Cisco live!

January 29 – February 2, 2018 · Barcelona

BRKSPG-2002

Cisco NFVI Network Function Virtualization Infrastructure

Naren Narendra, Senior Product Manager

Cisco live!

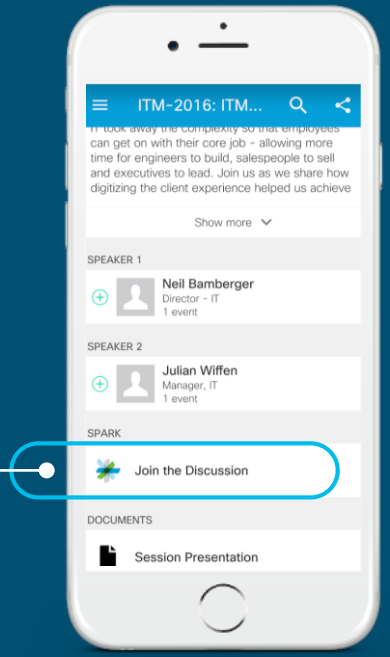
Cisco Spark

Questions?

Use Cisco Spark to communicate with the speaker after the session

How

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



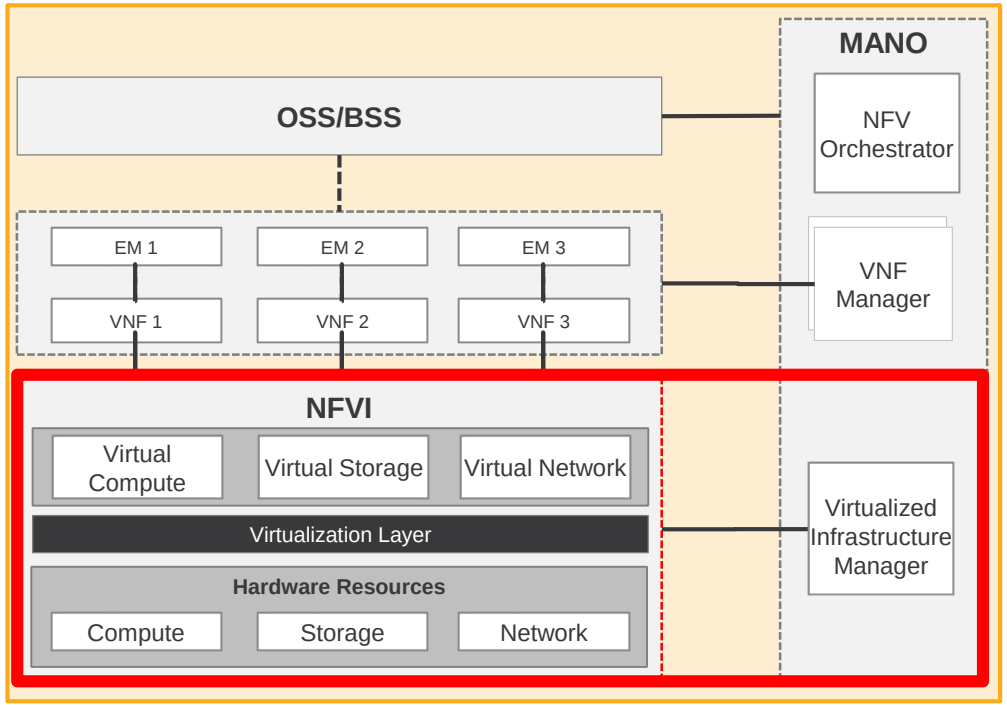
cs.co/ciscolivebot#BRKSPG-2002

Agenda

- Network Function Virtualization Infrastructure (NFVI) Fundamentals
- Cisco NFVI Components
- Cisco VIM (Virtualized Infrastructure Manager)
- Cisco VIM Unified Management
- Monitoring & Assurance
- SDN Integrations
- Where are we headed?
- Conclusion

Network Function Virtualization Infrastructure Fundamentals

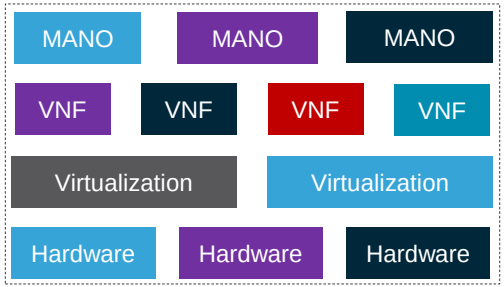
The ETSI NFV Reference Architecture and NFVI



- **NFVI -** Network Function Virtualization Infrastructure is the totality of all hardware and software components that build the platform in which VNFs are deployed
- **VIM -** Virtualized Infrastructure Manager Controls and manages the NFVI compute, storage, and network resources. VIM is the NFVI software platform

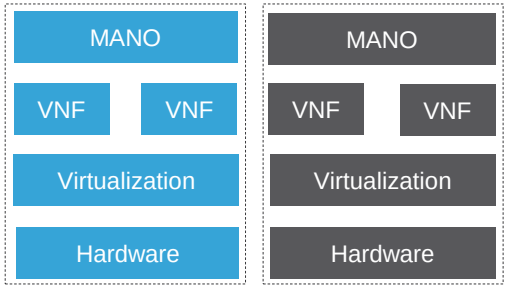
SP Approaches to NFV

Fully Disaggregated (DIY or SI Led)



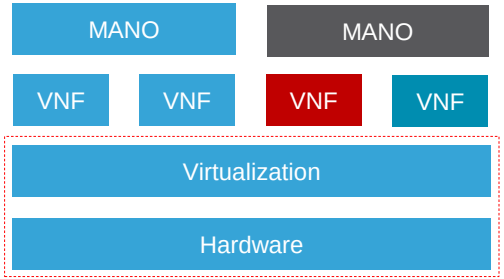
- Fully disaggregated approach with different elements of the solution coming from different vendors
- SP is driving Systems Integration – either by self or by appointing a SI
- Integration overhead is very high
- Arbitraging between vendors is difficult, **no single point of ownership**
- Takes longer to deploy – **perceived cost benefit may be lost in higher coordination & slower time to market**

Vertical NFV Solution Stack (Use Case Led)



- Use-case focused NFV solution stacks, each from same or different vendors
- Pre-integrated, tested and validated by vendor with single point of ownership
- Faster time to market
- However, convergence of platform may be very challenging in future due to platform architecture inconsistency
- May lead to multiple silo's that are not cross-leveraged and more expensive to manage in longer term

Common & Horizontal NFVI (Infrastructure Led)



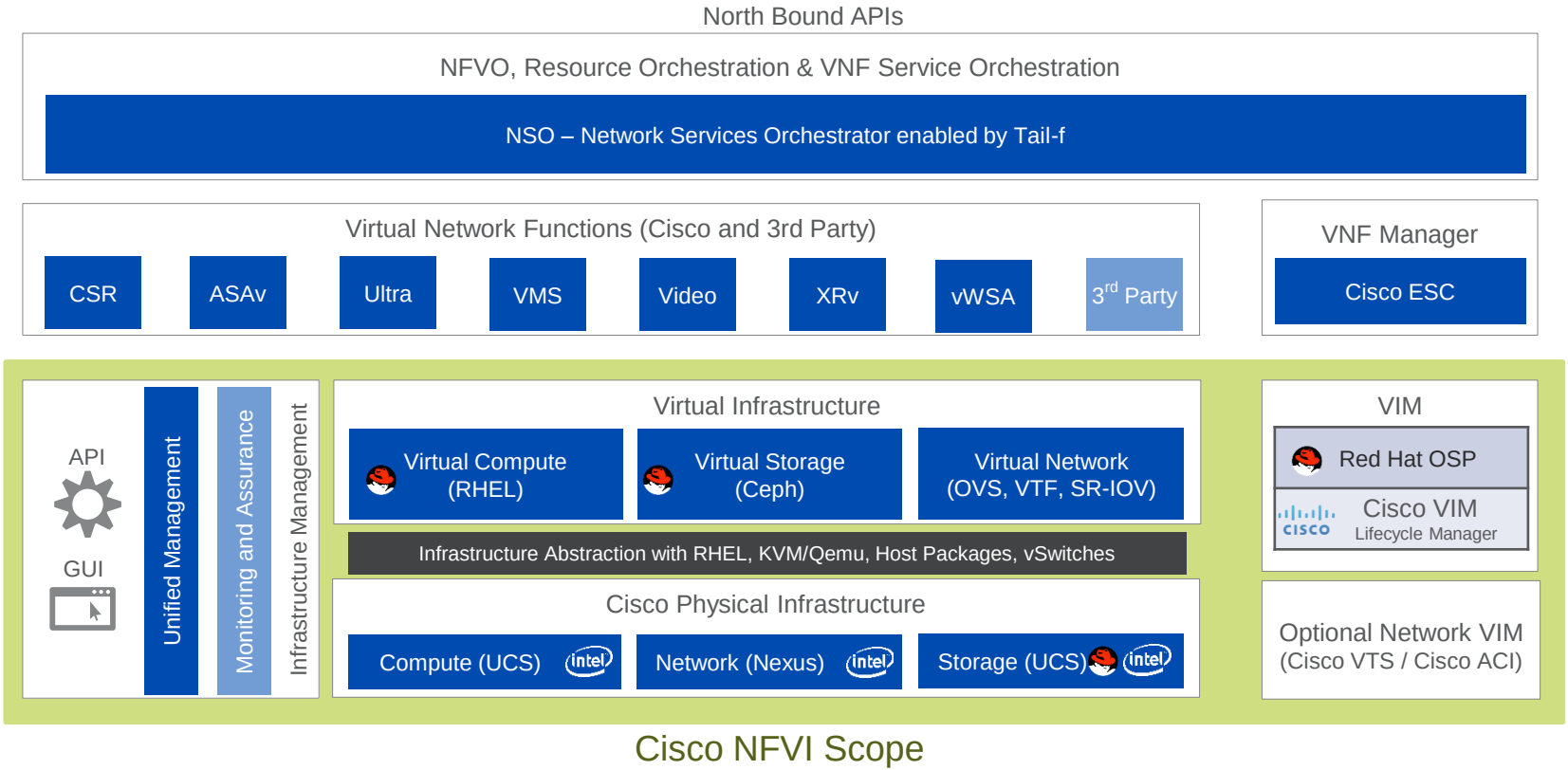
- Common, horizontal carrier-grade NFV infrastructure for multiple use cases – from one vendor
- VNF and MANO packages comes per use case from the target vendors
- Pre-integrated, tested and validated NFVI with single point of ownership
- Faster time to market
- Convergence of the platform is achieved with this platform architecture strategy

