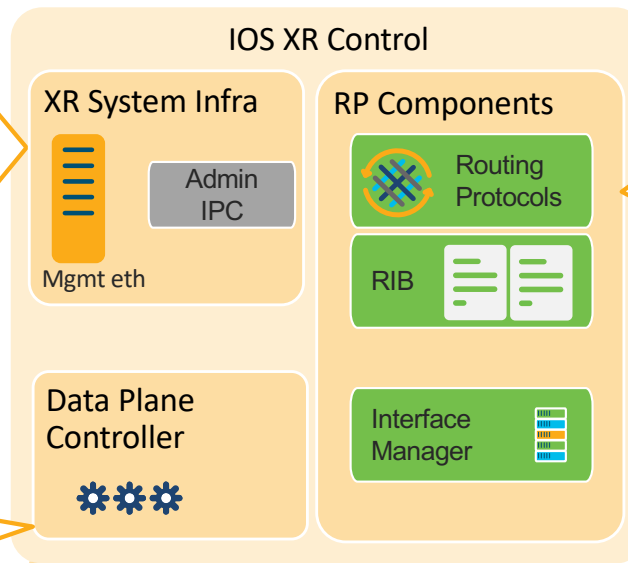Upgrade/Downgrade
Light Weight

IOS XRv 9000

IOS XR 64-bit Control Plane

Typical XR Maintenance and Managemt tasks
- Software management and SMUs
- Admin LXC process interaction
- Mgmt Eth
- SNMP
- SSH/Telnet
- etc.

Route and feature programming and control

IOS XR Control

XR System Infra

Admin IPC

Mgmt eth

RP Components

Routing Protocols

RIB

Interface Manager

Data Plane Controller

Elastic control plane profiles vRR and vPE

In vRR profile tested up to:
- 25M BGP IPv4
- 8M BGP IPv6
- 5k BGP IPv4 peers

Fwd'ng | Routing | Mgmt | Admin

IOS XRv 9000

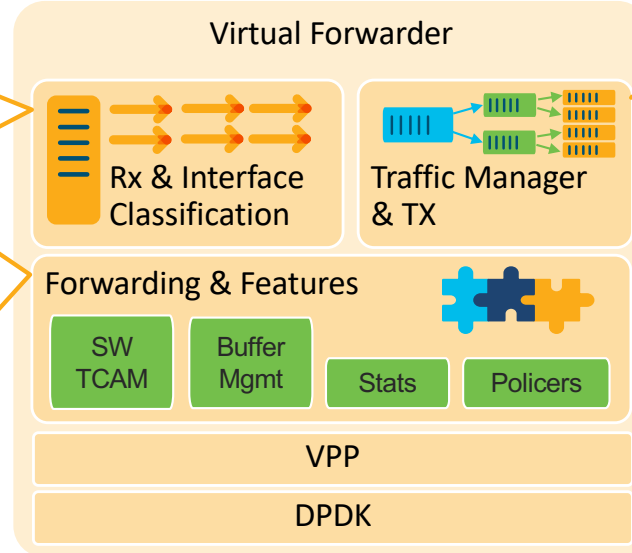Linux 64-bit kernel

hypervisor

Host
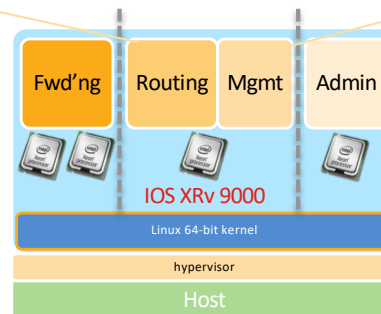
IOS XRv 9000
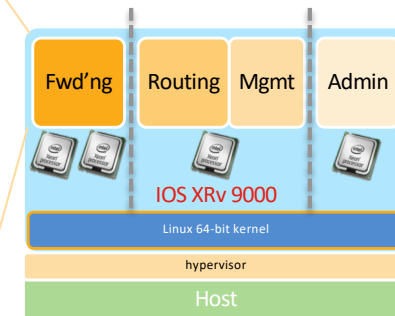## Virtual Forwarder

High speed interface classification
Fine grained LB

Elastically Scalable Feature Path
- ACLs
- uRPF
- Policing and Marking
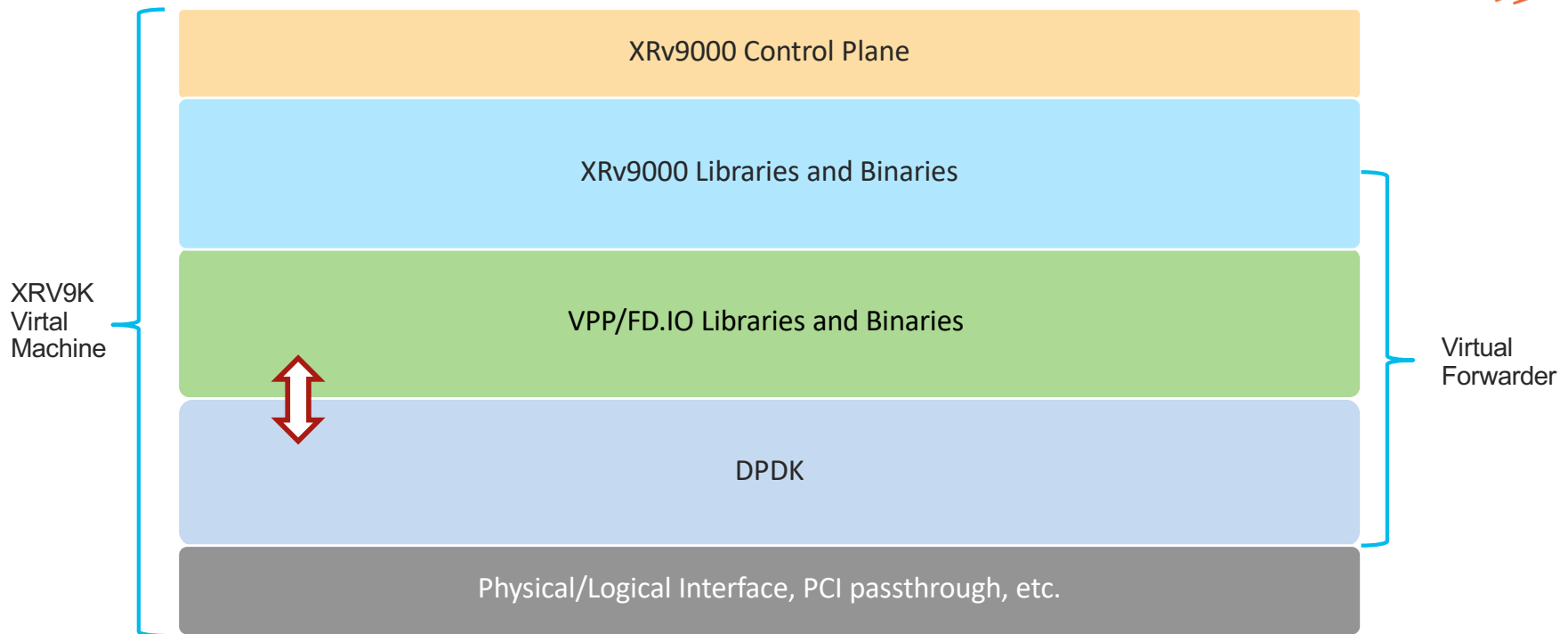- IPv4/IPv6/MPLS
- Segment Routing
- BFD

Virtual Forwarder

Rx & Interface Classification

Traffic Manager & TX

Hierarchical QoS Scheduler
- 512k queues
- 3-layer HQoS

Forwarding & Features

SW TCAM

Buffer Mgmt

Stats

Policers

VPP

DPDK

Fwd'ng | Routing | Mgmt | Admin

IOS XRv 9000

Linux 64-bit kernel

hypervisor

Host

CISCO Live!

IOS XRv 9000
VPP & DPDK

XRv9000 Control Plane
XRv9000 Libraries and Binaries
VPP/FD.IO Libraries and Binaries
DPDK
Physical/Logical Interface, PCI passthrough, etc.

XRV9K
Virtal
Machine

Virtual
Forwarder

VPP : Vector Packet Processing
DPDK : Data Plane Development Kit

IOS XRv 9000
VPP & DPDK Interaction

XRv9000 Control Plane

XRv9K – Data Forwarding & Features (L3/L2 Forwarding, Feature - qos/acl/pbr/LI etc)	XRv9K DPA/HAL

XRV9K Libraries & Functions

Graph & Batching of packets

VPP-Vnet (Tx/Rx)	VPP-Vlib (CLI/Graph)	VPP-Executable (Core VPP)	VPP-Infra (Low Level)

VPP / FD.IO Libraries & Executable

Send/receive batches of packets to the DPDK Rx burst and Tx burst functions & Statically links to DPDK

DPDK

Heap memory management, timers, vector operation abstraction

Physical/Logical Interface, PCI passthrough, etc.

VPP : Vector Packet Processing
DPDK : Data Plane Development Kit

IOS XRv 9000
Emulated NICs and PCI passthrough

NICs full virtualization

LXC — Admin | LXC — Mgmt | Routing | LXC — Fwd'ng

IOS XRv 9000

1G
E1000 driver
VPP/DPDK

hypervisor
Driver

Host

NICs paravirtualization

LXC — Admin | LXC — Mgmt | Routing | LXC — Fwd'ng

IOS XRv 9000

1G
virtIO/VMXNET3 driver
VPP/DPDK

hypervisor
Driver

Host

PCI passthrough

LXC — Admin | LXC — Mgmt | Routing | LXC — Fwd'ng

IOS XRv 9000

10G
p10GE driver
VPP/DPDK

hypervisor

Host
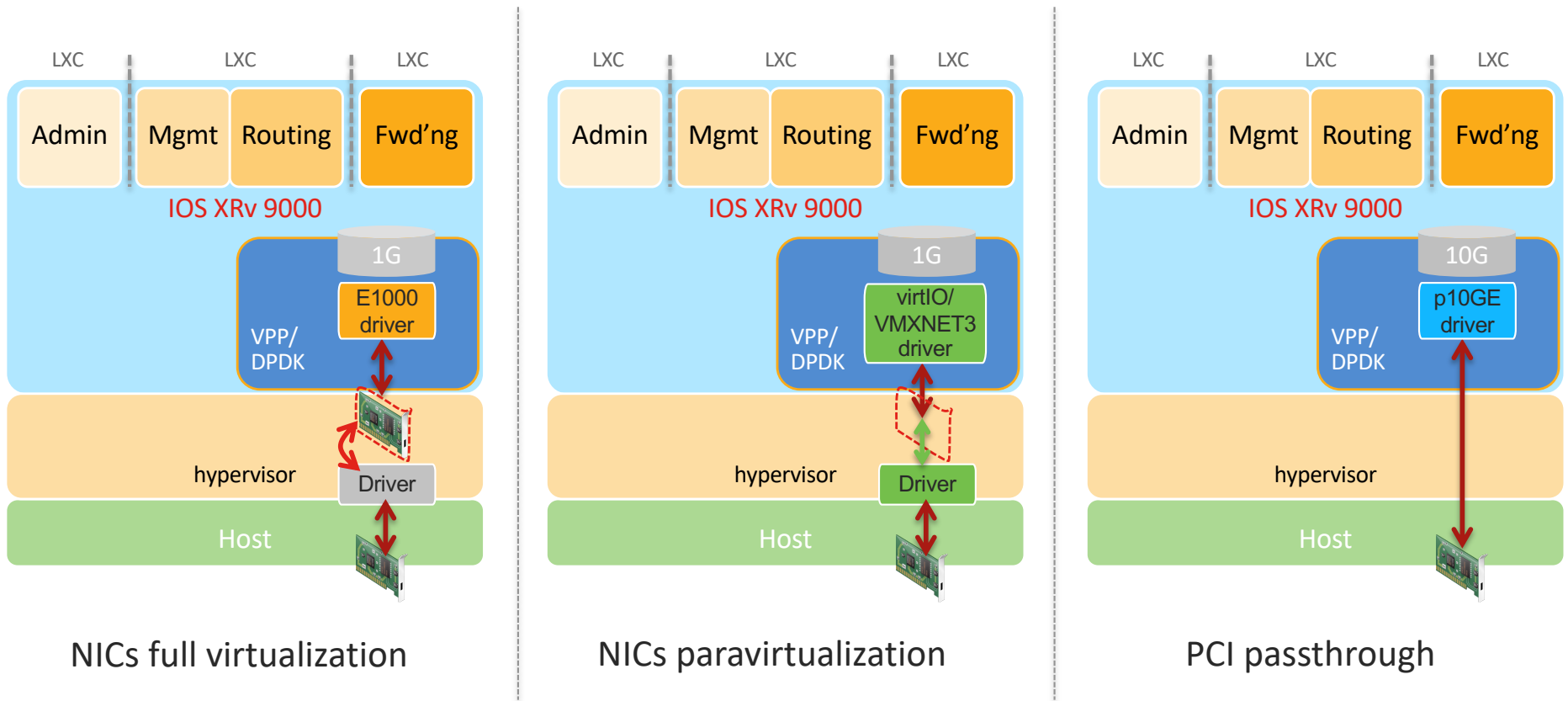
Cisco IOS XRv 9000
NFV Design Trade Offs