NFV Infrastructure Requirements

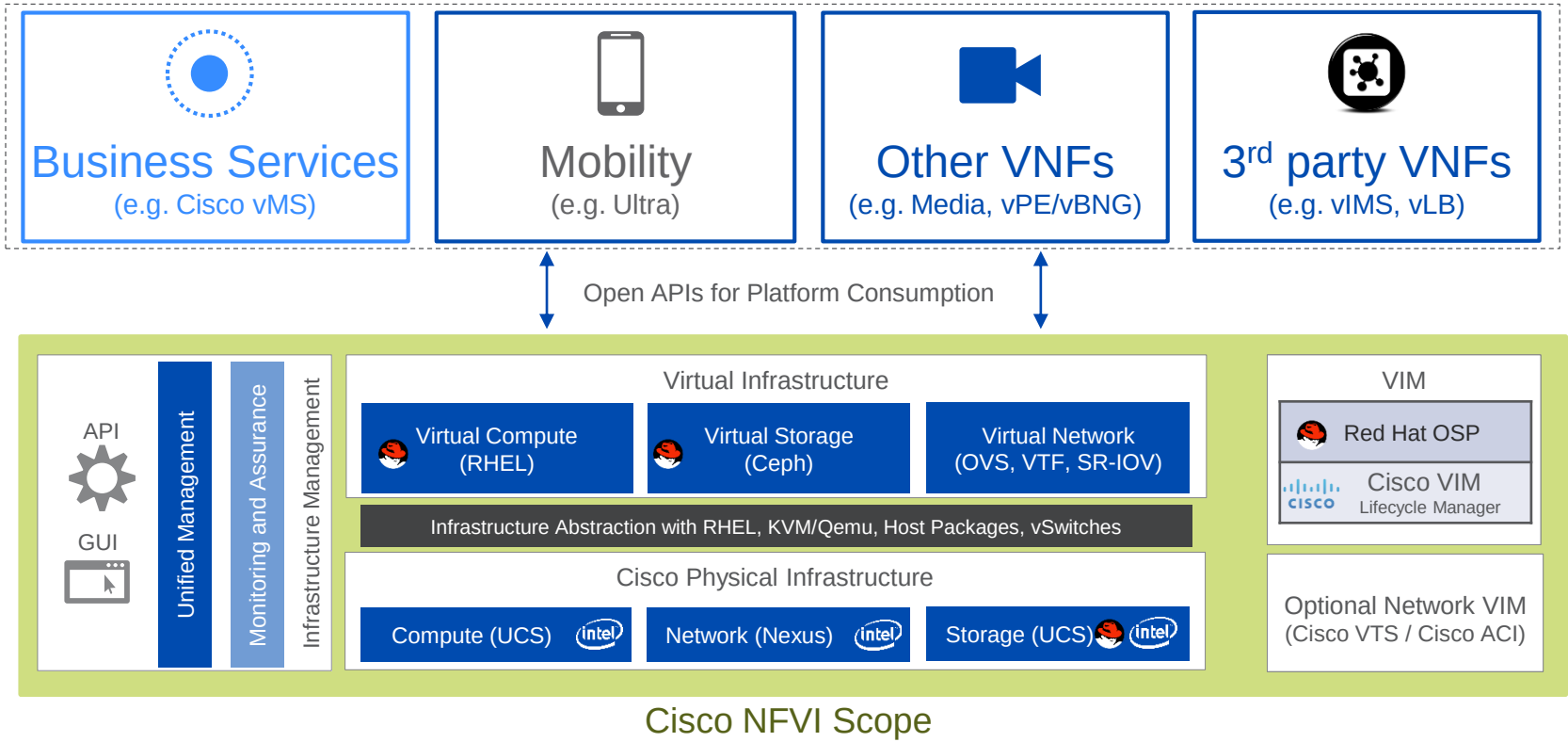
- Carrier Class Performance
- Use Case Agnostic Infrastructure
- Open Standards Based, Modular and Elastic
- Easy to use with Unified Management
- Integrated Solution with Single Point of Ownership
- Multi-level Security

Service Velocity **Operational Simplification** Open Architecture

Cisco NFV Solution Architecture



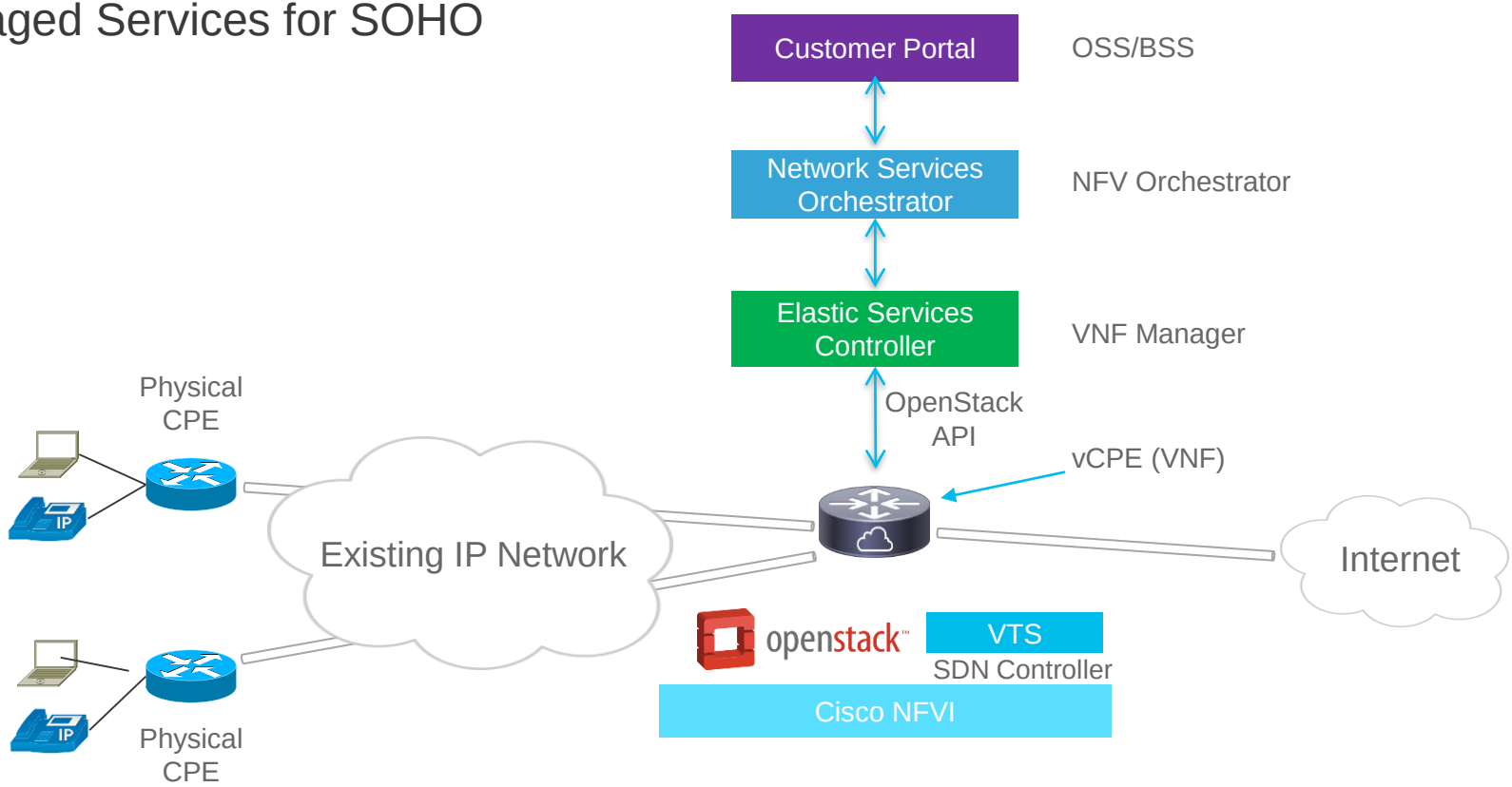
Cisco NFVI Platform Use Cases



NTT East

Managed Services for SOHO

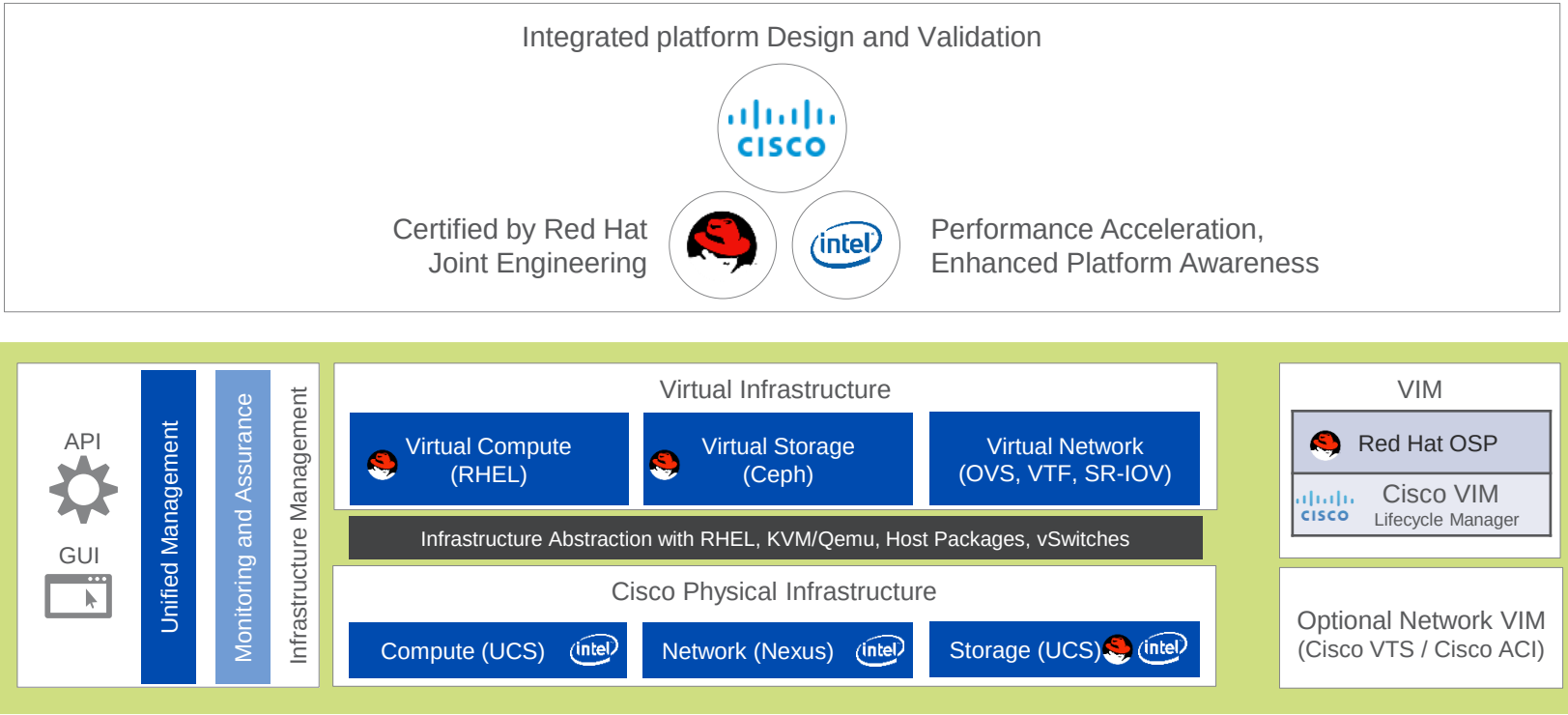
In Production



https://newsroom.cisco.com/press-release-content?type=webcontent&articleId=1896371

Cisco NFVI Solution

Leading Industry Partnerships

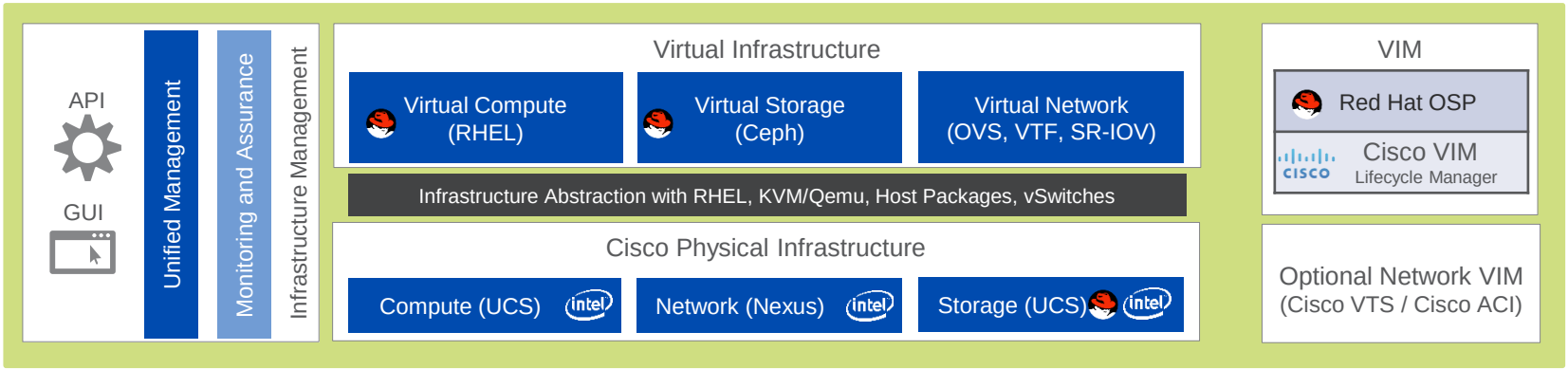


Cisco NFVI Solution

Leading Industry Partnerships

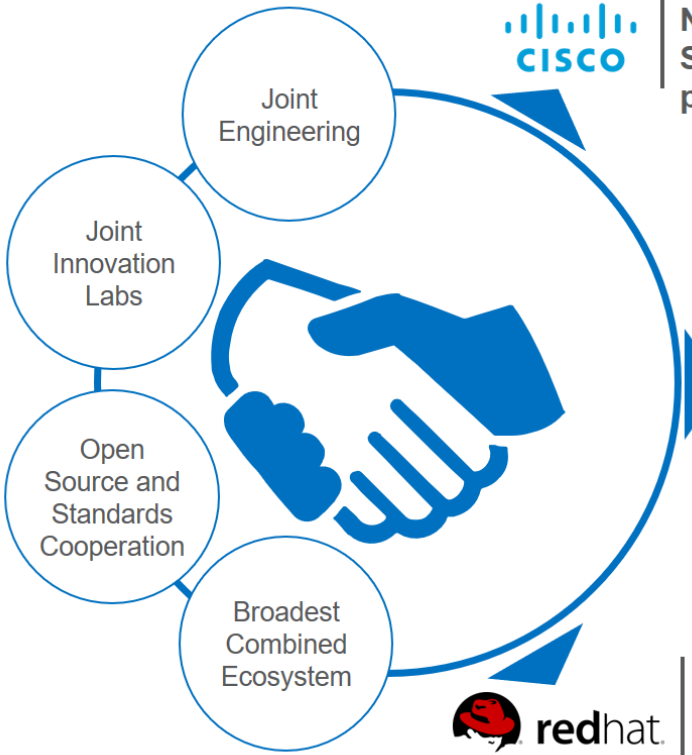
Simple Access to Support

Single Point of Contact



Cisco NFVI Scope

Best of Breed Partnership



cisco — Leading Networking Solutions provider

intel — Leading Data center Silicon / Technology provider

redhat — Leading Open source Linux, OpenStack, CEPH Provider

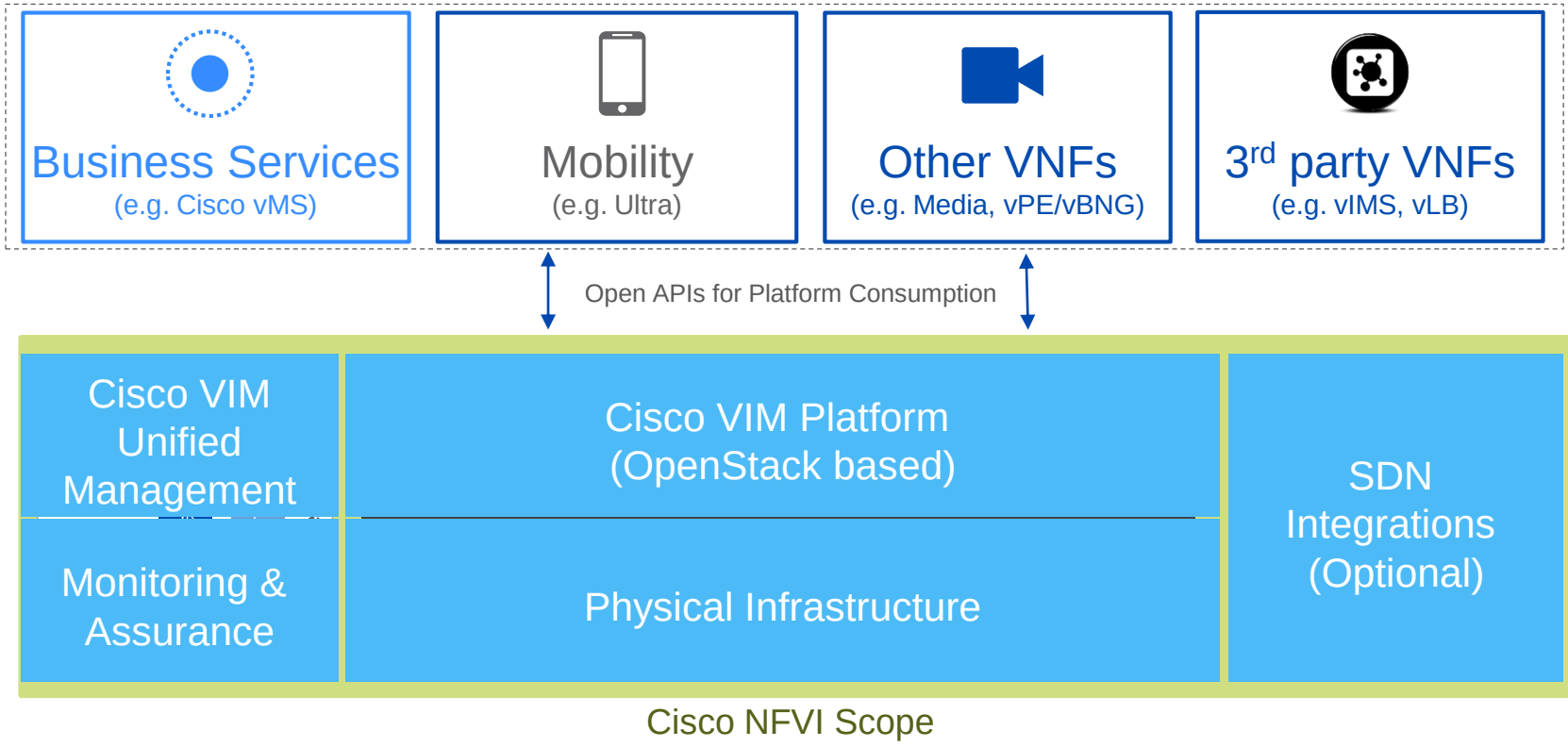
OPEN NETWORKING FOUNDATION · OpenFlow · OPNFV · .io · openstack

Joint innovation and optimization across the stack

- Intel PTT (Platform Trust Technology) (TPM enabled)
  Deep Security Hooks (planning)
- CPU/Memory Access
  NUMA, huge pages, CPU pinning, socket affinity
- Network Access
  SR-IOV, NSH, PCI-Passthrough
- Virtual switching
  VPP, OVS-DPDK

Cisco NFVI Components

Cisco NFVI Components



Cisco VIM
Virtualized Infrastructure Manager

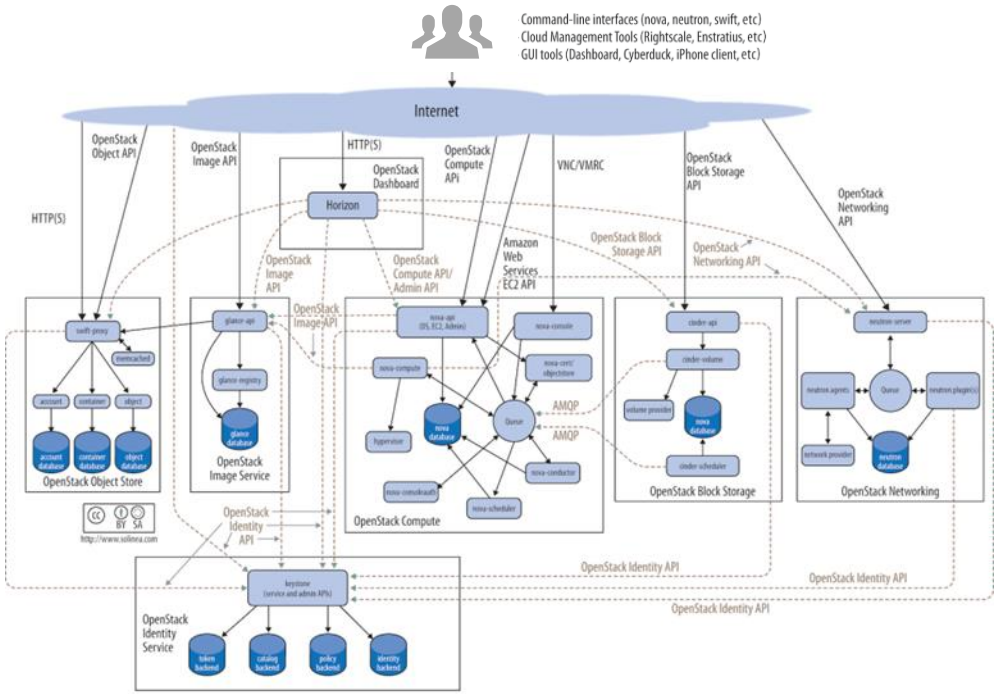
OpenStack as the VIM

OpenStack can be complex to operate:

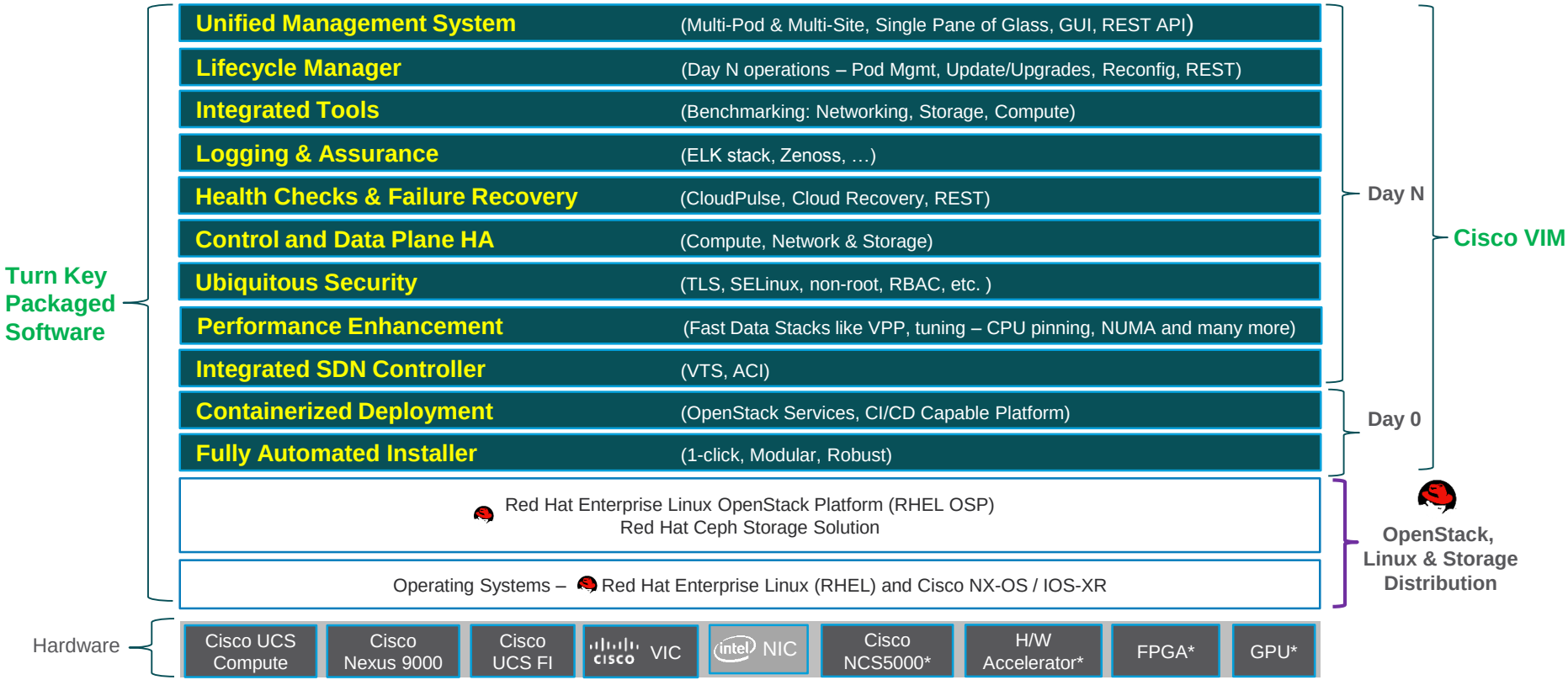
Complex interactions between services, databases, messaging queues, etc.,