Performance at Low Scale

Performance with L2/L3 FIB & Labels

Price/Port

Performance: ACE, TM, & Queues

Topology Convergence

Feature Parity
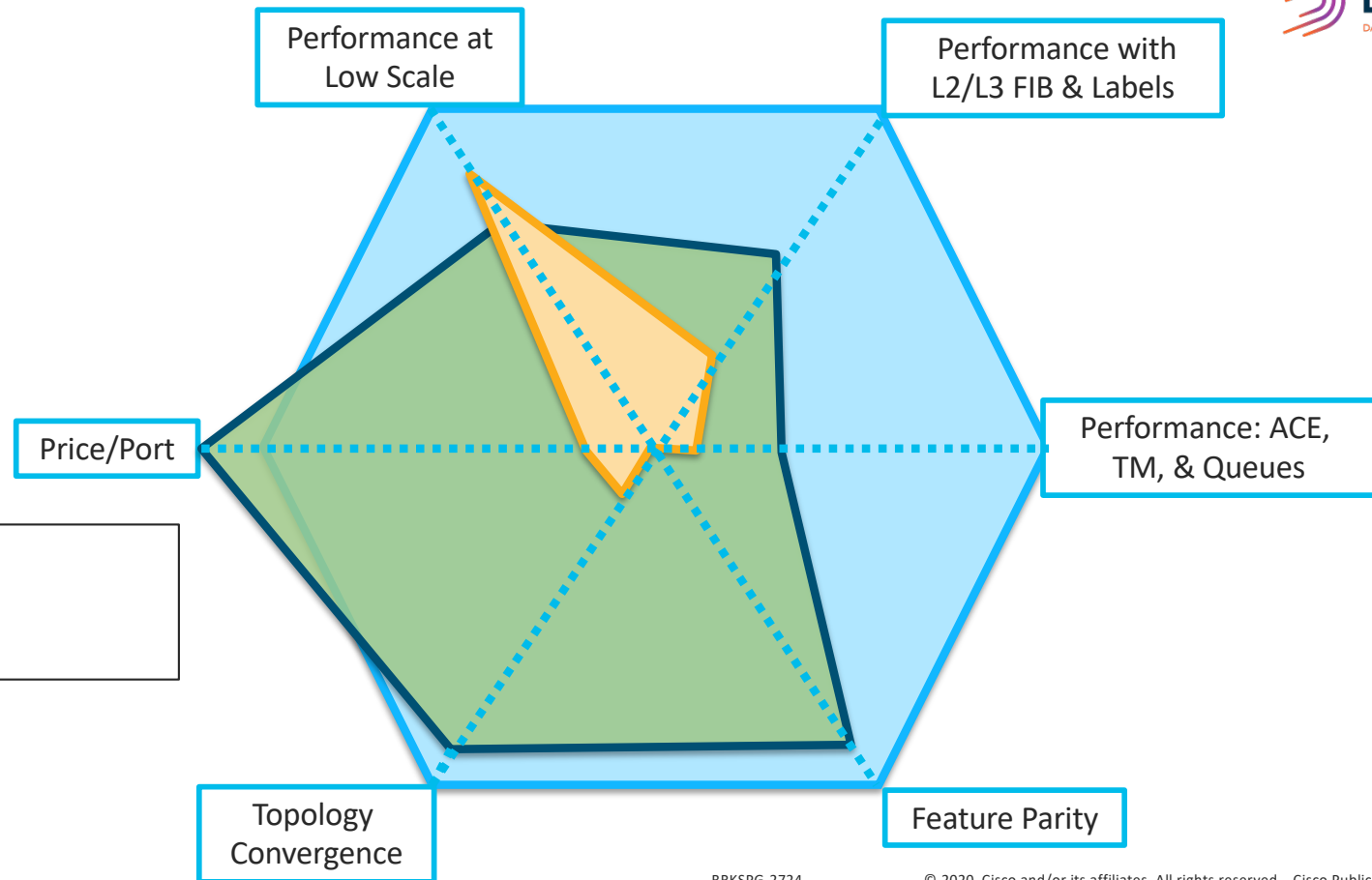
Physical XR Router
IOS XRv 9000
Other Virtual Router

IOS XRv 9000 Performance

40 Gbps

160 Gbps

8 Gbps

40 Gbps

160 Gbps

640 Gbps

Vanilla IPv4

IMIX traffic packet size with features (ACL, HQoS, Policing) enabled

Single Core | Multi-Core | Multi-Socket | Multi-Server

2015 | 2016 - 2020 | 2020+
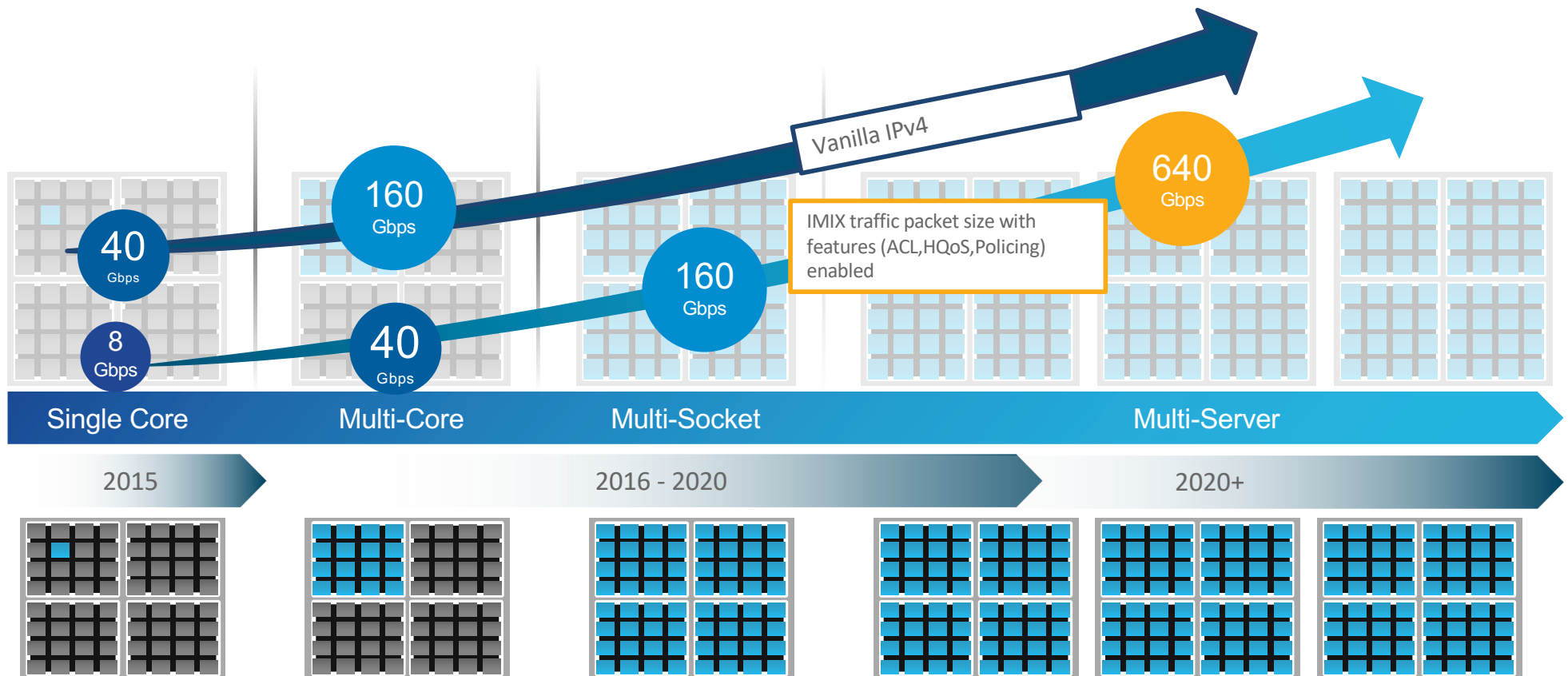
IOS XRv 9000 Positioning
Completing the XR Edge Portfolio

ASR 9922

ASR 9912

ASR 9910

ASR 9904

ASR 9901

ASR 9001

IOS XRv 9000

160

80

Tbps

20

5

1280

Gbps

320

80

Virtual
XR DP
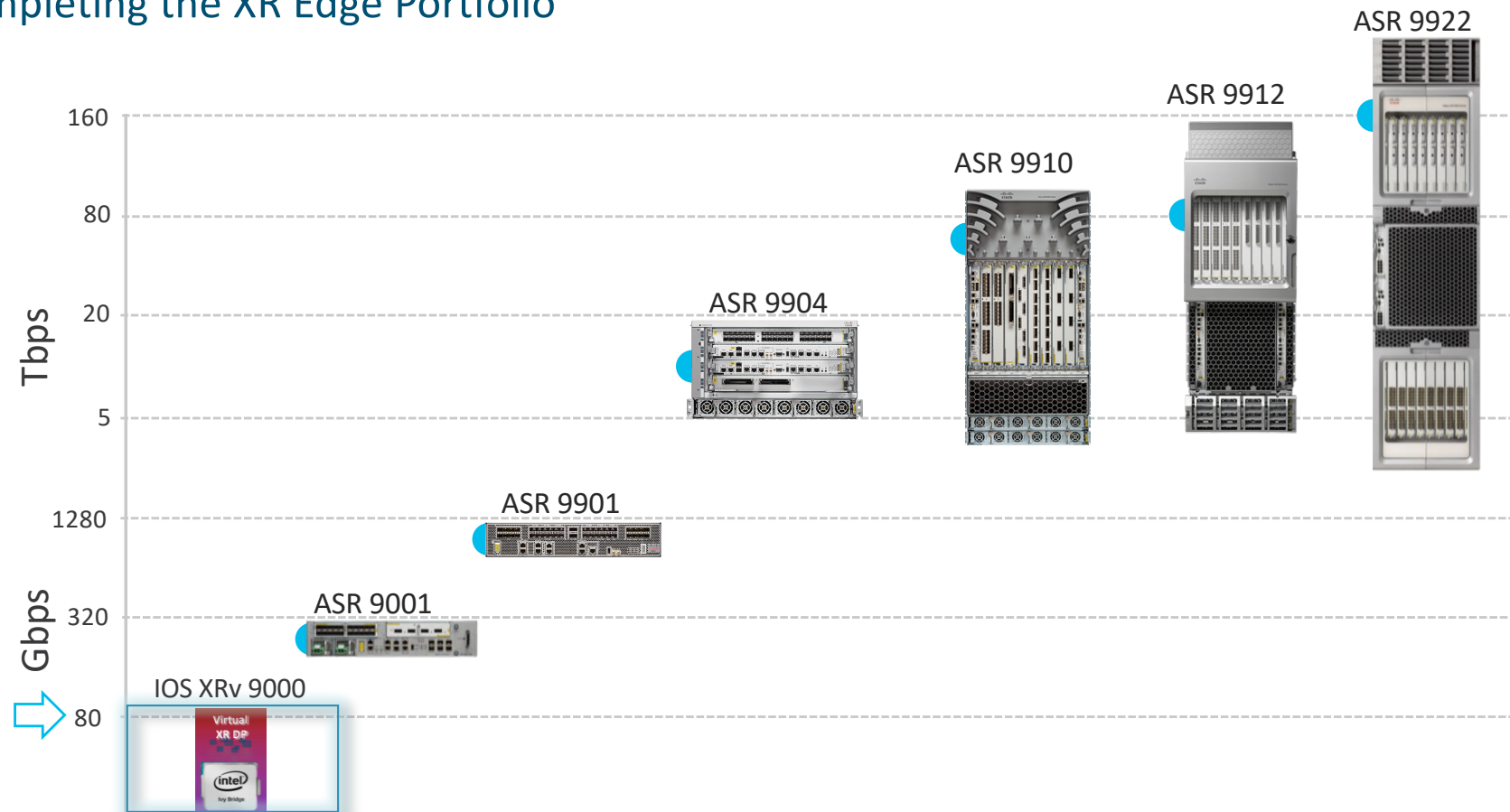
(intel)
Ivy Bridge

Benefits & Use Cases

IOS XRv 9000
Benefits

NFV

Lower Opex
Easy provisioning , configuration & deployment for VMs

Elastic
Dynamic resource allocation & de-allocation
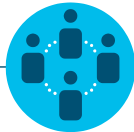
SDN Ready
Independent control and forwarding

IOS XRv 9000

Green
low power consumption → Lower carbon footprint

Flexible Design
CP & DP Separation and independent resource allocation

Lower Capex
IOS XRv on standard compute Consumption Based Growth

IOS XRv 9000

Use Cases

Education and Training

Network Simulation & Planning
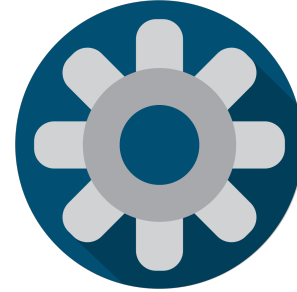
Network Functions Virtualization

Enterprise – Public Sector – Service Providers

IOS XRv 9000 as vRR

RR role evolution -
centralized provision, services, and applications

1 Per Service

2 Per Address Family

3 Redundant

4 Optimized Placement

5 Scalable

- Not in packet path
- Focal point for iBGP sessions

Primary   Backup

IPv4 RR

L3VPN RR

L2VPN RR

IPv6 RR

IOS XRv 9000 as vRR

Primary   Backup

IPv4 RR

L3VPN RR

L2VPN RR

IPv6 RR

8 Physical Devices

Primary   Backup

IPv4 vRR

L3VPN vRR

L2VPN vRR

IPv6 vRR

**2 Physical Devices
Virtualized RRs per AFI**
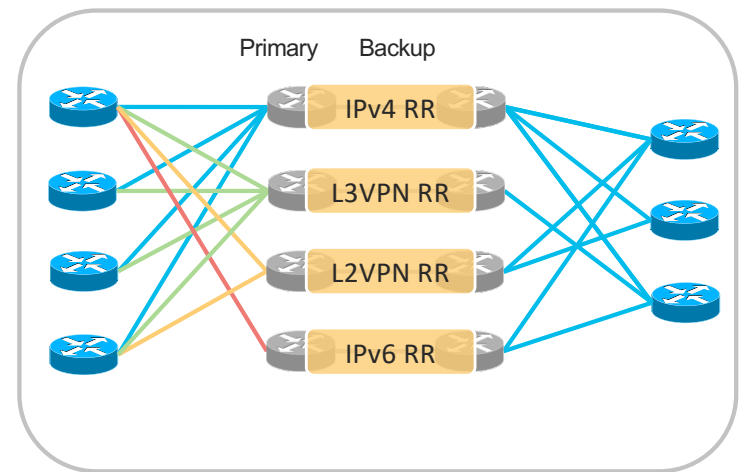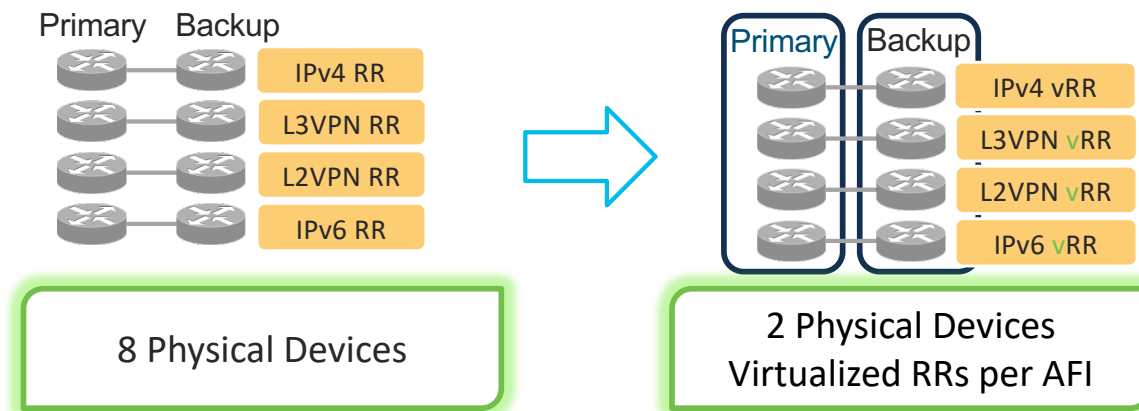
Without Compromising

✔ Scale & Performance

✔ High Availability

✔ Independent Operation

✔ Full BGP Stack (XR)

IOS XRv 9000 as vRR
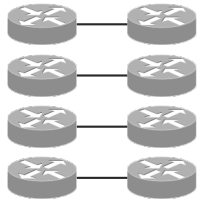
Physical Router	VRR on UCS Server
Typical Power consumption ~425W	Typical Power consumption ~360W
Total power for 8 instance ~3.4kW	Total power for 8 instances ~720W
Power/Year = 29,784 KWh	Power/Year = 6,307 KWh
Power Cost/Year = $5,659 (19c/kWh)	Power Cost/Year= $1,198 (19c/KWh)

Primary Backup

Primary Backup
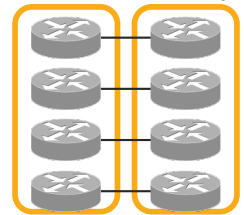
Power Calculations based on:
-ASR9001 (Typ Power)
-UCS C220 M5 LFF with 2x Intel 6142 2.6 GHz/150W with 192GB DDR4 RAM, 4 HDD with RAID, and 2 Quad 10GE Adapters.

IOS XRv 9000 as vPE

✓ Consumption Based Growth

✓ Single Tenant vRouters

✓ High availability at lower cost

✓ Elastic deployments

CE

CE

CE

CE

IOS XR

IOS XR

IOS XRv 9000
as : vPEç

vPE vPE vPE

CE CE CE

⟷ L3VPN
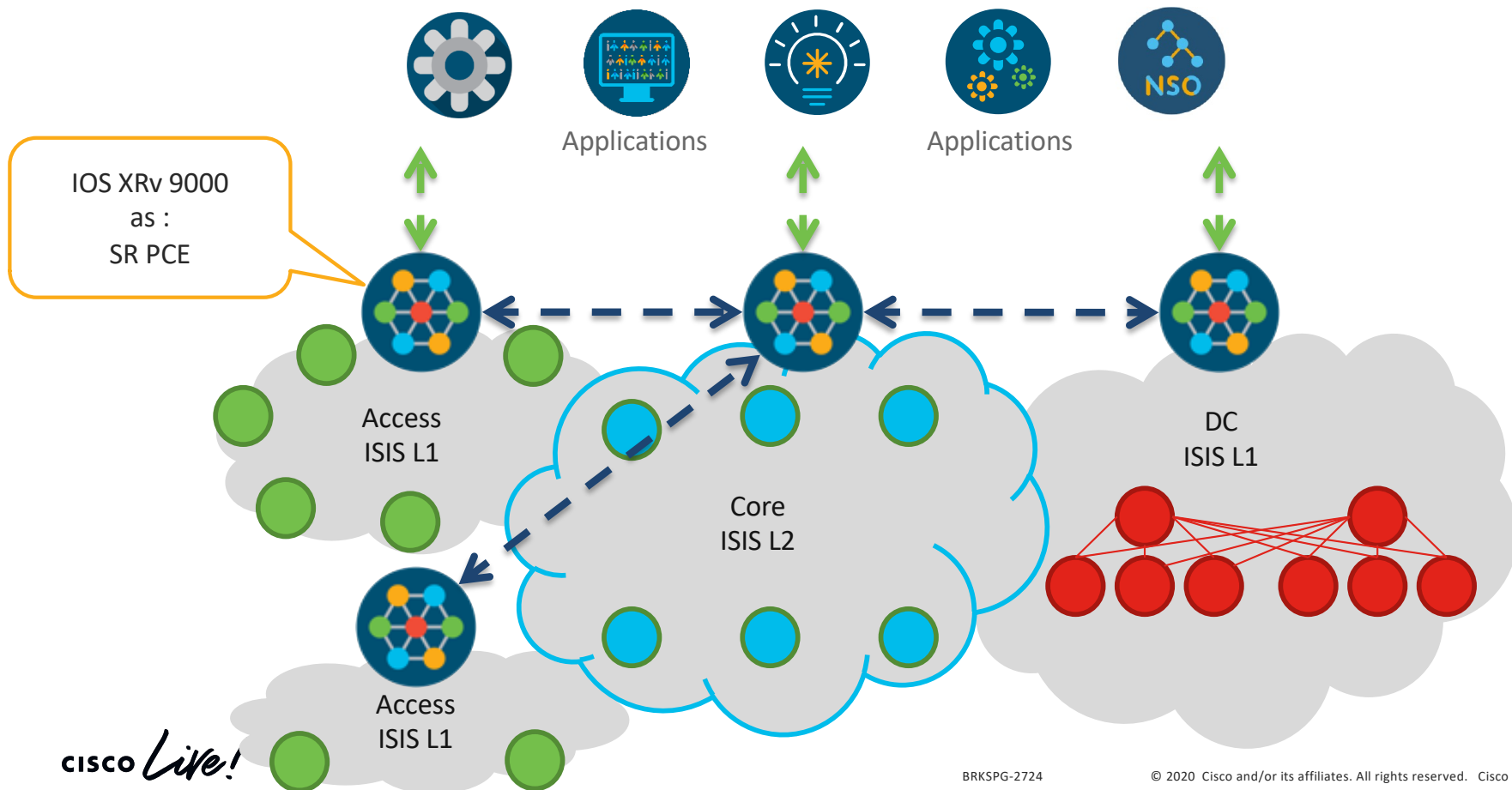Customer A

⟷ L3VPN
Customer B

⟷ L3VPN
Customer C

cisco Live!
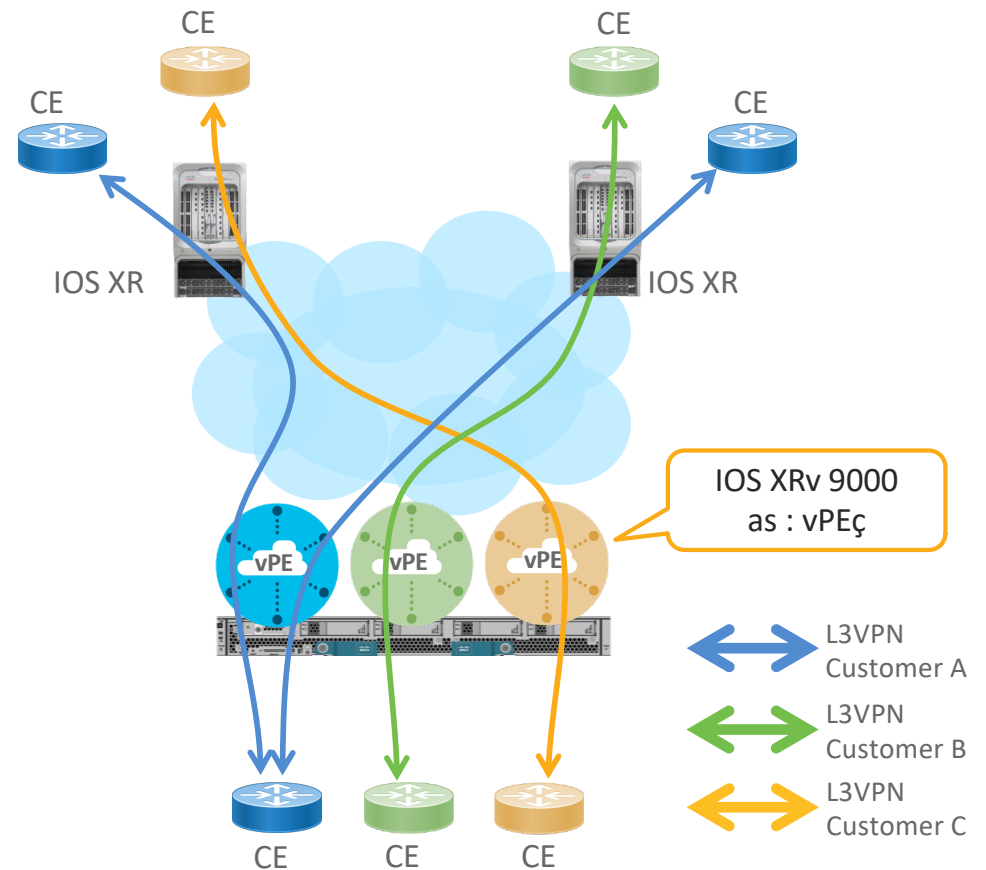
IOS XRv 9000 as a vBNG

✔ XR Geo-Redundancy

✔ Flexibility & Scalability

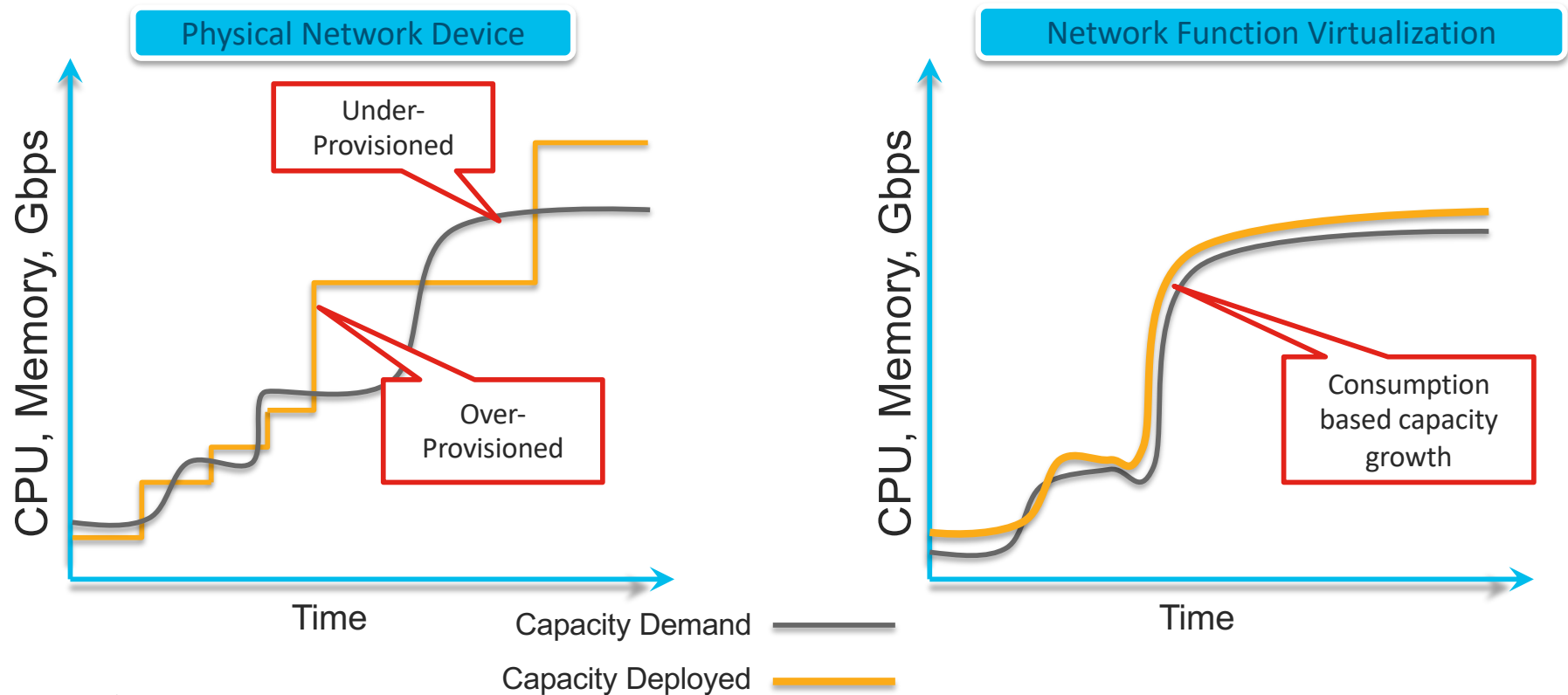✔ Real-Time Visibility (Telemetry)