Health and performance of a cloud is difficult to quantified, verify and monitor

Updates/upgrades require extensive human effort and are prone to issues

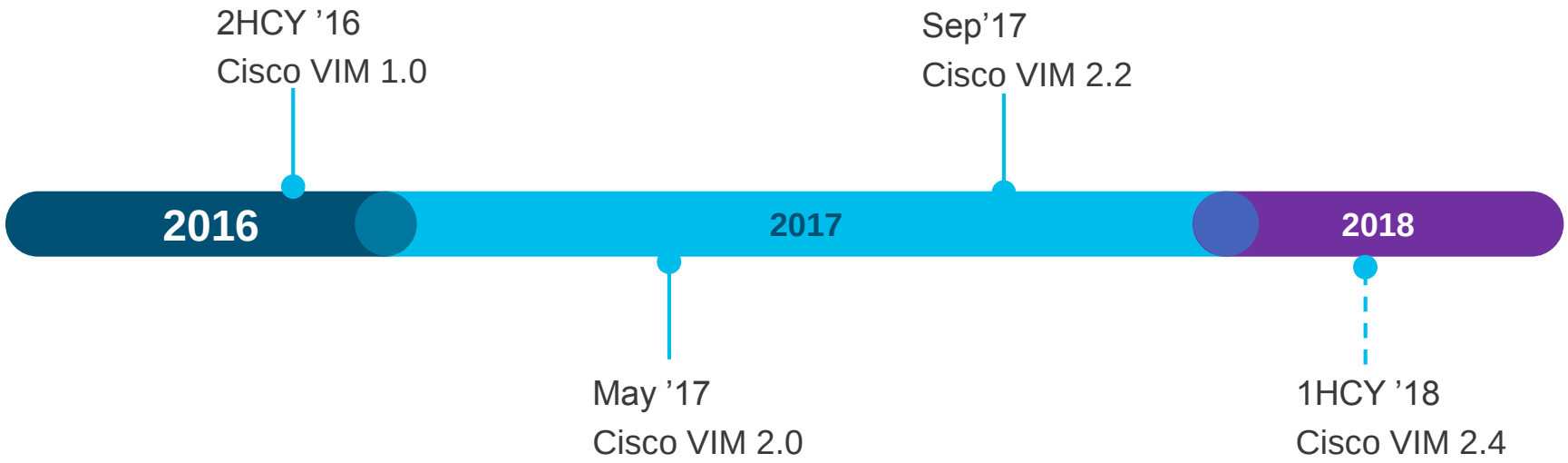


Cisco VIM Carrier Class Platform



* Future

Cisco VIM Release Schedule



Cisco NFVI follows Cisco VIM schedule

Shipping
Roadmap

Cisco VIM 2.0 Features

Software

- Newton OSP 10
- Mgmt Node Auto Backup
- VM Cold Migration
- VM Resizing
- Auto Configuration ToR
- IP source Filtering
- Keystone V3
- Automated SW Upgrade Framework
- Unified Management UI (TechPreview)

Hardware

- Intel X710 NIC
- UCS C240 M4 compute
- Intel v4 (Broadwell)
- Scale up to 20 Storage nodes
- ToR Switches
  - Nexus 9396PX
  - Nexus 93180YC
- Micropod (TechPreview)

Data Plane

- SRIOV with Intel x710
- ML2 VPP
- NFVbench Performance Benchmarking

Third Party Integration

- SwiftStack
- Zenoss

Cisco VIM 2.2 Features

Software

- Cisco VIM Insight GUI
- Software Upgrade – Liberty to Newton
- VTS Upgrade – 2.3 to 2.5
- VTS 2.5 Integration
- ACI/APIC SDN controller Integration
- Fluentd Integration
- Post Install Enable TLS
- Post Install Re-config Provider and Tenant VLAN ranges
- Post Install CIMC password change
- IPv6 support (management and data plane)
- Platform Security
- LDAP integration with Microsoft AD
- Disk Maintenance

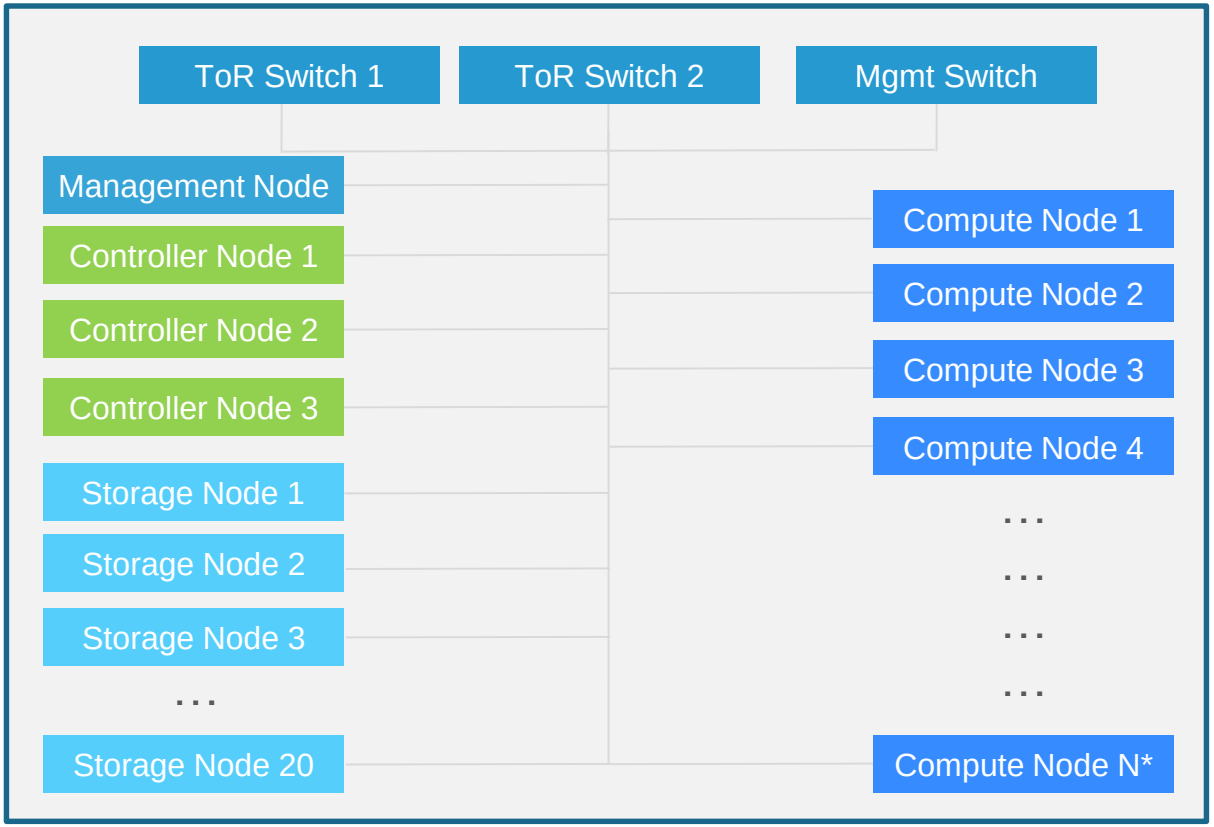
Hardware

- MicroPod GA
- ML2 VPP and SRIOV for both Full and Micropod

Data Plane

- ML2 VPP with L3 and SRIOV
- NFVbench REST API and visualization
- Scale Support for both control and data plane

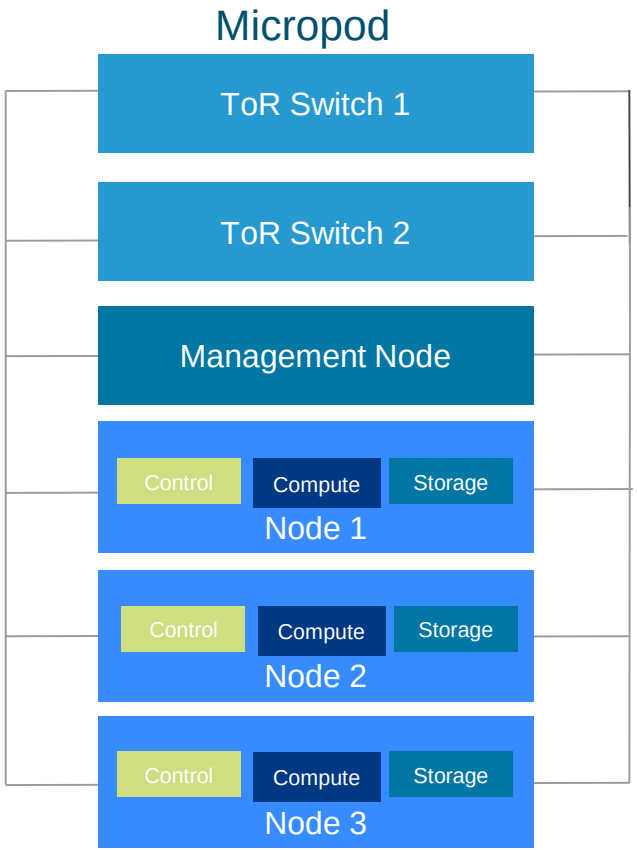
Cisco VIM 2.2 Full Pod



* Total of 64 Compute & Storage nodes in a pod

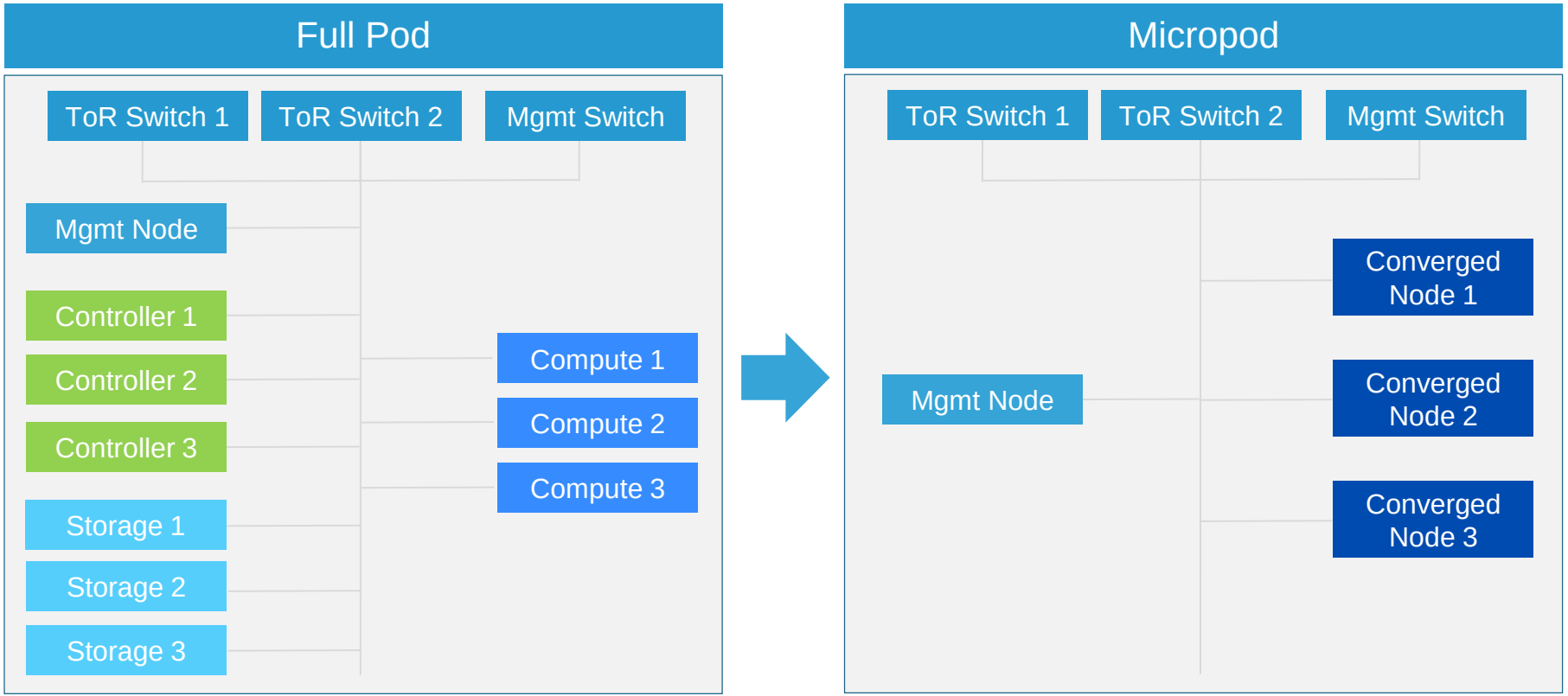
Cisco VIM 2.2 Micropod

- One management node and three converged nodes
- Control, Compute and Storage on all 3 nodes
- Same HA capabilities as a full pod
- Same software and hardware lifecycle capabilities as full pod
- Reduces pod footprint by 60% (Mandatory nodes)