✔ Automation of Operations

IOS XRv 9000

Data Center

vBNG vBNG vBNG vBNG

Internet GW

DCI DCI

IP/MPLS Network

pBNG
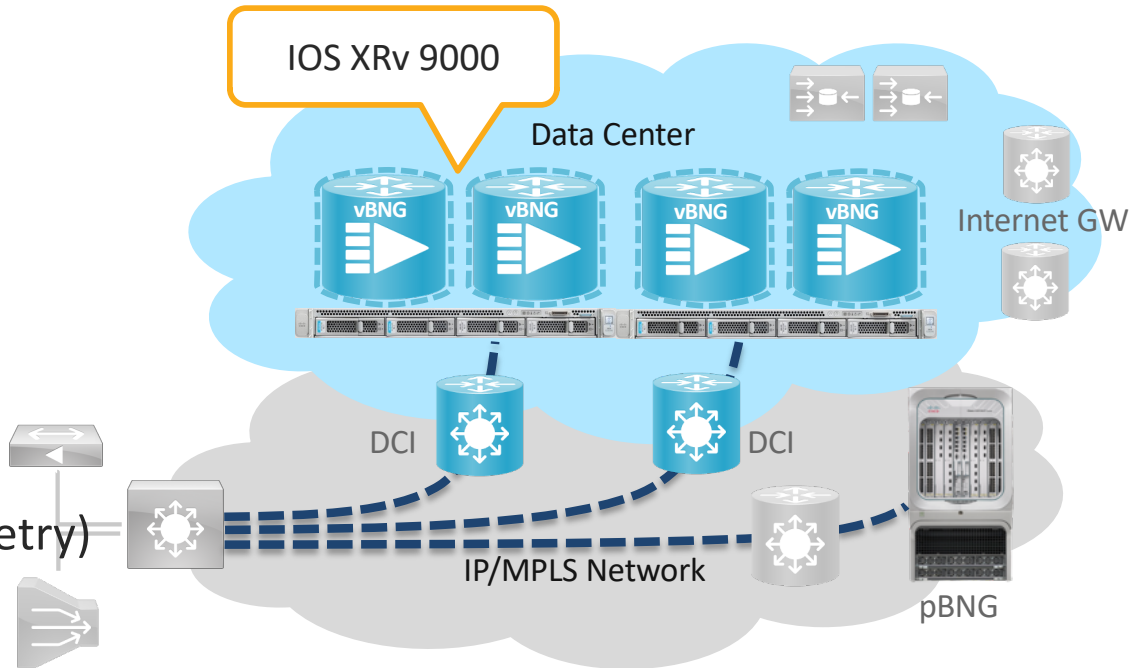
IOS XRv 9000 as Path Computation Element

IOS XRv 9000
as :
SR PCE

Applications

Applications

Access
ISIS L1

Access
ISIS L1

Core
ISIS L2

DC
ISIS L1

Physical Network Device vs NFV

Consumption Based Deployment

Physical Network Device

CPU, Memory, Gbps

Under-Provisioned

Over-Provisioned

Time

Network Function Virtualization

CPU, Memory, Gbps

Consumption based capacity growth

Time

Capacity Demand

Capacity Deployed

IOS XRv 9000 Features

IOS XR 7.0.1

- IGP & BGP Optimal RR

- IPv4 L3vpn, L2vpn-VPWS

- BGP FlowSpec

- Link Aggregation (LAG)

- BFD

- LDP/MPLS, 6PE, 6vPE, RFC 3107 (3 labels), L3VPN

- IPv4 ACL (chained), uRPFv4/v6, LPTS

- Netconf/YANG & SNMP

- Hierarchical QoS policing, WRED

- EFD

- Lawful Intercept

- IOS XR Manageability & Control Plane
  - PIE/SMU Upgrades
  - LPTS/ CoPP

- Gratuitous ARP

- VRRP/HSRP

- MPLS-TE

- Inter-AS L3VPN

- Segment Routing

https://www.cisco.com/c/en/us/td/docs/routers/virtual-routers/xrv9k-70x/general/release/notes/b-release-notes-xrv9k-r701.html

Virtualizing Network Functions using IOS XRv 9000

|				
Performance	Portability & Agility	Lower Opex/Capex	IOS XR Based Implementation	Route Scalability (64-bit NOS)
Elasticity & Flexibility	High Availability	Orchestration	Real-Time Visibility	Independent Operation
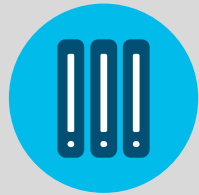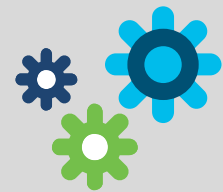
IOS XRv 9000
Deployment

IOS XRv 9000 Hardware/Software Requirements

- ## Hardware
  - Any x86-based server capable of virtualization
    - e.g. Intel® CPUs with VT-x support

- ## Hypervisor
  - hypervisor agnostic (VMWare 5.5,6.0,6.5. KVM on RHEL/CentOS7+, Ubuntu14.03LTS, 16.04LTS…)
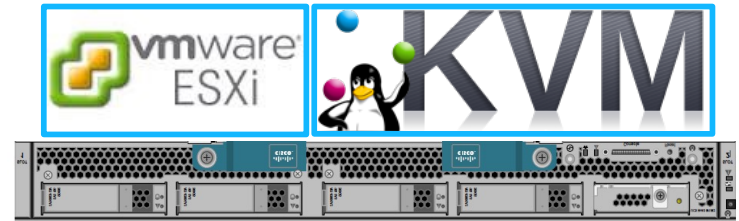
Parameter	Minimum	Recommended/Max
CPU (Cores)	2 (1 Control Plane, 1 Data Plane)	4 Sockets
Memory (RAM)	12 GB	19GB recommended
Hard Disk	45GB	
NIC Port (E1000,VirtIO,Intel1/10/40G, VMXNet3,SR-IOV)	4 (2 reserved, 1 traffic)	Production 11 (2 reserved, 8 traffic) Simulation : 128

https://www.cisco.com/c/en/us/products/collateral/routers/ios-xrv-9000-router/datasheet-c78-734034.html?dtid=osscdc000283

IOS XRv 9000 Deployment

Getting Images

- Tarballs for vPE and vRR profiles
  - Control Plane and Data Plane vCPU distribution
  - CP/DP Memory distribution

- OVA for generic deployment over ESXi or other hypervisors

- QCOW2 image for KVM based deployments or Openstack

- ISO to bake an image on a new virtual disk

https://software.cisco.com

↓

Download & Upgrade

File Information

Cisco IOS XRV 9000 software, VRR profile
fullk9-R-XRV9000-701-RR.tar

Cisco IOS XRV 9000 software, VRR profile with VGA support
fullk9-R-XRV9000-701-RRVG.tar

Cisco IOS XRV 9000 software, Non VRR profile with VGA support
fullk9-R-XRV9000-701-VG.tar

Cisco IOS XRV 9000 software, Non VRR profile
fullk9-R-XRV9000-701.tar

↓

📁 fullk9-R-XRV9000-701
   📄 README-fullk9-R-XRV9000-701.txt
   📄 xrv9k-fullk9-x-7.0.1.iso
   📄 xrv9k-fullk9-x-7.0.1.ova
   📄 xrv9k-fullk9-x-7.0.1.qcow2
   📄 xrv9k-fullk9-x.virsh-7.0.1.xml

IOS XRv 9000 Deployment

LXC   LXC   LXC

Admin	Mgmt	Routing	Virtual Forwarder

IOS XRv 9000

MgmtEth0

VPP/ DPDK   TenGigE 0/0/0/0   GigE 0/0/0/1   GigE 0/0/0/x

reserved

vNIC1   vNIC2   vNIC3   vNIC4   vNICx

vSwitch   hypervisor   vSwitch   vSwitch

passthrough

Host

IOS XRv 9000 Deployment
OVA deployment in ESXi environment

IOS XRv 9000 Deployment

OVA deployment in ESXi environment, Interfaces

IOS XRv 9000 Deployment
OVA deployment in ESXi environment, PCI passthrough

📱 **pr-c220-esxi-5 - Manage**

| System | **Hardware** | Licensing | Packages | Services | Security & users |

PCI Devices

Power Management

🔄 Toggle passthrough | 🖊 Configure SR-IOV | 🖥 Reboot host | ♻ Refresh | 🔍 Search

	Address	Description	SR-IOV	Passthrough
☐	0000:00:03.0	Intel Corporation Xeon E7 v3/Xeon E5 v3/Core i7 PCI Express Root Port 3	Not capable	Not capable
☐	0000:07:00.1	Intel Corporation 82599EB 10-Gigabit SFI/SFP+ Network Connection	Disabled	Active
☐	0000:07:00.0	Intel Corporation 82599EB 10-Gigabit SFI/SFP+ Network Connection	Disabled	Active
☐	0000:00:05.0	Intel Corporation Xeon E7 v3/Xeon E5 v3/Core i7 Address Map, VTd_Misc, System Manage…	Not capable	Not capable

↓

Reboot ESXi

↓

🖥 **Edit settings - xrv9k-1 (ESXi 5.1 virtual machine)**

| **Virtual Hardware** | VM Options |

💽 Add hard disk   🖥 Add network adapter   💾 Add other device

| ▶ 🖥 PCI device 1 | 82599EB 10-Gigabit SFI/SFP+ Network Connection - 0000:07:00.0 ▼ | ⊗ |

CISCO *Live!*

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IOS XRv 9000 Deployment
OVA deployment in ESXi environment, Consoles, Aux

IOS XRv 9000 Deployment

OVA deployment in ESXi environment, first boot

```
SW_Images — telnet 10.201.24.103 50001 — 84×24
Sun Dec 15 19:00:11 UTC 2019 (/proc/self/fd/9): Hardware profile: vrr
Sun Dec 15 19:00:11 UTC 2019 (/proc/self/fd/9): Host has 23.40GB RAM / 8 vCPUs
Sun Dec 15 19:00:11 UTC 2019 (/proc/self/fd/9): Management plane: 1024MB RAM
Sun Dec 15 19:00:11 UTC 2019 (/proc/self/fd/9): XR control plane: 14336MB RAM
Sun Dec 15 19:00:11 UTC 2019 (/proc/self/fd/9): XR packet memory: 256MB RAM
Sun Dec 15 19:00:11 UTC 2019 (/proc/self/fd/9): Centralized LC: 8192MB RAM
Sun Dec 15 19:00:11 UTC 2019 (/proc/self/fd/9): Data plane core assignment: 6-7
Sun Dec 15 19:00:11 UTC 2019 (/proc/self/fd/9): Control plane core assignment: 0-5

##################################################################################
#                                                                                #
#               Welcome to the Cisco IOS XRv9k platform                          #
#                                                                                #
#       Please wait for Cisco IOS XR to start.                                   #
#                                                                                #
#       Copyright (c) 2014-2019 by Cisco Systems, Inc.                           #
#                                                                                #
##################################################################################

Cisco IOS XR console     will start on the 1st serial port
Cisco IOS XR aux console will start on the 2nd serial port
Cisco Calvados console   will start on the 3rd serial port
[   26.910470] reboot: Restarting system
Press any key to continue.
```
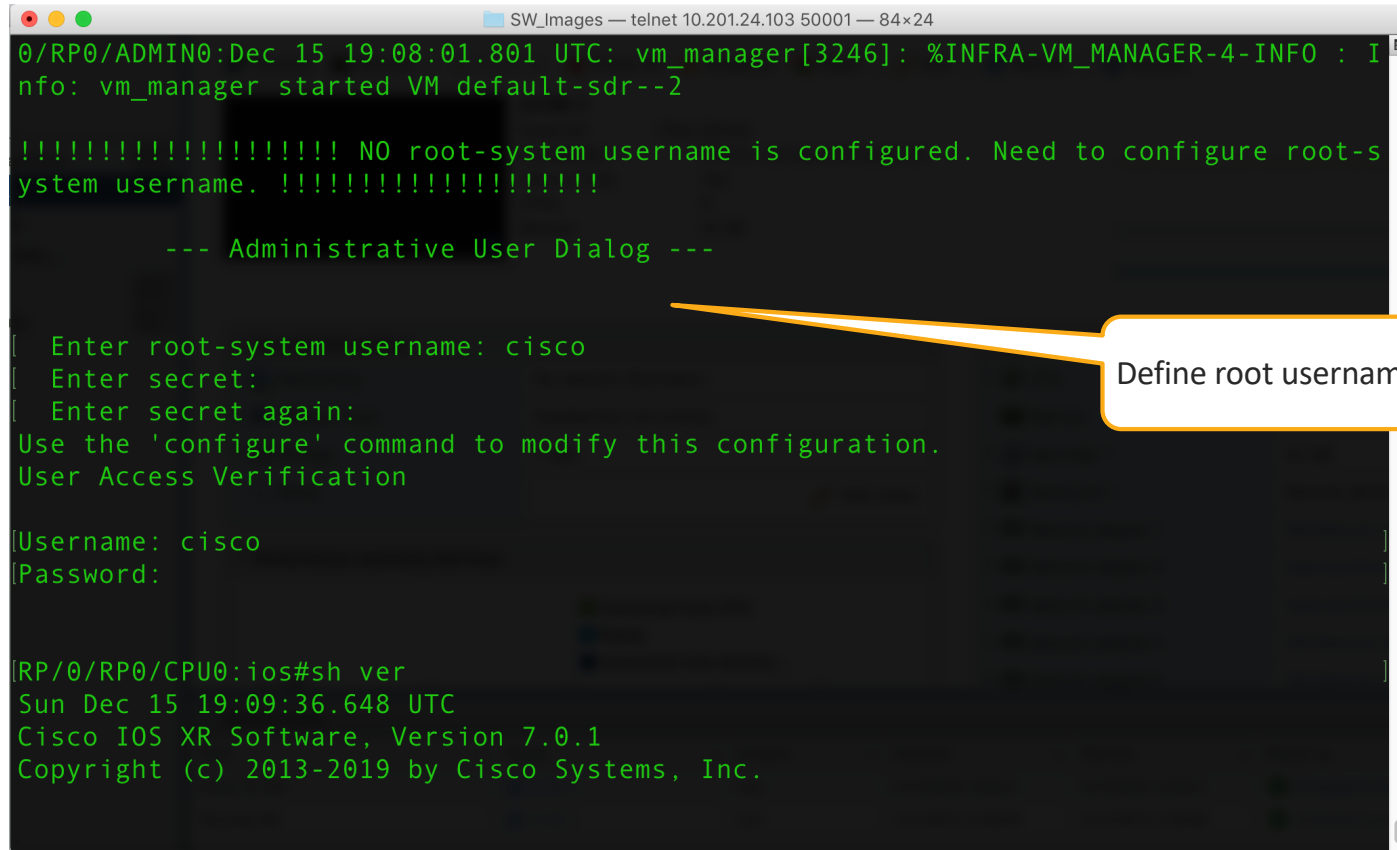
Telnet to the Serial Port
telnet <esxi_host_ip> <port_number>

Will go through baking process
on first boot up & reload
Only happens once, during the first bootup

IOS XRv 9000 Deployment

OVA deployment in ESXi environment, first boot

```
                 SW_Images — telnet 10.201.24.103 50001 — 84×24

0/RP0/ADMIN0:Dec 15 19:08:01.801 UTC: vm_manager[3246]: %INFRA-VM_MANAGER-4-INFO : I
nfo: vm_manager started VM default-sdr--2

!!!!!!!!!!!!!!!!!!! NO root-system username is configured. Need to configure root-s
ystem username. !!!!!!!!!!!!!!!!!!!!!

           --- Administrative User Dialog ---


[  Enter root-system username: cisco
[  Enter secret:
[  Enter secret again:
Use the 'configure' command to modify this configuration.
User Access Verification

[Username: cisco                                                                  ]
[Password:                                                                        ]


[RP/0/RP0/CPU0:ios#sh ver                                                         ]
Sun Dec 15 19:09:36.648 UTC
Cisco IOS XR Software, Version 7.0.1
Copyright (c) 2013-2019 by Cisco Systems, Inc.
```

Define root username and password

IOS XRv 9000 Deployment

OVA deployment in ESXi environment, first boot


```
cisco@jmp:~$ telnet 10.1.1.5 10001

Starting udev
Populating dev cache
Configuring network interfaces... done.
<snip>
Sun Dec 15 19:00:46 UTC 2019 (/proc/self/fd/9): Hardware profile: vrr
Sun Dec 15 19:00:46 UTC 2019 (/proc/self/fd/9): Host has 23.40GB RAM / 8 vCPUs
Sun Dec 15 19:00:46 UTC 2019 (/proc/self/fd/9): Management plane: 1024MB RAM
Sun Dec 15 19:00:46 UTC 2019 (/proc/self/fd/9): XR control plane: 14336MB RAM
Sun Dec 15 19:00:46 UTC 2019 (/proc/self/fd/9): XR packet memory: 256MB RAM
Sun Dec 15 19:00:46 UTC 2019 (/proc/self/fd/9): Centralized LC: 8192MB RAM
Sun Dec 15 19:00:46 UTC 2019 (/proc/self/fd/9): Data plane core assignment: 6-7
Sun Dec 15 19:00:46 UTC 2019 (/proc/self/fd/9): Control plane core assignment: 0-5
```
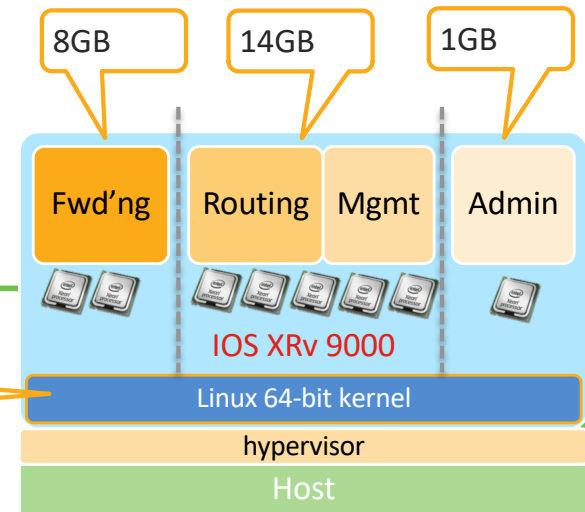
Diagram labels:
- 8GB — Fwd'ng
- 14GB — Routing
- Mgmt
- 1GB — Admin
- IOS XRv 9000
- 24GB RAM — Linux 64-bit kernel
- hypervisor
- Host

IOS XRv 9000 Deployment

show version

```
RP/0/RP0/CPU0:ios#show version

Cisco IOS XR Software, Version 7.0.1
Copyright (c) 2013-2019 by Cisco Systems, Inc.

Build Information:
 Built By      : ahoang
 Built On      : Thu Aug 29 16:11:57 PDT 2019
 Built Host    : iox-ucs-030
 Workspace     : /auto/srcarchive15/prod/7.0.1/xrv9k/ws
 Version       : 7.0.1
 Location      : /opt/cisco/XR/packages/

cisco IOS-XRv 9000 () processor
System uptime is 3 minutes

RP/0/RP0/CPU0:ios#
```

IOS XRv 9000 Deployment

Show Commands

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

Node                Type                     State           Config state
---------------------------------------------------------------------------
0/0/CPU0            R-IOSXRV9000-LC-C        IOS XR RUN      NSHUT
0/RP0/CPU0          R-IOSXRV9000-RP-C(Active) IOS XR RUN     NSHUT


RP/0/RP0/CPU0:ios#show interfaces brief
               Intf        Intf        LineP                 Encap  MTU      BW
               Name        State       State                 Type   (byte)   (Kbps)
---------------------------------------------------------------------------
               Nu0         up          up
      Mg0/RP0/CPU0/0  admin-down   admin-down
          Gi0/0/0/1    admin-down   admin-down
          Gi0/0/0/2    admin-down   admin-down
          Te0/0/0/0    admin-down   admin-down
```

Hypervisor interfaces to XRv9000 mapping:
Virtual iface1: MgmtEth0
Virtual iface2: reserved
Virtual iface3: reserved
PCI passthrough: Te0/0/0/0
Virtual iface4: Gi0/0/0/0

....

IOS XRv 9000 Deployment

Checking License Status

```
RP/0/RP0/CPU0:ios#show license summary

Smart Licensing is ENABLED

Registration:
  Status: UNREGISTERED
  Export-Controlled Functionality: NOT ALLOWED

License Authorization:
  Status: No Licenses in Use
RP/0/RP0/CPU0:ios#sh license udi
Sun Dec 15 19:34:51.934 UTC
UDI: PID:R-IOSXRV9000-IMG,SN:9FD798465A3,SUVI:R-IOSXRV9000-
IMG9FD798465A3,UUID:564D20B7-A72C-4FD4-C40E-9633A282CDC1
```
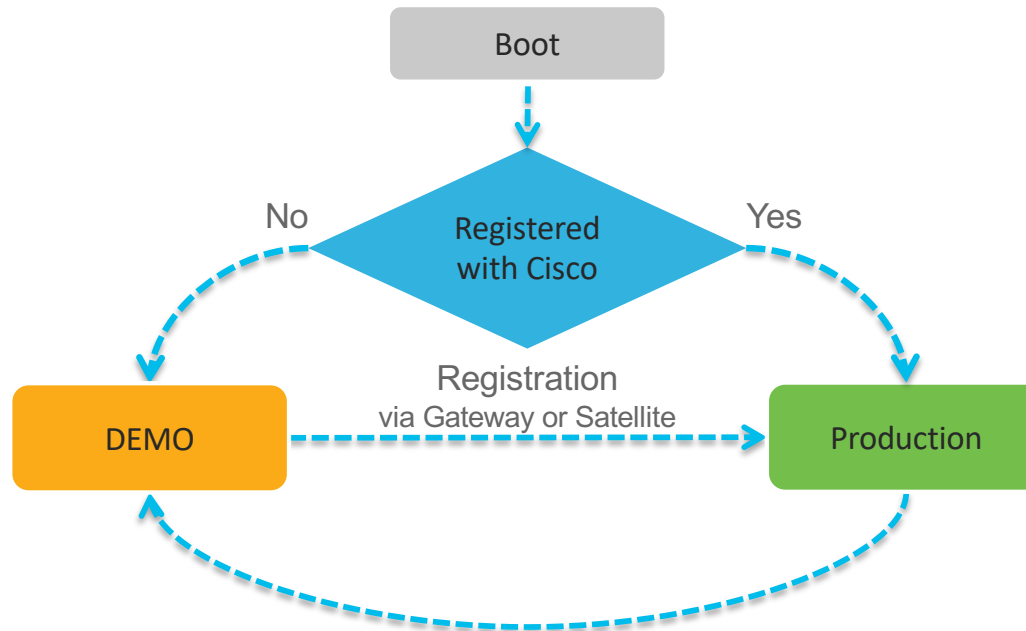
IOS XRv 9000 Smart Licensing Modes

Boot

Registered with Cisco

No

Yes

DEMO

Production

Registration
via Gateway or Satellite

- De-Registration
- 90 days without backend communication
- Expired ID Token

IOS XRv 9000 Deployment

Linux: Creating TAP and Bridge

```
cisco@linux:~$ sudo tunctl -t tap1
Set 'Tap1' persistent and owned by uid 0
cisco@linux:~$ sudo ifconfig tap1 up

cisco@linux:~$ sudo tunctl -t tap2
Set 'Tap2' persistent and owned by uid 0
cisco@linux:~$ sudo ifconfig tap2 up
```

```
cisco@linux:~$ sudo brctl addbr vbridge1
cisco@linux:~$ sudo brctl addbr vbridge2
cisco@linux:~$ sudo brctl addif vbridge1 Tap1 eth2
cisco@linux:~$ sudo brctl addif vbridge2 Tap2 eth3

cisco@linux:~$ sudo brctl show vbridge1
bridge name      bridge id              STP enabled      interfaces
vbridge1         8000.b6c7102ae0f6      no               Tap1
                                                         eth4
```
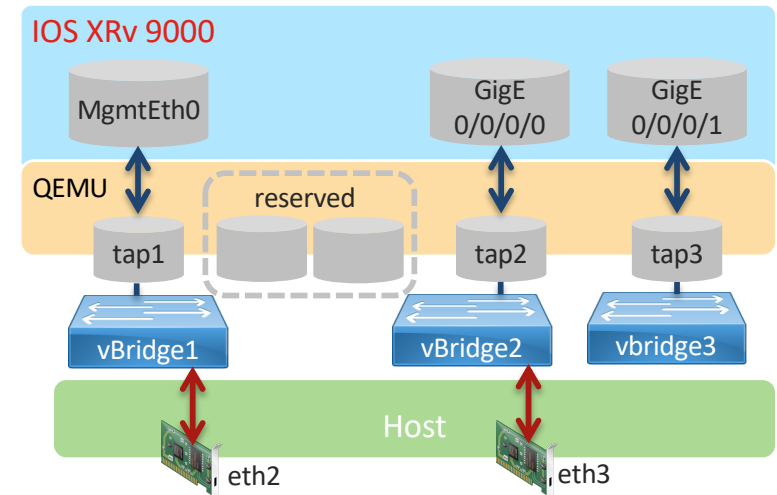
IOS XRv 9000 Bring-up

Launching the IOS XRv 9000 Virtual Machine

```
cisco@linux:~$ sudo qemu-system-x86_64 -enable-kvm \
-m 24576 \
-smp cpus=8 \
-hda xrv9k-1_img.qcow2 \
-cpu host \
-serial telnet::5010,server,nowait \
-netdev tap,id=tap1,ifname=tap1,script=no,downscript=no
-device virtio-net-pci,netdev=tap1,mac=00:00:00:00:00:19
-device virtio-net-pci
-device virtio-net-pci
-netdev tap,id=tap2,ifname=tap2,script=no,downscript=no
-device virtio-net-pci,netdev=tap2,mac=00:00:00:00:00:1a
```

- 24G Memory
- 8 CPU Cores
- XRv9K Disk
- Host CPU features pass
- Console port
- MgmtEth0
- 2x reserved interfaces
- Ethernet (GigE0/0/0)

IOS XRv 9000 Deployment using Openstack

IOS XRv 9000 Deployment using Openstack

Create Image

Boot Source

Assign Network

IOS XRv 9000 Deployment on AWS

IOS XRv 9000
Troubleshooting

IOS XRv 9000 Troubleshooting
Hierarchy

LXC   LXC   LXC

| Admin | Mgmt | Routing | Fwd'ng |

IOS XRv 9000

VPP/DPDK

hypervisor

Host

Hardware

XR Level

VNF Level

Hypervisor Level

Host OS Level

Hardware Level
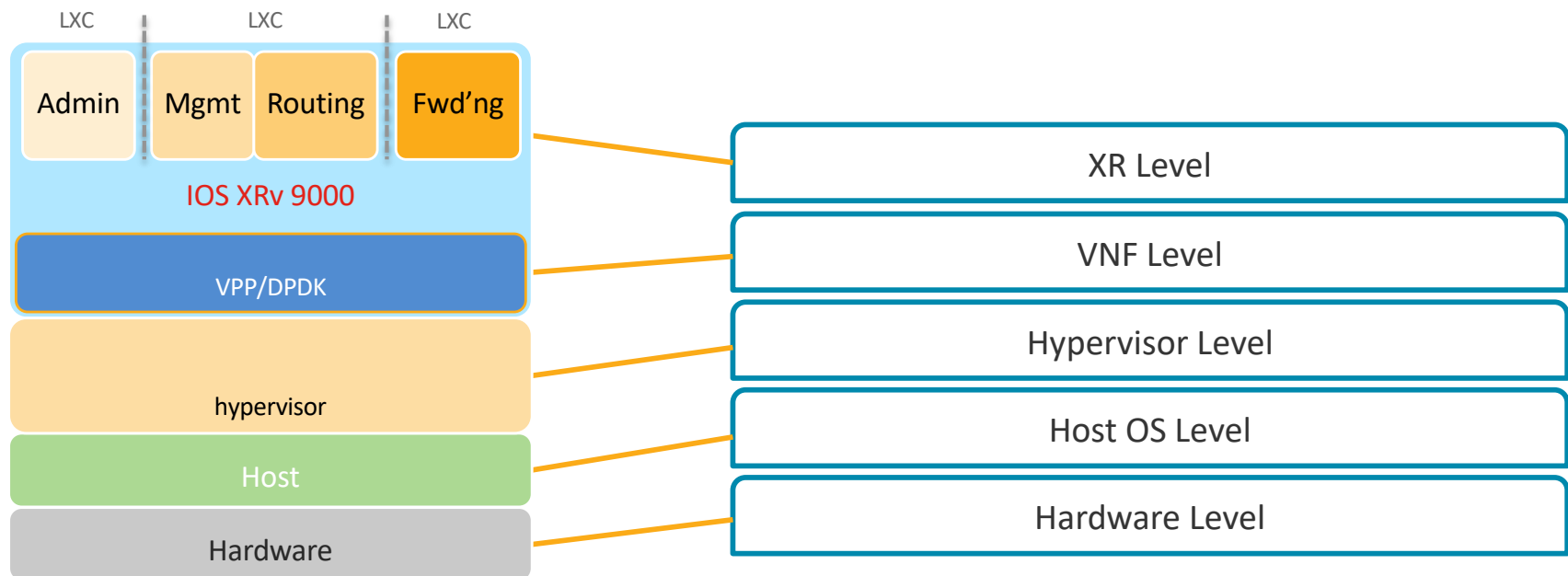
IOS XRv 9000 Troubleshooting

Common problems