Significant Efficiencies with Pod footprint

Use Case: Cisco VMS IWAN



Cisco VIM 2.2 – Hardware Compatibility

Node	Server	Intel CPU V3	Intel CPU v4	Intel NIC X710	1x Cisco VIC + 2x Intel NIC X520	Cisco VIC1227	Cisco VIC1240	Cisco VIC1340	Cisco VIC1340 & 1380
Control	UCS C240 M4	✓	✓	✓	✓	✓			
	UCS C220 M4	✓	✓	✓	✓	✓			
	UCS B200 M4	✓	✓				✓	✓	✓
Compute	UCS C240 M4	✓	✓	✓	✓	✓			
	UCS C220 M4	✓	✓	✓	✓	✓			
	UCS B200 M4	✓	✓				✓	✓	✓
Storage	UCS C240 M4	✓	✓	✓	✓	✓			
Management	UCS C240 M4	✓	✓	✓*		✓			

Supported from CVIM 2.2 onwards

Data Plane Support – Full Pod

Combinations listed below are supported in Cisco VIM 2.2

NFVI Type	Virtual Switch	Tenant virtual Networks Encapsulation	Provider Virtual Networks Encapsulation	SR-IOV Passthrough
UCS C220/C240 + Cisco VIC1227	OVS	VLAN	VLAN	No
	VTF + VTS	VXLAN	VLAN	No
	VPP + ML2	VLAN	VLAN	No
UCS C220/C240 + Intel NIC X710	OVS	VLAN	VLAN	Yes
	VPP + ML2	VLAN	VLAN	Yes
UCS C220/C240 + Intel NIC X520	OVS	VLAN	VLAN	Yes
UCS B-series	OVS	VLAN	VLAN	Yes

Data Plane Support – Mircopod

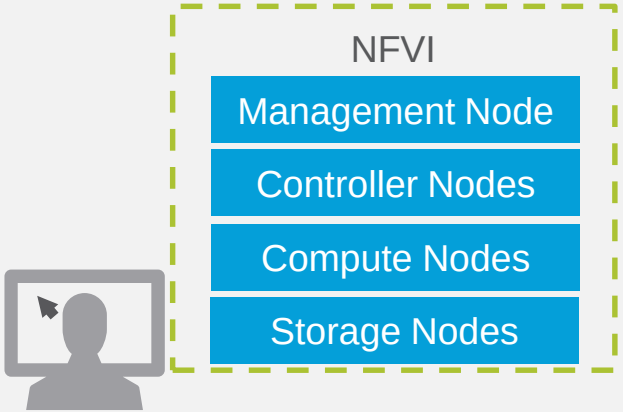
Combinations listed below are supported in Cisco VIM 2.2

NFVI Type	Virtual Switch	Tenant virtual Networks Encapsulation	Provider Virtual Networks Encapsulation	SR-IOV Passthrough
UCS C220/C240 + Cisco VIC1227	OVS	VLAN	VLAN	No
	VPP + ML2	VLAN	VLAN	No
UCS C220/C240 + Intel NIC X710	OVS	VLAN	VLAN	Yes
	VPP + ML2	VLAN	VLAN	Yes

Containerized Install, Update and Upgrade

Container-Based Deployment

Cisco

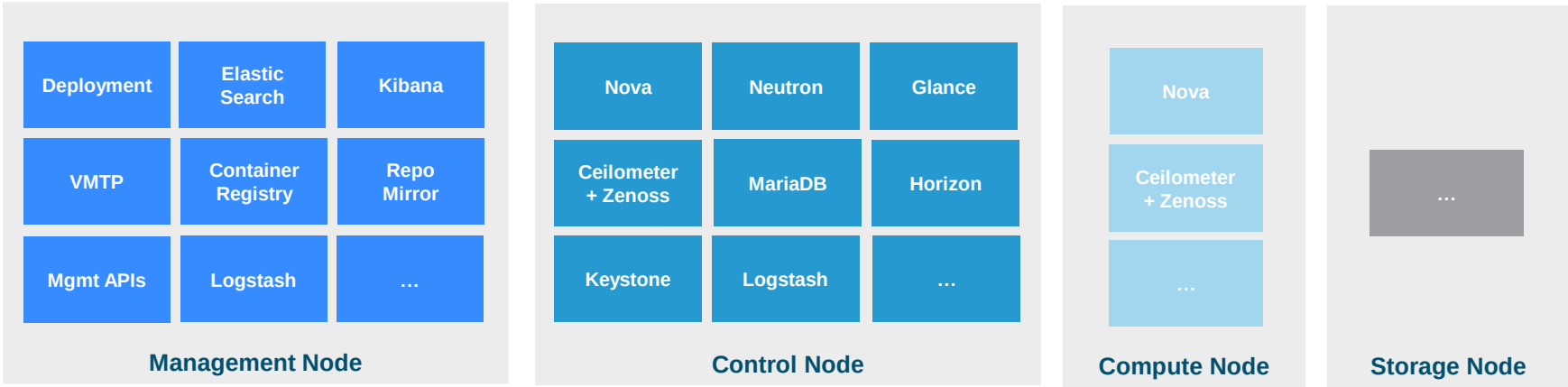


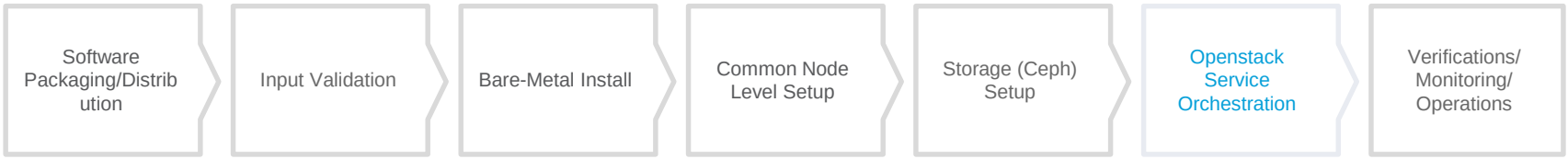
Customer Controlled

Containerized OpenStack Services

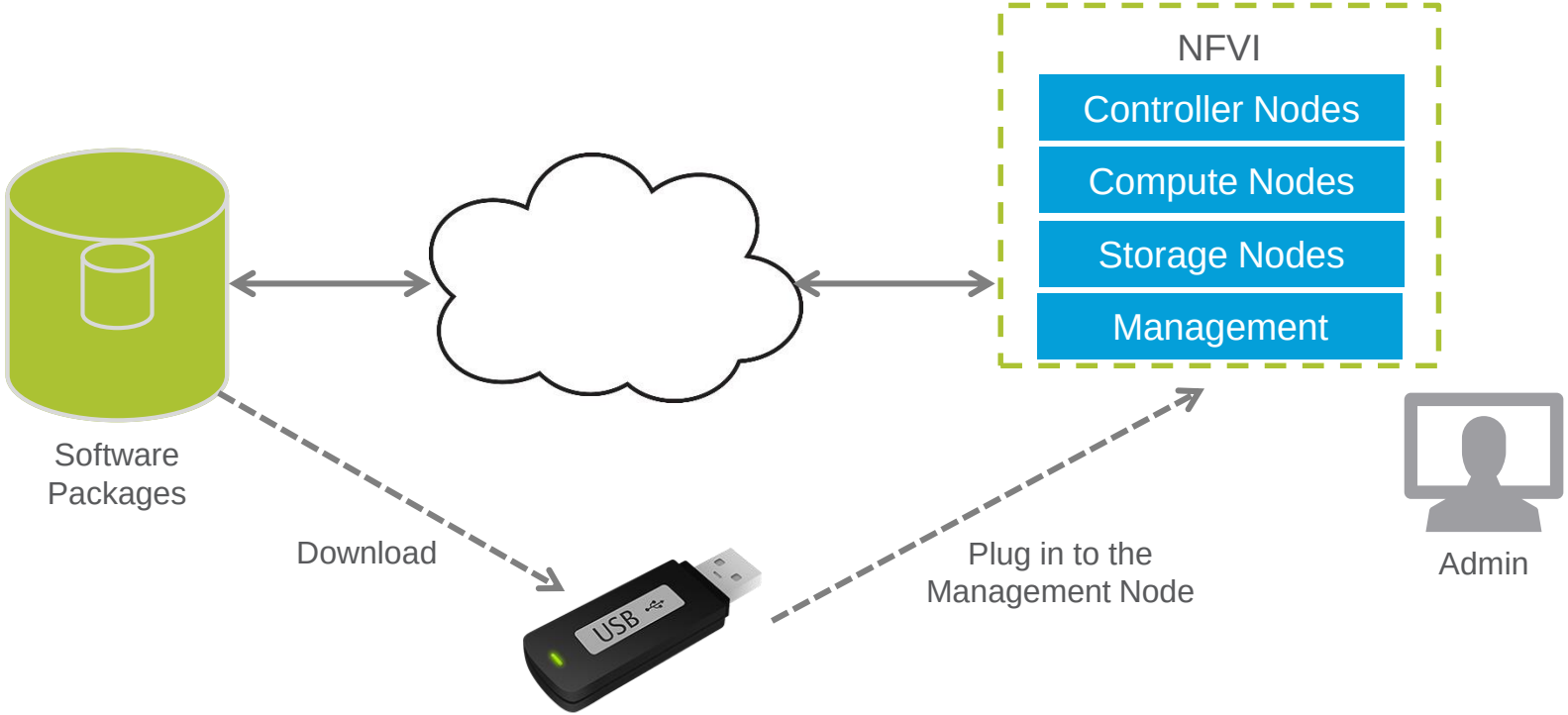
Verifications/ Monitoring/ Operations

- Consistent deployment of software versions
- Isolation of services from each other gives better resiliency
- Predictable and low impact updates (both software patches and major version upgrades)



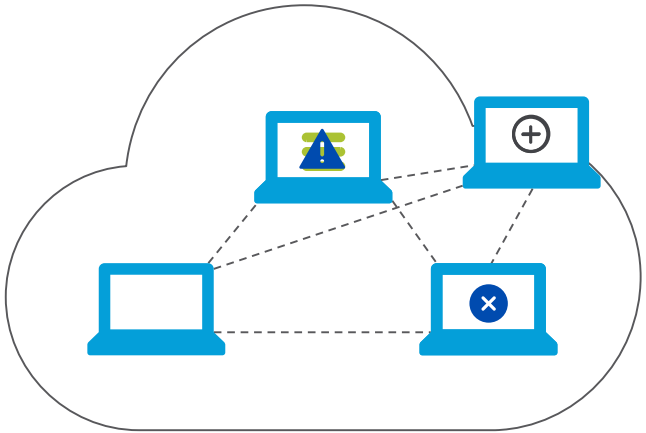


Offline and Online Install / Update / Upgrade



Hardware Life Cycle Management

Verifications/
Monitoring/
Operations



Cisco NFVI

- Add and remove of compute nodes to scale the pod on demand
- Replacement of control nodes in case of maintenance
- Replacement of storage nodes in case of maintenance

Automated Software Updates & Upgrades

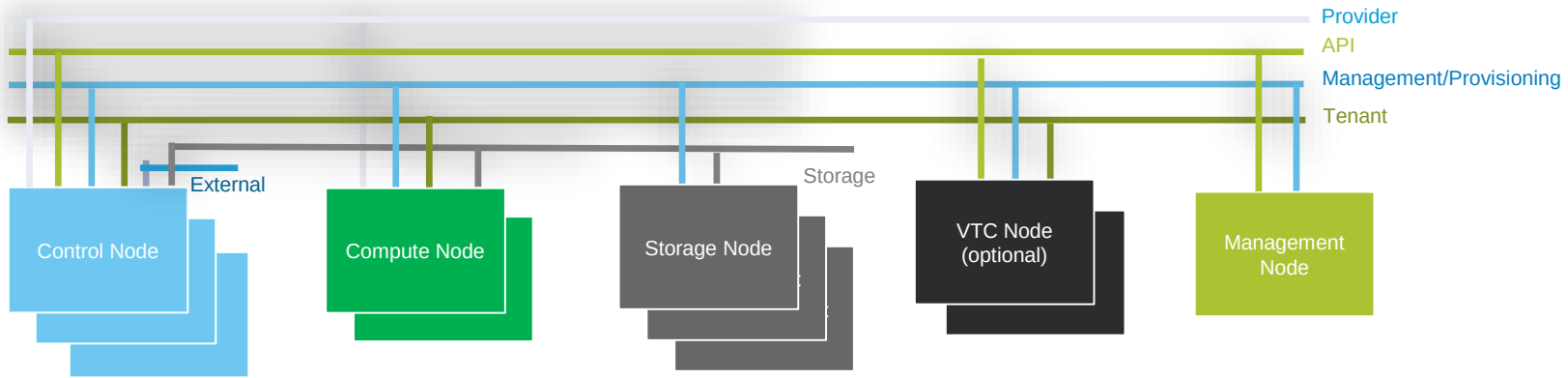
Verifications/
Monitoring/
Operations

Cisco NFVI

- Update/upgrade on demand
- Update with patches and security updates
- Rollback to previous version in case of any error