```
RP/0/RP0/CPU0:R10#show interfaces brief
              Intf        Intf        LineP               Encap  MTU       BW
              Name        State       State               Type   (byte)    (Kbps)
--------------------------------------------------------------------------------
               Lo0          up          up            Loopback   1500           0
              Lo100         up          up            Loopback   1500           0
                Nu0         up          up                Null   1500           0
    Mg0/RP0/CPU0/0          up          up                ARPA   1514     1000000

RP/0/RP0/CPU0:ios#sh run int

interface MgmtEth0/RP0/CPU0/0
!
interface preconfigure GigabitEthernet0/0/0/1
!
interface preconfigure GigabitEthernet0/0/0/2
!
```

IOS XRv 9000 Troubleshooting

Common Problems

```
RP/0/RP0/CPU0:R10#show controllers dpa uptime
```
```
RP/0/RP0/CPU0:R10#LC/0/0/CPU0:Dec 15 22:09:39.075 UTC: processmgr[51]: %OS-SYSMGR-3-
ERROR : dp_launcher(1) (jid 166) exited, will be respawned with a delay (slow-restart)
RP/0/RP0/CPU0:R10#
RP/0/RP0/CPU0:R10#show controllers dpa uptime
Sun Dec 15 22:09:20.033 UTC

RP/0/RP0/CPU0:R10#
```

QEMU "-cpu host" option is missing
or
Nested virtualization is not supported

normal
```
RP/0/RP0/CPU0:R10#show controllers dpa uptime
Sun Dec 15 22:23:52.096 UTC
DPA started Dec 15 18:49:04,  up 0 days, 03:14:49
RP/0/RP0/CPU0:R10#
```

IOS XRv 9000 Troubleshooting

Common Problems

```
RP/0/RP0/CPU0:Dec 15 22:54:31.816 UTC: devc-conaux-aux_aux[111]: %MGBL-TTY-3-INTERNAL :
Unexpected internal error encountered: 0xa8f48205, ''Subsystem(4585)' detected the
'fatal' condition 'Code(1)': Input/output error'  : devc-conaux-aux : (PID=3418) :  -
Traceback= 7f05ef52fea3 7f05ef5329ac 5645b8310031
```

Server disk caching may not be set up properly

IOS XRv 9000 Troubleshooting

Common Problems

```
RP/0/RP0/CPU0:R10#show controllers dpa threads
ID        Name                    Type        LWP      lcore  Core   Socket State
0         vpe_main                            6297     2      0      0      wait
1         vpe_rx0_0               rx0         6326     3      0      0      running
2         vpe_wk0_0               worker0     6328     5      0      0      running
3         vpe_wk0_1               worker0
4         vpe_wk0_2               worker0
5         vpe_tx0_0               tx0
6                                 stats
```

This is normal!
VPP runs in constant poll mode, thus CPUs assigned to DP run @ 100%

```
SW_Images — cisco@cowl-rcdn-99:~ — ssh cisco@10.201.24.109 — 82×23
top - 20:25:28 up 6 days,  3:54,  2 users,   load average: 6.54, 6.42, 6.33
Tasks: 465 total,   1 running, 464 sleeping,    0 stopped,    0 zombie
%Cpu0  :  9.4 us,  1.3 sy,  0.0 ni, 88.6 id,  0.0 wa,  0.3 hi,  0.3 si,  0.0 st
%Cpu1  :  0.0 us,  0.0 sy,  0.0 ni,100.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu2  :  0.0 us,  0.0 sy,  0.0 ni,100.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu3  : 22.9 us, 74.8 sy,  0.0 ni,  0.0 id,  0.0 wa,  2.3 hi,  0.0 si,  0.0 st
%Cpu4  :  0.0 us,  0.0 sy,  0.0 ni,100.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu5  :  0.0 us,  0.0 sy,  0.0 ni,100.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu6  : 99.7 us,  0.0 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.3 hi,  0.0 si,  0.0 st
%Cpu7  : 99.3 us,  0.0 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.7 hi,  0.0 si,  0.0 st
%Cpu8  : 99.7 us,  0.0 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.3 hi,  0.0 si,  0.0 st
%Cpu9  :  0.0 us,  0.0 sy,  0.0 ni,100.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu10 : 99.3 us,  0.3 sy,  0.0 ni,  0.0 id,  0.0 wa,  0.3 hi,  0.0 si,  0.0 st
%Cpu11 :  0.0 us,  0.0 sy,  0.0 ni,100.0 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu12 :  0.3 us,  0.0 sy,  0.0 ni, 99.7 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu13 :  7.5 us,  2.7 sy,  0.0 ni, 89.4 id,  0.0 wa,  0.3 hi,  0.0 si,  0.0 st
%Cpu14 : 11.6 us, 86.4 sy,  0.0 ni,  0.0 id,  0.0 wa,  2.0 hi,  0.0 si,  0.0 st
%Cpu15 :  0.3 us,  0.3 sy,  0.0 ni, 99.3 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
MiB Mem : 64419.0 total, 26766.1 free, 26033.5 used, 11619.4 buff/cache
MiB Swap:  6556.0 total,  6556.0 free,     0.0 used, 37650.4 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU  %MEM     TIME+ COMMAND
10496 root      20   0   25.3g  23.9g  21460 S 616.9  38.0 954:46.47 qemu-system+
```

IOS XRv 9000 Troubleshooting

XR and VNF levels

Regular XR Troubleshooting Techniques

DPA / DPC Communication and Packet Stats

Non-Uniform-Memory-Access (NUMA) Aware

Hyper-threading (HT) Agnostic

XR Level

VNF Level

Hypervisor Level

Host OS Level

Hardware Level
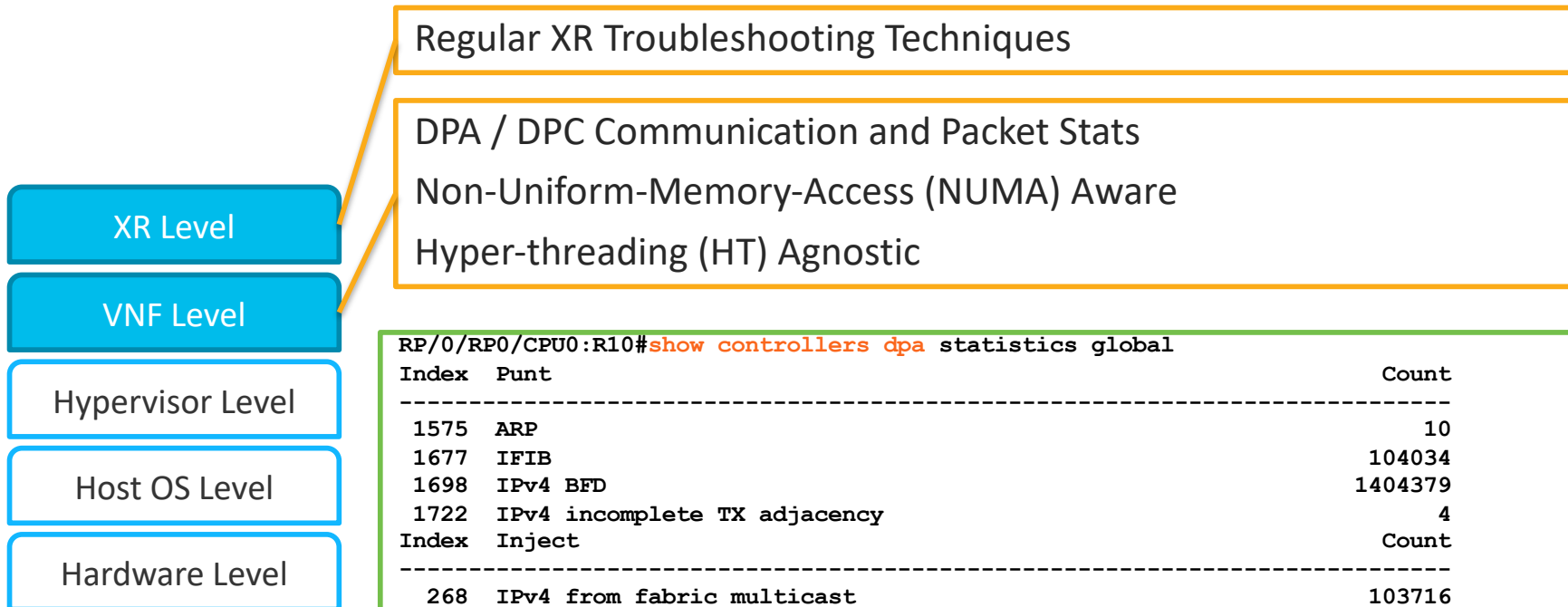
```
RP/0/RP0/CPU0:R10#show controllers dpa statistics global
Index  Punt                                              Count
---------------------------------------------------------------
 1575  ARP                                                  10
 1677  IFIB                                             104034
 1698  IPv4 BFD                                        1404379
 1722  IPv4 incomplete TX adjacency                          4
Index  Inject                                            Count
---------------------------------------------------------------
  268  IPv4 from fabric multicast                       103716
  270  IPv4 from fabric next-hop                            330
  275  Inject to fabric                                 104047
  276  Inject to port                                  1510764
Index  Drop                                              Count
---------------------------------------------------------------
   85  IPv4 disabled in uIDB                              3888
  113  IPv6 disabled in uIDB                                60
  236  Preroute PIT lookup missed                            1
```

IOS XRv 9000 Troubleshooting

XR and VNF levels

```
RP/0/RP0/CPU0:R10#sh lpts pifib hardware entry statistics location 0/0/CPU0


                Node: 0/0/CPU0:
-----------------------------------------
* - Vital; L4 - Layer4 Protocol; Intf - Interface;
DestNode - Destination Node,
LU(0xY) Y is SFP, packet will reach to location sfp
MU(0xY) Y is FGID, packet will reach to all location
Local - packet will be punted to line card;
VRF ID - vrf_id or hardware table id, same as UIDB
Slice - slice/np number of the line card;
FlowType - Type of flow, entry belongs to;
na - Not Applicable or Not Available;
def - default

Local Address.Port,
Remote Address,Port/(BFD disc)  VRF ID       L3        L4      Intf     Slice  FlowType        Accepts  Drops DestNode(s)
--------------------------------------------------------------------------------------------------------------------------
 any any                        any          IPv4_frag  any     any      0      Fragment        0        0     Local
 any,ECHO any                   any          IPv4       ICMP    any      0      ICMP-local      0        0     Local
 6.1.1.10,179 6.1.1.6           def (0x60000000)  IPv4  TCP     any      0      BGP-cfg-peer    0        0     0/RP0/CPU0
 6.1.1.10,179 6.1.1.7           def (0x60000000)  IPv4  TCP     any      0      BGP-cfg-peer    0        0     0/RP0/CPU0
 any,23 any                     def (0x60000000)  IPv4  TCP     any      0      TELNET-default  0        0     0/RP0/CPU0
 any,3503 any                   def (0x60000000)  IPv4  UDP     any      0      MPLS-oam        0        0     0/RP0/CPU0

--More--
```

LPTS is an XR feature!
Check for drops, which may be expected

IOS XRv 9000 Troubleshooting

XR and VNF levels

```
RP/0/RP0/CPU0:R10#show controllers dpa interfaces GigabitEthernet 0/0/0/0

            Name                  Idx        State          Counter          Count
GigabitEthernet0/0/0/0             5          up          rx packets          1324
                                                          rx bytes           78496
                                                          punts               1324
                                                          rx-miss            23182
                                                          rx-error           23182
```

Datapath is not keeping up
NICs overflowing and dropping!

IOS XRv 9000 Troubleshooting

Hypervisor, Host and Hardware levels

| XR Level |
| VNF Level |
| Hypervisor Level |
| Host OS Level |
| Hardware Level |

- Intel Virtualization turned on in BIOS

- Dedicated pinned CPU (vCPU = pCPU) for best performance
- Non-Uniform-Memory-Access (NUMA)
    use local memory same node as dedicated CPU, not foreign memory

- HyperTreading (HT) agnostic
- Turn Off Power Optimization
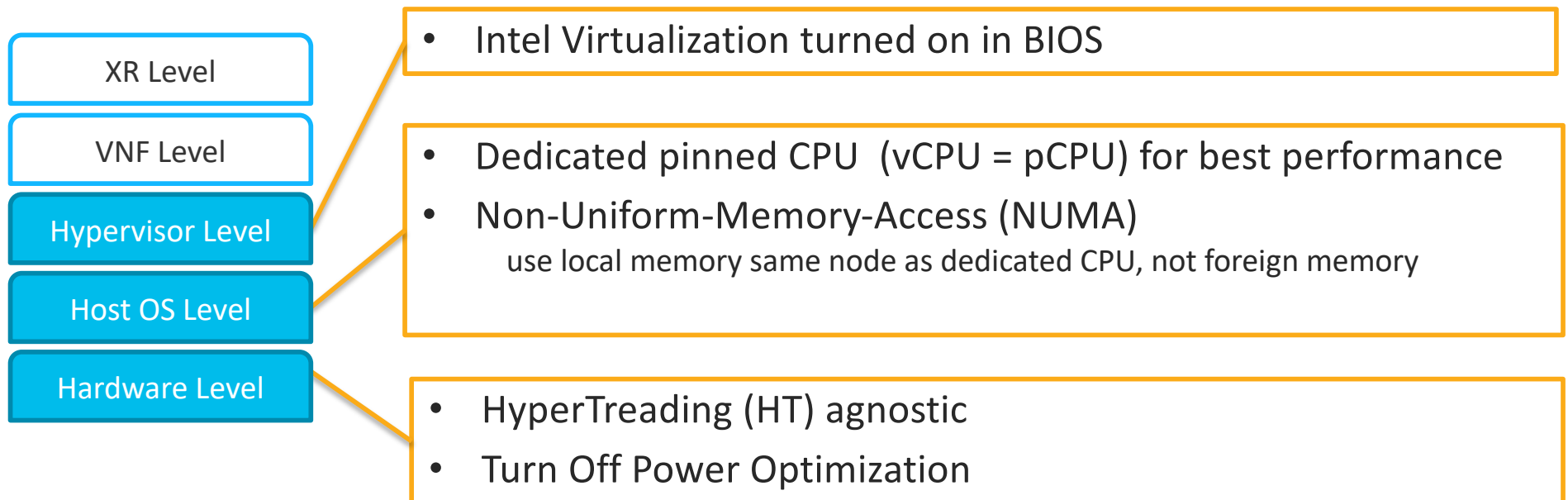
IOS XRv 9000 Troubleshooting

Check Server BIOS parameters
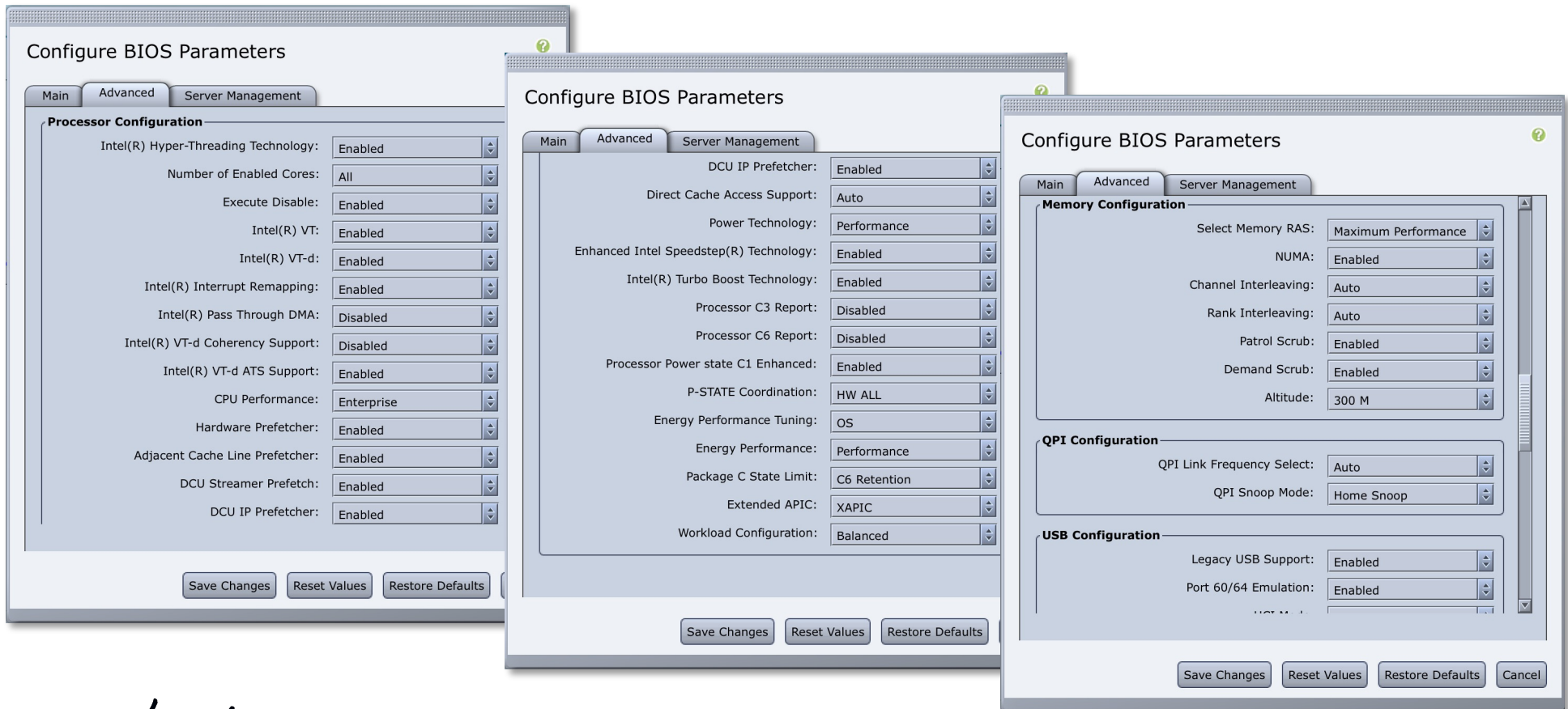
IOS XRv 9000 Performance Tuning

- Multiple levels impact Performance

- System performance vs. single-VM performance

- At system level, other bottlenecks may affect throughput
  - Physical NIC capacity
  - vSwitch
  - Hypervisor performance
  - Number of concurrent VMs
  - Performance tuning

- VM performance emulated by assuming an unconstrained I/O path (e.g. SR-IOV)

IOS XRv 9000 Performance Tuning

NUMA example

```
server!~$ sudo netstat -pln | grep 12346
tcp        0        0 0.0.0.0:12346        0.0.0.0:*        LISTEN        18135/qemu-system-
x


server!~$ numactl –hardware
available: 2 nodes (0-1)
node 0 cpus: 0 1 2 3 4 5 6 7 16 17 18 19 20 21 22 23
node 0 size: 257762 MB
node 0 free: 194589 MB
node 1 cpus: 8 9 10 11 12 13 14 15 24 25 26 27 28 29 30 31
node 1 size: 258045 MB
node 1 free: 247971 MB
```

PID of XRv9000 Process

CPU / Memory across NUMA nodes

Node 0	0	1	2	3	4	5	6	7	16	17	18	19	20	21	22	23	Memory Node0

Node 1	8	9	10	11	12	13	14	15	24	25	26	27	28	29	30	31	Memory Node1

IOS XRv 9000 Performance Tuning

NUMA Example

```
top - 12:58:16 up 64 days, 13:03,  4 users,  load average: 2.63, 2.58, 2.24
Tasks: 443 total,   2 running, 441 sleeping,   0 stopped,   0 zombie
%Cpu0  :  1.7 us,                    .2 id,  0.0 wa,  0.0
%Cpu1  : 99.7 us,                   .0 id,  0.0 wa,  0.0
%Cpu2  :  1.0 us,                   .0 id,  0.0 wa,  0.0
%Cpu3  :  1.0 us,                   .0 id,  0.0 wa,  0.0
%Cpu4  :  1.7 us,    0.3 sy,  0.0 hi, 97.9 id,  0.0 wa,  0.0 hi,  0.0 si,  0.0 st
%Cpu5  :  7.2 us,   3
%Cpu6  :  1.3 us,   0
%Cpu7  :  4.4 us,   2
%Cpu8  :100.0 us,   0
%Cpu9  :  0.0 us,   0
%Cpu10 :  0.7 us,   0
%Cpu11 :  1.3 us,   0
%Cpu12 :  3.0 us,   1
%Cpu13 :  1.0 us,   0
```

CPU 1 & 8 allocated (NUMA 0 and 1)

Memory from NUMA Node 0

```
cisco@uLinux-4:~$ sudo numastat -p 18135

Per-node process memory usage (in MBs) for PID 18135 (qemu-system-x86)
                           Node 0          Node 1           Total
                  --------------- --------------- ---------------
Huge                         0.00            0.00            0.00
Heap                         0.71            1.37            2.08
Stack                        0.07            0.03            0.10
Private                   9735.30          372.94        10108.23
                  --------------- --------------- ---------------
Total                     9736.07          374.34        10110.41
```

IOS XRv 9000 Performance Tuning

NUMA Example

```
server!~$ sudo taskset -pc 1 18135
pid 18135's current affinity list: 0-31
pid 18135's new affinity list: 1