Underlay Networking

- API – OpenStack API end points for managing/using the NFVI
- External – Link to world beyond the cloud via OpenStack virtual routers (L3 agent)
- Management/Provisioning network – PXE boot and Openstack inter-service communication
- Provider – Link to existing infrastructure networks
- Tenant – Inter VM traffic via OpenStack tenant networks
- Storage – Ceph data replication traffic



Cisco VIM Security - Defense in Depth

Proactively design & secure the platform

- Cisco Secure Development Lifecycle (CSDL) compliant
- Cisco Product Security Baseline (PSB) compliant
- Network segmentation
- SELinux at host and container level
- Immutable containers
- Containers running as non-root
- ANSSI review of VPC deployment

- Minimum attack surface…
  - No unnecessary open ports
  - No unnecessary software bits installed
- Passwords management
- Authenticated and secure access to APIs and Dashboards
- Seamless update of security patches
- Bandit security analyzer
- File/Process ownership/permissions

Disk Maintenance

- Ability to check, identify and repair faulty disks without having to remove the node
- Disk maintenance can be performed on:
  - Management
  - Control
  - Compute
- Hardware RAID is pre-requisite for disk maintenance
- REST API and CLI can be used to query information on pod nodes
- Supported from CVIM 2.2 onwards

Post-Install: UCS CIMC Password Change

- Ability to change CIMC password for all or specific servers
- CIMC password change or reconfigure supported via Cisco VIM UM
- The new password must satisfy atleast 3 of the following conditions
  - ***At least 1 letter between a to z***
  - ***At least 1 letter between A to Z***
  - ***At least 1 number between 0 to 9***
  - ***At least 1 character from !$#@%^-_+=*&***
  - ***And "password length between 8 and 20 characters***
- Supported only on UCS C series

Post-Install: Provider & Tenant VLAN Range Changes

- Cisco VIM 2.2 provides the ability to increase Provider and Tenant VLAN ranges Post Install
- This provides customer with the flexibility in network design and planning
- Applies to both C-series and B-series pods enabled with UCSM plugin
- To run this feature, you should already have tenant and provider networks enabled on their pod with Day 0 configuration
- Sample day-0 setup_data.yaml configuration

```
TENANT_VLAN_RANGES: 1002:1004          # Must match the range given in tenant network segment
PROVIDER_VLAN_RANGES: 2002:2004        # Must match the range given in provider network segment
```

Post-Install: Enable TLS

- Why TLS?
  - TLS encrypts and authenticates communication to cloud endpoints
  - Enabling TLS is important to ensure network security

- Supported TLS certificates configuration
  - Cisco VIM Rest API endpoints
  - OpenStack API endpoints
  - SwiftStack Service through Horizon
  - Fluentd Service

Keystone LDAP Integration with MS Active Directory

- **LDAP Integration with Microsoft Active Directory**

  With introduction of Keystone V3, OpenStack service authentication can be delegated to external LDAP/AD server

- **Expose LDAP user filter configurations with setup_data.yaml**

  user_filter: '(memberOf=CN=os-users,OU=OS-Groups,DC=mercury,DC=local)

- **Enable v4,v6 connectivity to LDAP server**

  url: 'ldap://[2001:420:293:2487:d1ca:67dc:94b1:7e6c]:389, ldap://172.26.233.104:389‘

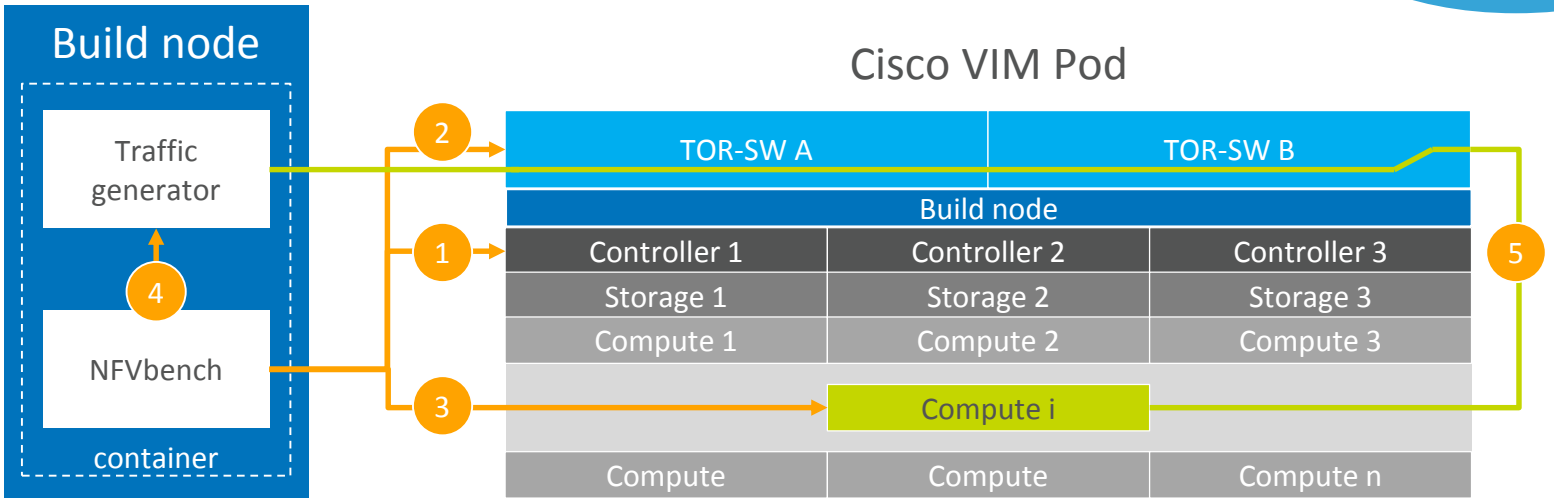
- **High availability with multiple LDAP domain servers**

  url: 'ldap://172.26.233.104:389, ldap://172.26.233.105:389'

NFVbench

Addressing Network Benchmarking

Fully integrated with CVIM



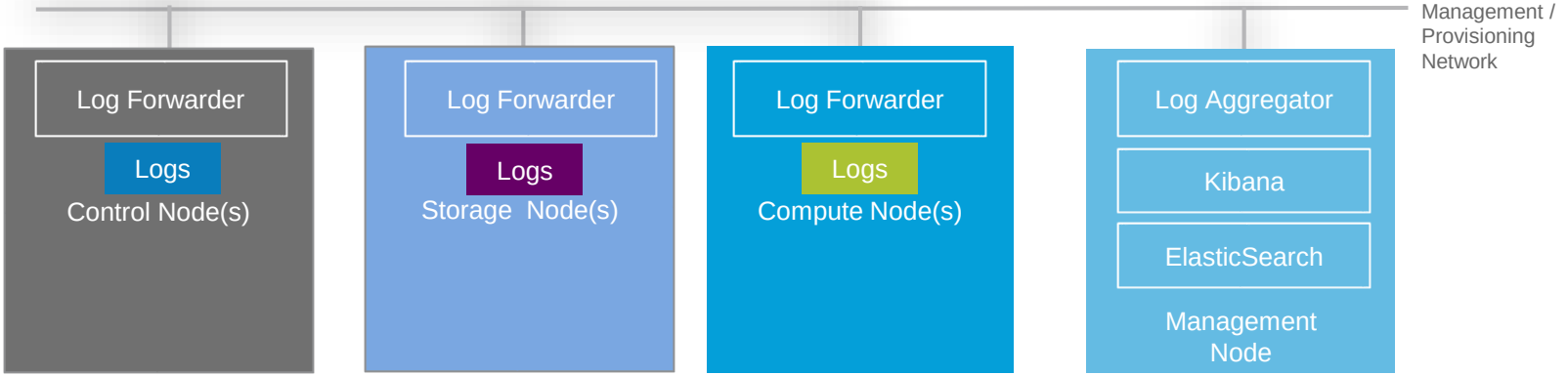
1 Stage VNF chain (OpenStack API)
2 Stitch traffic generator interfaces to VNF chain
3 Clear counters in vswitch(es)
4 Start traffic
5 Traffic flows to the VNF

An integrated network performance benchmarking toolkit, pre-installed on every POD along with a set of best known practices

Centralized Logging

Cisco VIM – Centralized Logging

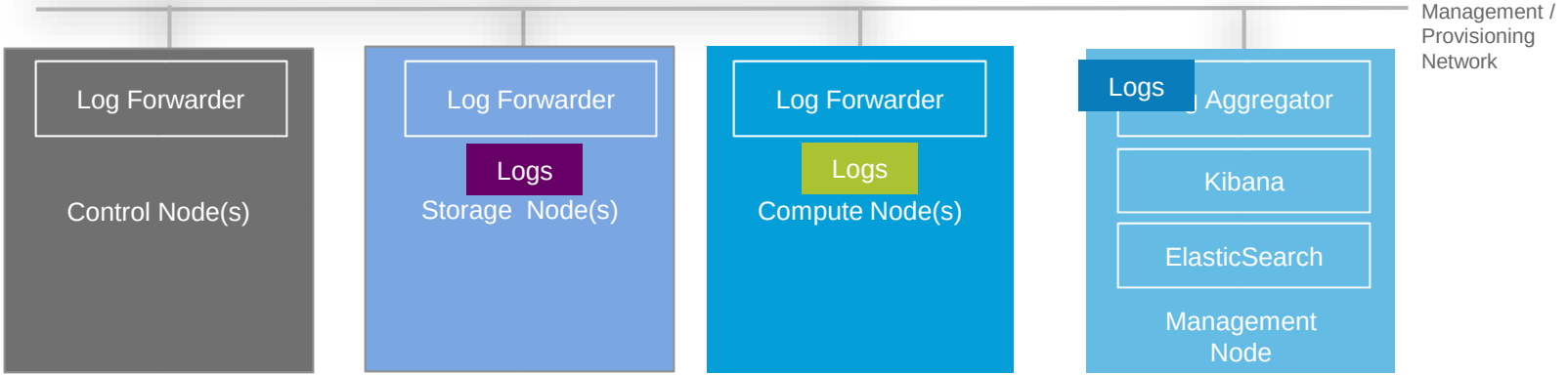
- Log forwarders on all nodes forward logs to Fluentd-aggregator on Management node
- Fluentd-aggregator to forward logs to ElasticSearch database
- Kibana dashboard for viewing logs stored in ElasticSearch
- Fluentd-aggregator to forward logs to remote Syslog



- Fluentd is used as Log Forwarder and Log Aggregator from CVIM 2.2
- Logstash as Log Forwarder and Log Aggregator in CVIM 1.0 ad 2.0

Cisco VIM – Centralized Logging

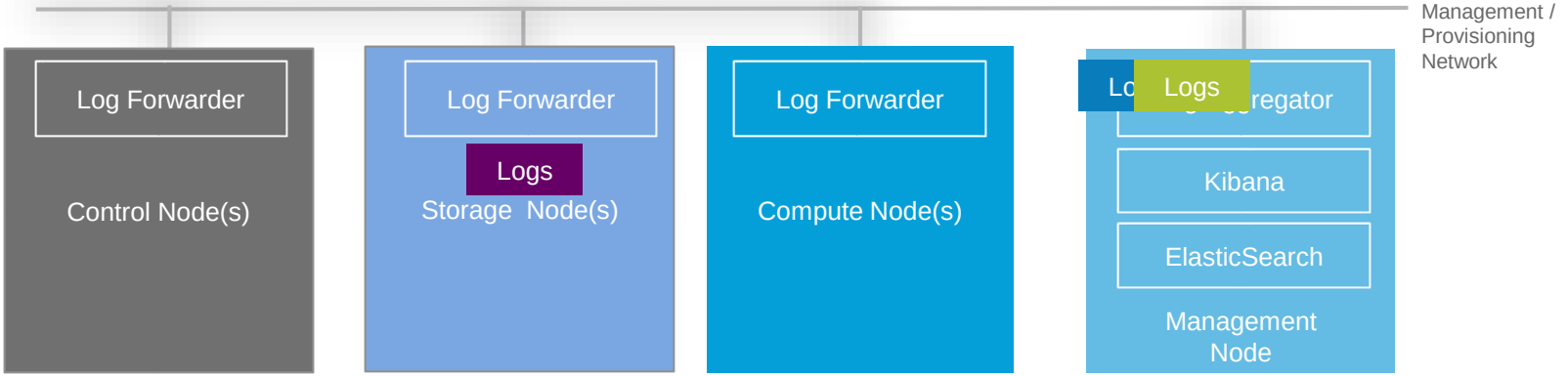
- Log forwarders on all nodes forward logs to Fluentd-aggregator on Management node
- Fluentd-aggregator to forward logs to ElasticSearch database
- Kibana dashboard for viewing logs stored in ElasticSearch
- Fluentd-aggregator to forward logs to remote Syslog



- Fluentd is used as Log Forwarder and Log Aggregator from CVIM 2.2
- Logstash as Log Forwarder and Log Aggregator in CVIM 1.0 ad 2.0

Cisco VIM – Centralized Logging

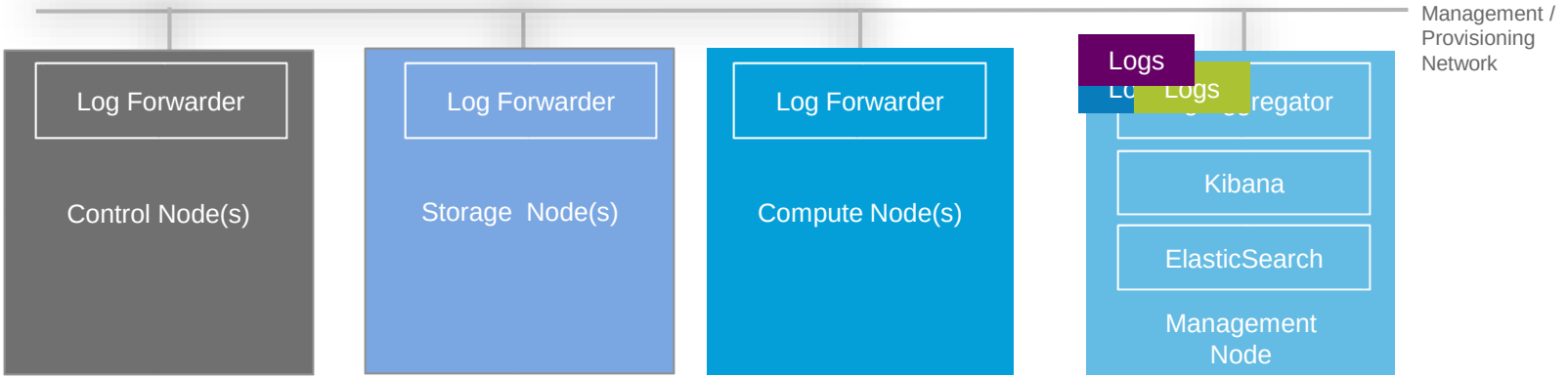
- Log forwarders on all nodes forward logs to Fluentd-aggregator on Management node
- Fluentd-aggregator to forward logs to ElasticSearch database
- Kibana dashboard for viewing logs stored in ElasticSearch
- Fluentd-aggregator to forward logs to remote Syslog



- Fluentd is used as Log Forwarder and Log Aggregator from CVIM 2.2
- Logstash as Log Forwarder and Log Aggregator in CVIM 1.0 ad 2.0

Cisco VIM – Centralized Logging

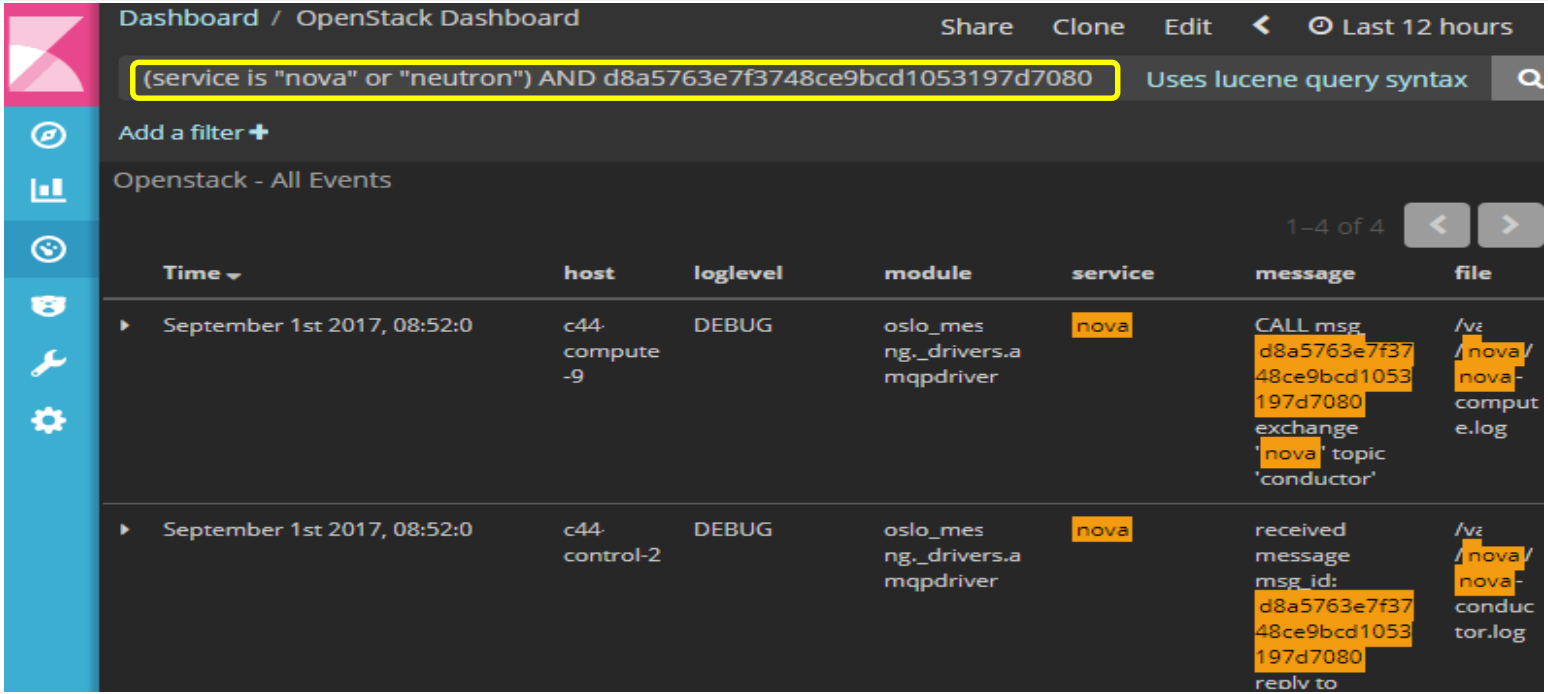
- Log forwarders on all nodes forward logs to Fluentd-aggregator on Management node
- Fluentd-aggregator to forward logs to ElasticSearch database
- Kibana dashboard for viewing logs stored in ElasticSearch
- Fluentd-aggregator to forward logs to remote Syslog



- Fluentd is used as Log Forwarder and Log Aggregator from CVIM 2.2
- Logstash as Log Forwarder and Log Aggregator in CVIM 1.0 ad 2.0

Cisco VIM – Monitoring Logs

- Kibana visualizes the data stored in Elasticsearch using custom dashboards
- User can add filters or create queries to search through the logs



Log Management & Export

Cisco VIM – Log Rotation

- **ELK rotation parameters**
  - CISCO VIM stores all the logs in Elasticsearch on the management node

```
# elk_rotation_frequency: "monthly"  # Available options: "daily", "weekly", "fortnightly", "monthly"
# elk_rotation_size: 2  # Gigabytes (float is allowed)
# elk_rotation_del_older: 10 # Delete older than 10 units (where units depends on elk_rotation_frequency)
```

- **Cloud log rotation parameters**
  - Log rotation and management for compute, control and storage nodes

```
# log_rotation_frequency: "monthly"  # Available options: "daily", "weekly", "monthly", "yearly"
# log_rotation_size: "100M"  # Max file size to start rotating (must pecify the unit. Available options: k, M, G))
# log_rotation_del_older: 10 # Number of files to keep before starting deleting them
```

Cisco VIM – Syslog Export

- **Syslog Forwarding supports the following options :**
  - Forwarding logs from Management node to External Syslog Server
  - Reconfigure existing Syslog settings to point to a different syslog
  - Supports both IPv4 and IPv6

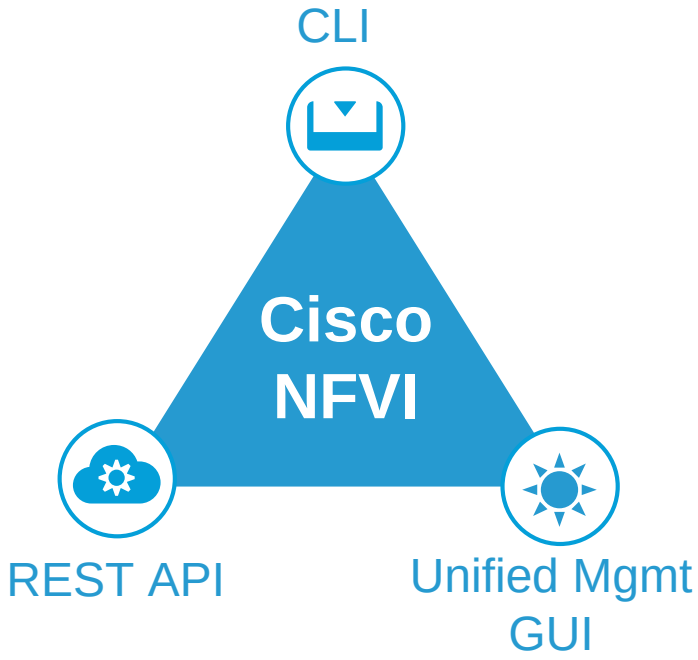
The following needs to be configured in setup_data.yaml

```
# SYSLOG_EXPORT_SETTINGS:
#  remote_host: <Syslog_ip_addr>   # required
#  protocol: udp   # required between tcp/udp defaults to udp
#  facility: local5  # required; defaults to local5
#  severity: debug # ; required, value of debug
#  port: <int>  # typically 514 (required)
#  clients: 'ELK'   # required
```