server!~$ sudo taskset -pc 2 18135
pid 18135's current affinity list: 1
pid 18135's new affinity list: 2
```

Node 0	0	1	2	3	4	5	6	7	16	17	18	19	20	21	22	23	Memory Node0
Node 1	8	9	10	11	12	13	14	15	24	25	26	27	28	29	30	31	Memory Node1

Service Orchestration for NFV

Service Orchestration for IOS XRv 9000

BSS

OSS

Cisco NSO

NSO

Cisco ESC

XRv9000 XRv9000 XRv9000

VMWare/
Openstack

hypervisor
Host OS
Server

hypervisor
Host OS
Server
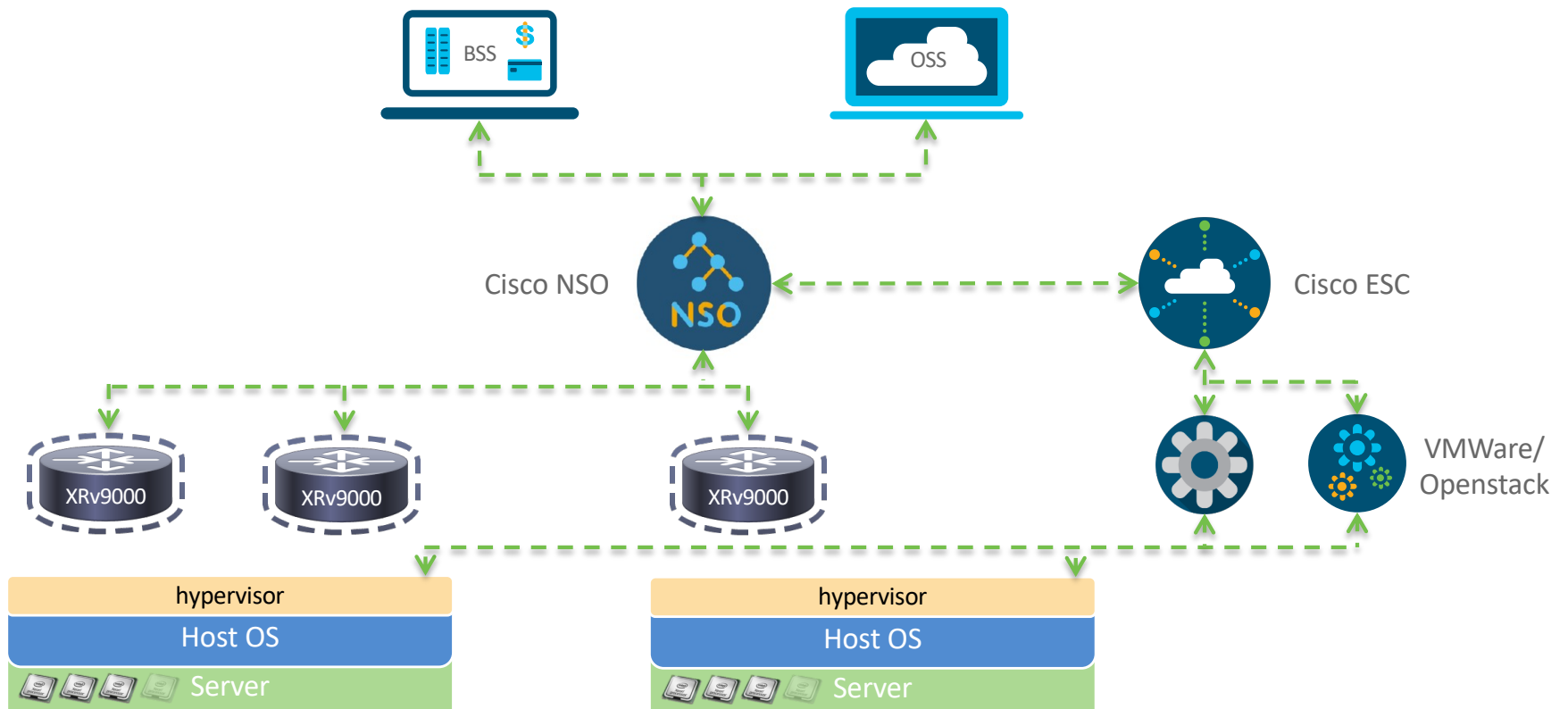
BRKSPG-2724

Service Orchestration for IOS XRv 9000
Example

1. Service request created

2. NFVO identifies which network components it needs to deliver

3. NFVO maps service intent to the topology and identifies appropriate ESC to spin up the VNF VMs

Cisco NSO

4. NFVO configures service on ESC

8. ESC signals VM and service alive to NFVO

7. ESC monitors VM coming up

Cisco ESC

9. NFVO configures VNF

5. ESC calls Openstack to create required virtual appliances

VM VM VM

hypervisor

Host OS

Server

6. Openstack spins up VMs

Openstack

IOS XR 9000 as VNF – Flexible Choices

Right Sizing Your Deployment

Choose your Service	Size up your Data Plane	Adapt your Control Plane

Choose your Service:
- Core / Transport
- Peering
- DCI
- PE
- Subscriber Services
- Virtual PE (vPE)
- Virtual RR (vRR)

Size up your Data Plane (Data Plane: High → Low)
- Multichassis NCS 6000 / Multichassis CRS-X
- NCS 6000 / NCS 5500 / ASR 9000 Tomahawk / CRS-X
- NCS5500/CRS / ASR 9000 Typhoon
- IOS-XRv 9K

Adapt your Control Plane (Control Plane: High → Low)

Choose between On-box, Hybrid or Pure Virtual CP Based on Use Case

- Virtualized CP or Expansion CP from Physical System
- Today's IOS-XR on box Control Plane

NFV with IOS XR
Completing Portfolio

IOS XR

CRS Portfolio

Edge Routing
ASR 9000 Portfolio

NCS 5500
NCS 5000

NCS 6000
Single & Multi
Chassis

NFV Virtual Router
IOS-XRv 9000
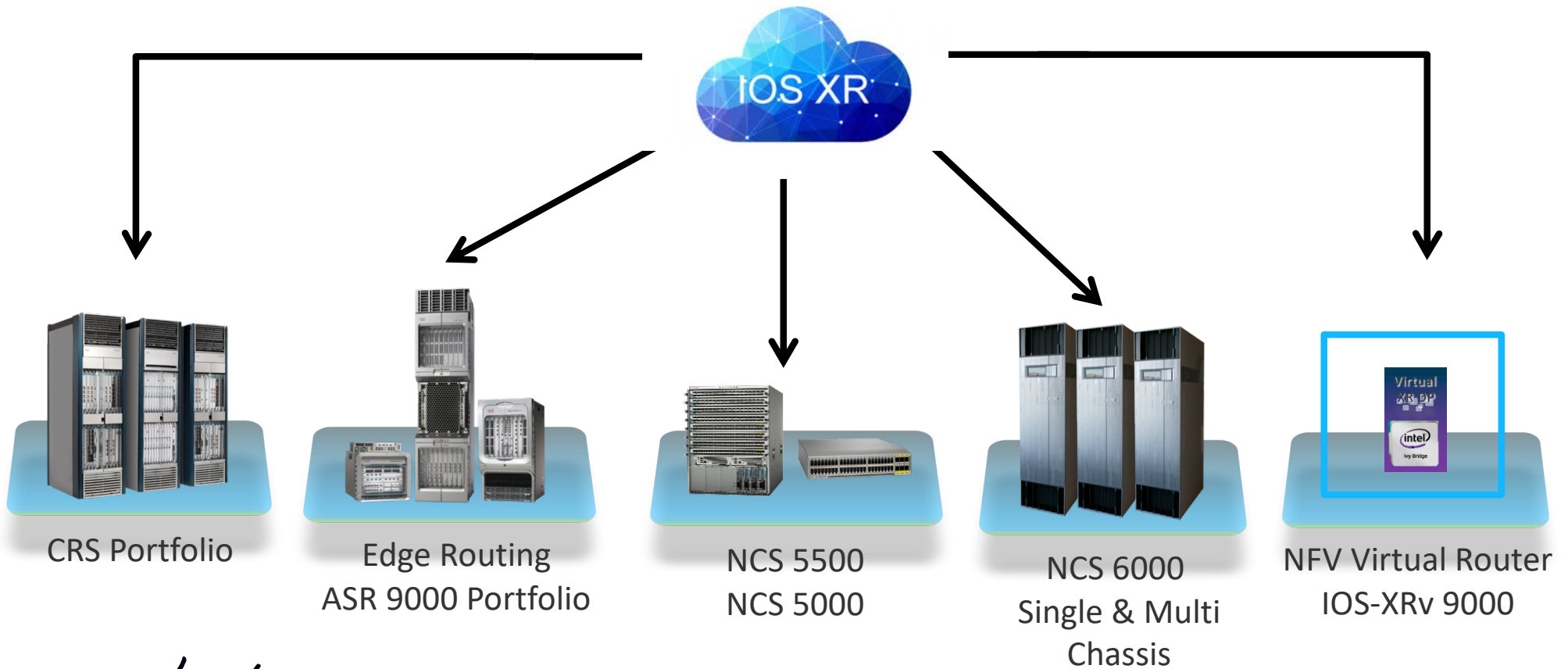
Putting it all together…

SMU-ability

Opex Saving

High Availability

Scalable

IOS XRv 9000
Virtual Router
Real Performance

Low Capex

Multi-threaded

Flexible

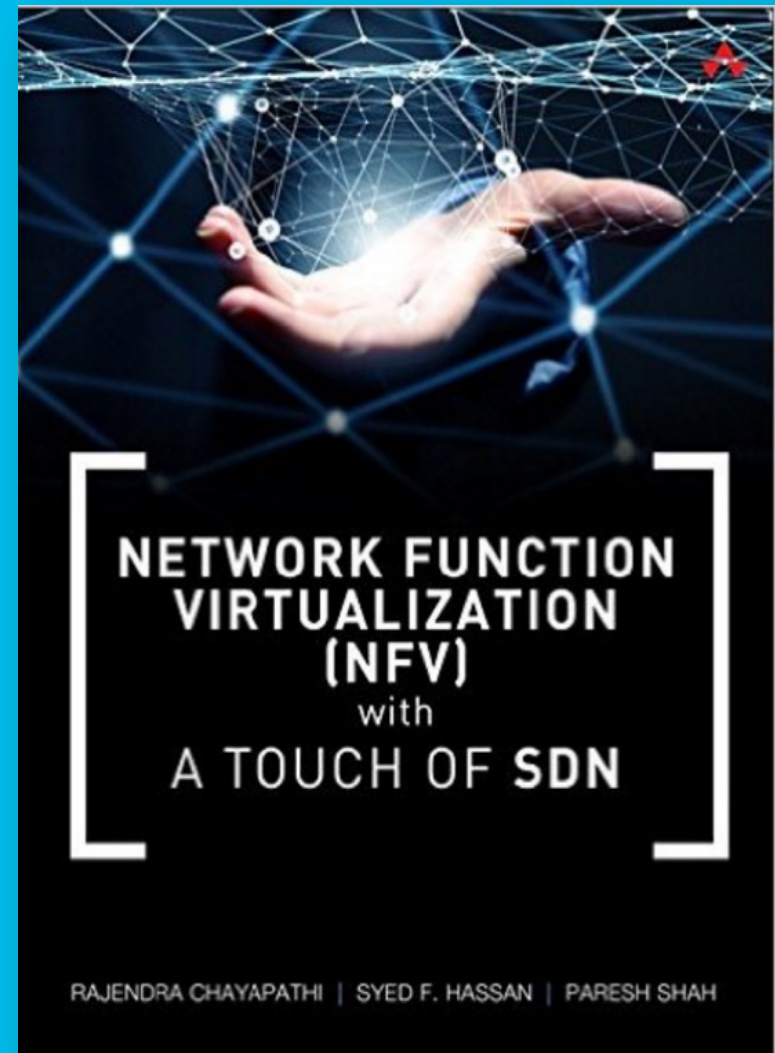Carrier Class

Elastic
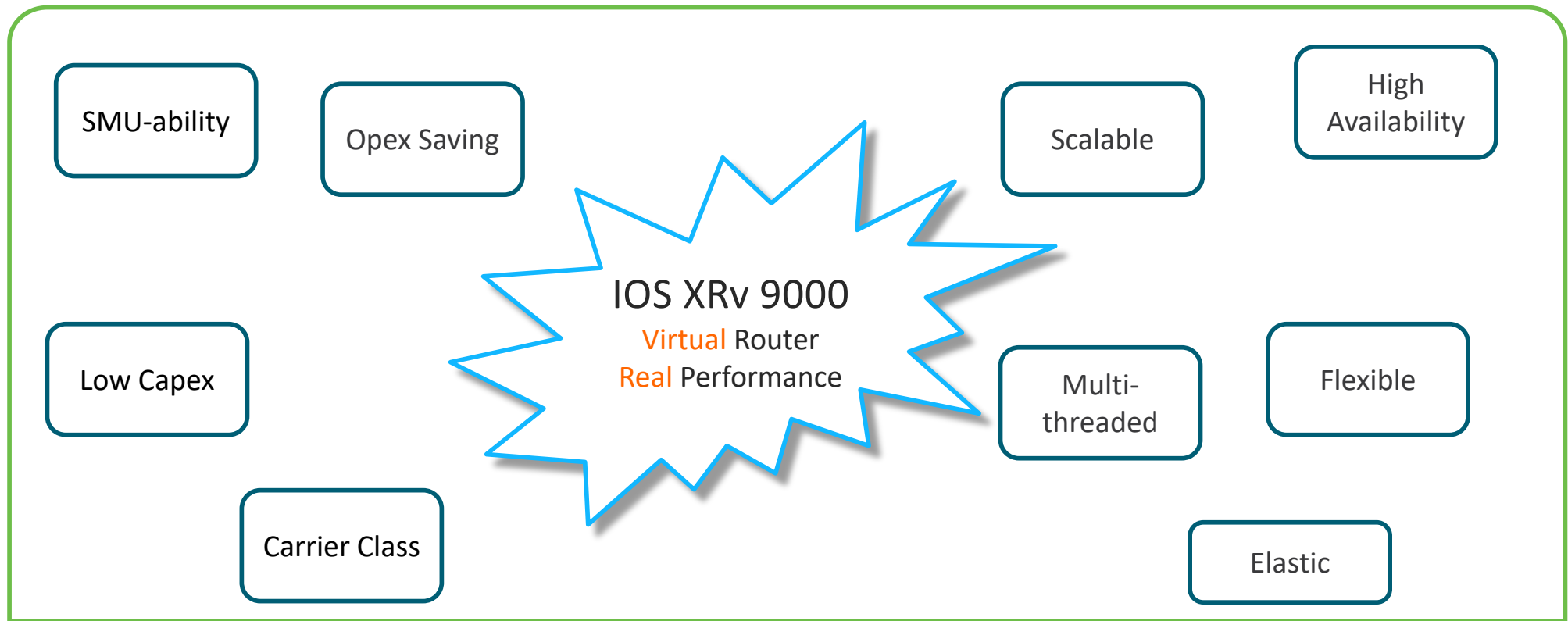
Summary

- Role of NFV in Network

- IOS XRv 9000

- Benefits & Use Cases

- Deployment & Troubleshooting

- Service Orchestration for NFV

- Summary

Some reading ideas…

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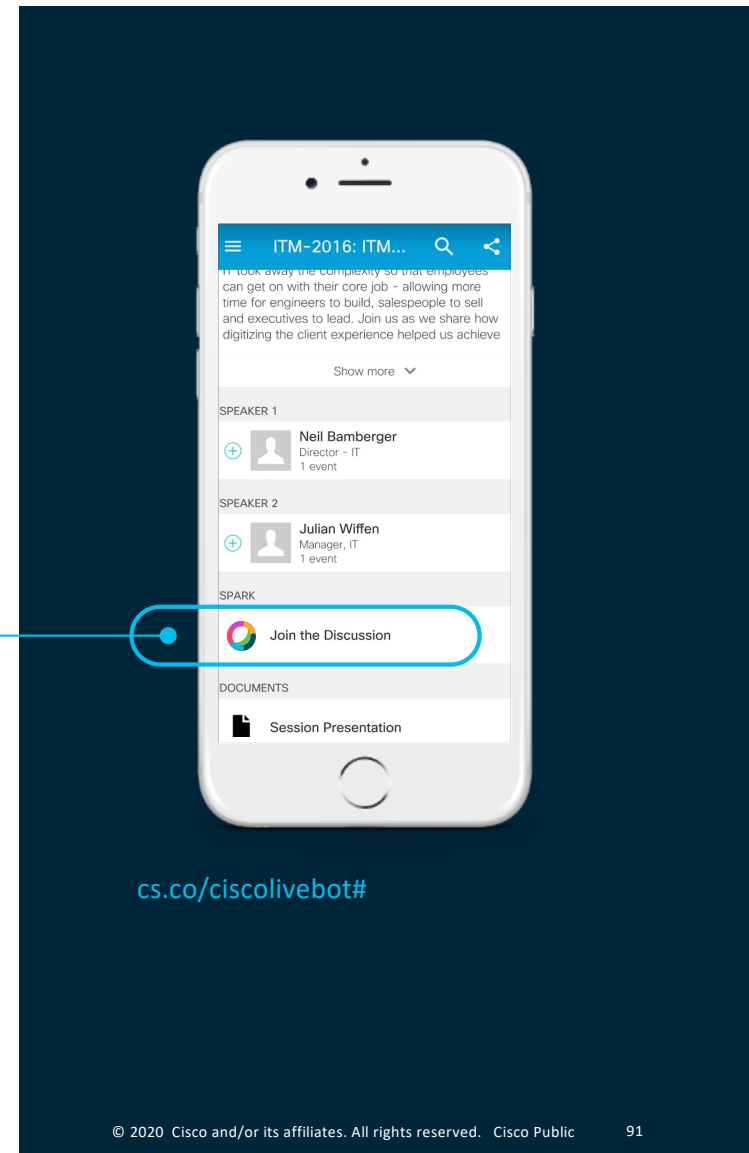
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cs.co/ciscolivebot#

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