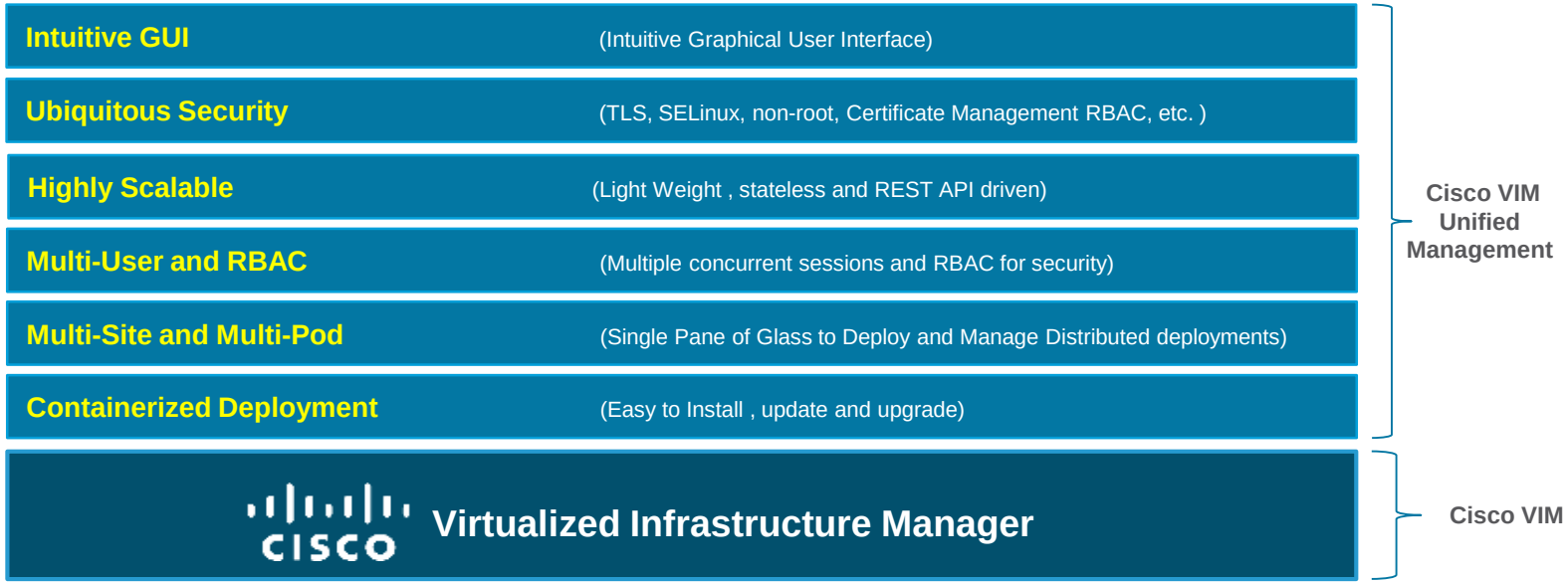
Cisco VIM Unified Management

Unified Management

- Cisco NFVI can be managed through GUI, CLI and REST API interfaces
- Unified Management GUI
  - Multi-pod
  - Multi-user
  - RBAC
  - Containerized, lightweight, stateless



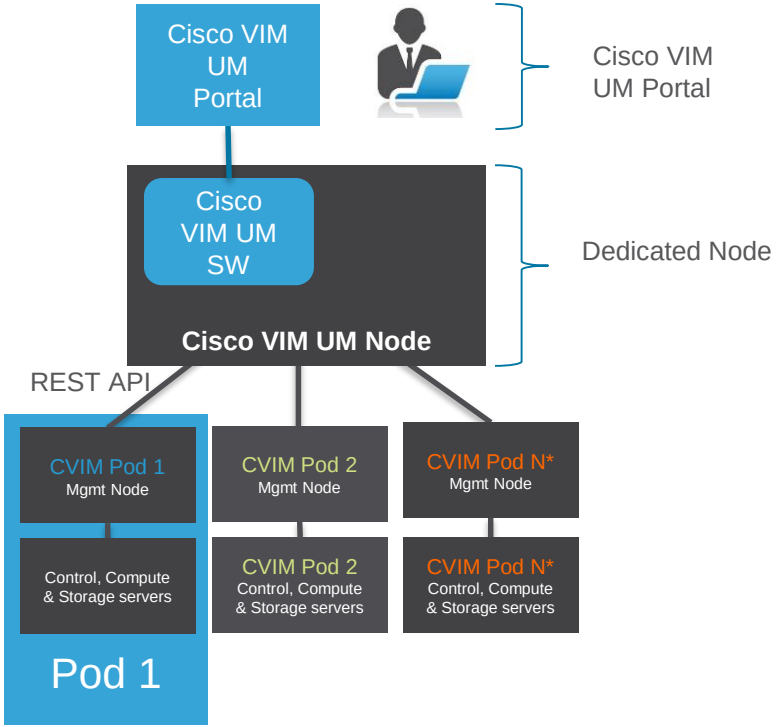
Cisco VIM Unified Management (UM)



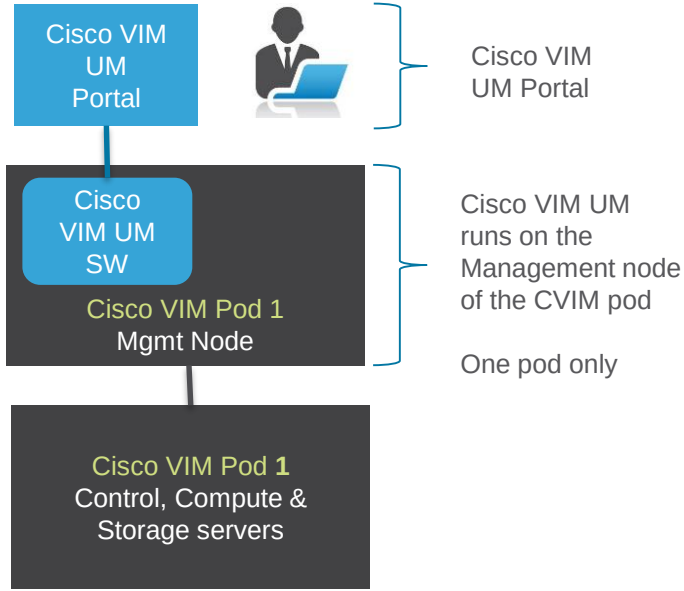
Cisco VIM Unified Management

Deployment Models

Cisco VIM UM on Dedicated UM Node



Cisco VIM UM on Management Node

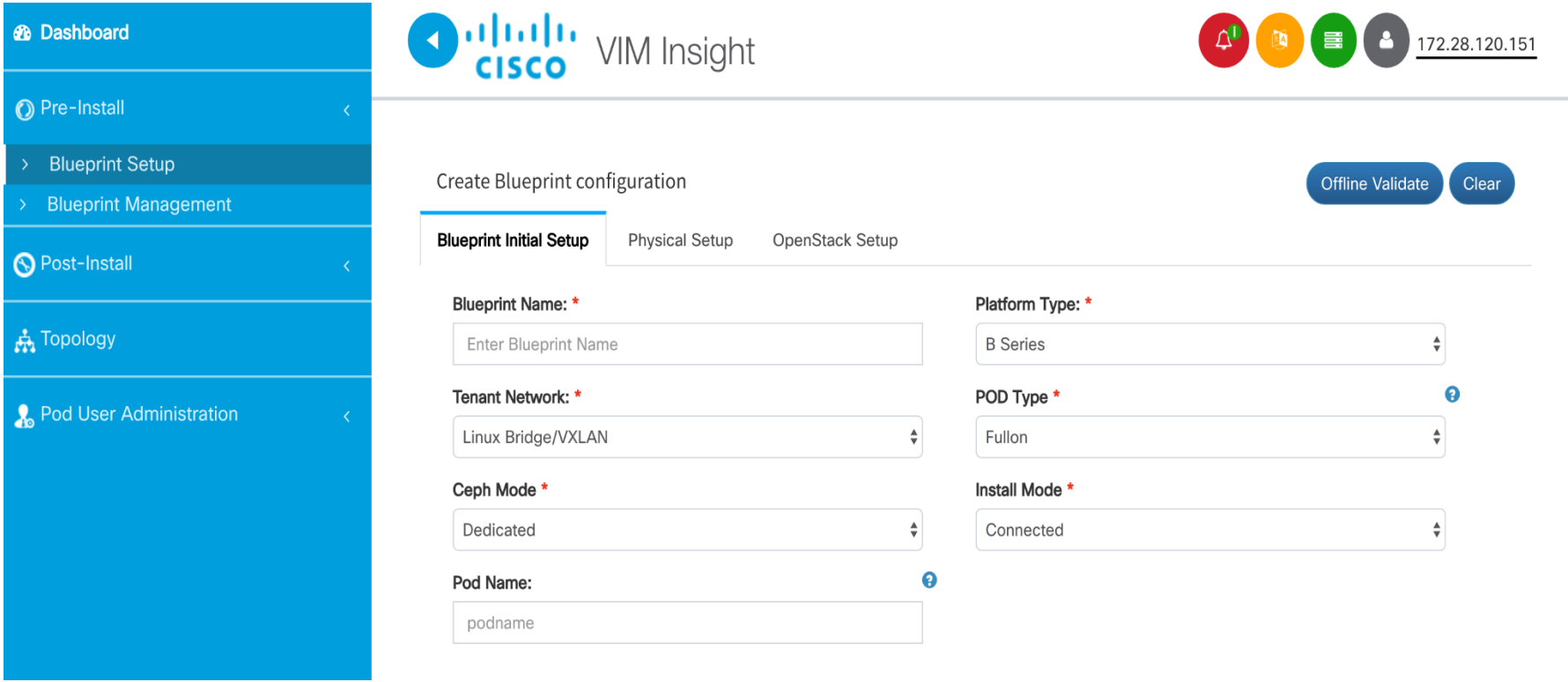


Cisco VIM Unified Management

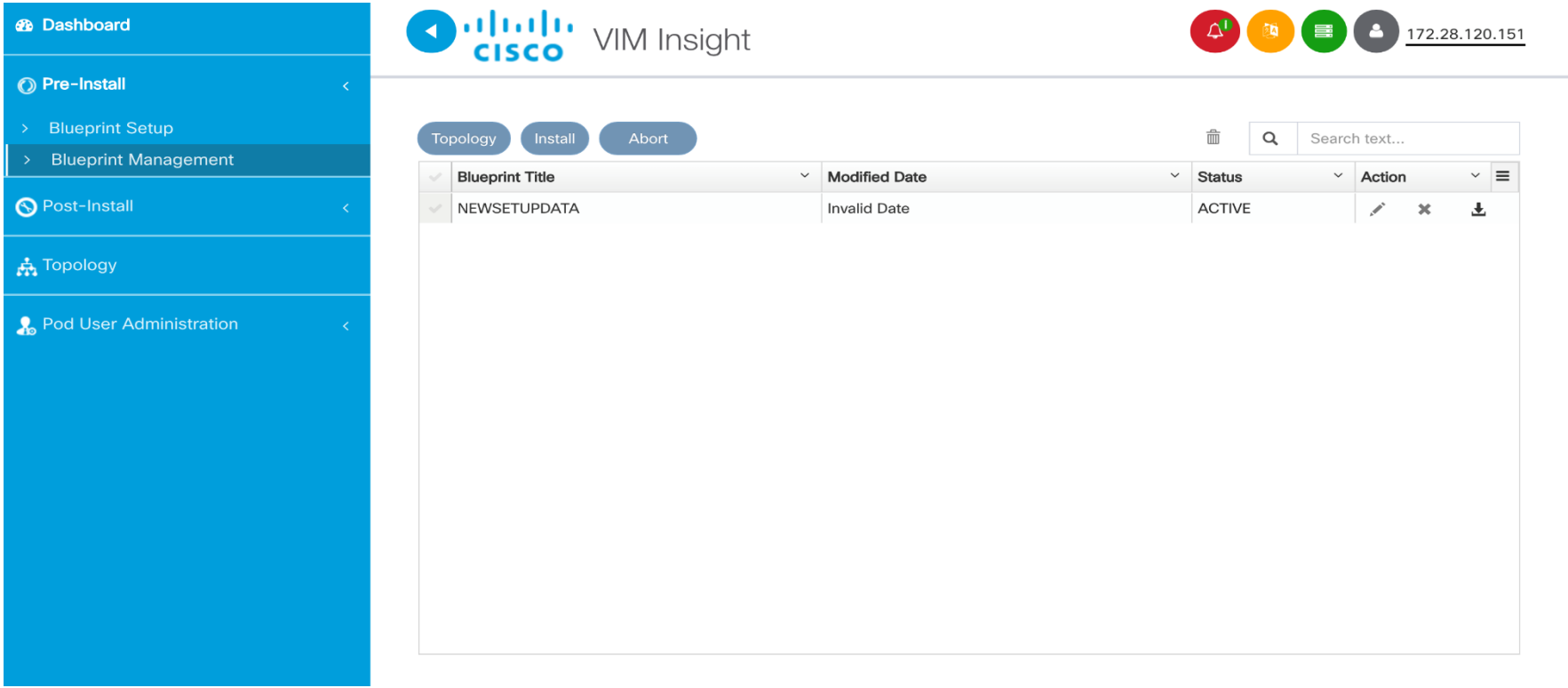
Deployment Models

On Unified Management Node	On CVIM Management Node
Runs on a dedicated Unified Management node	Runs on the management node of the pod
Multi-pod Support	No Multi-pod support
All Features supported	All features but for NFVbench
Recommended	Only for local pod management

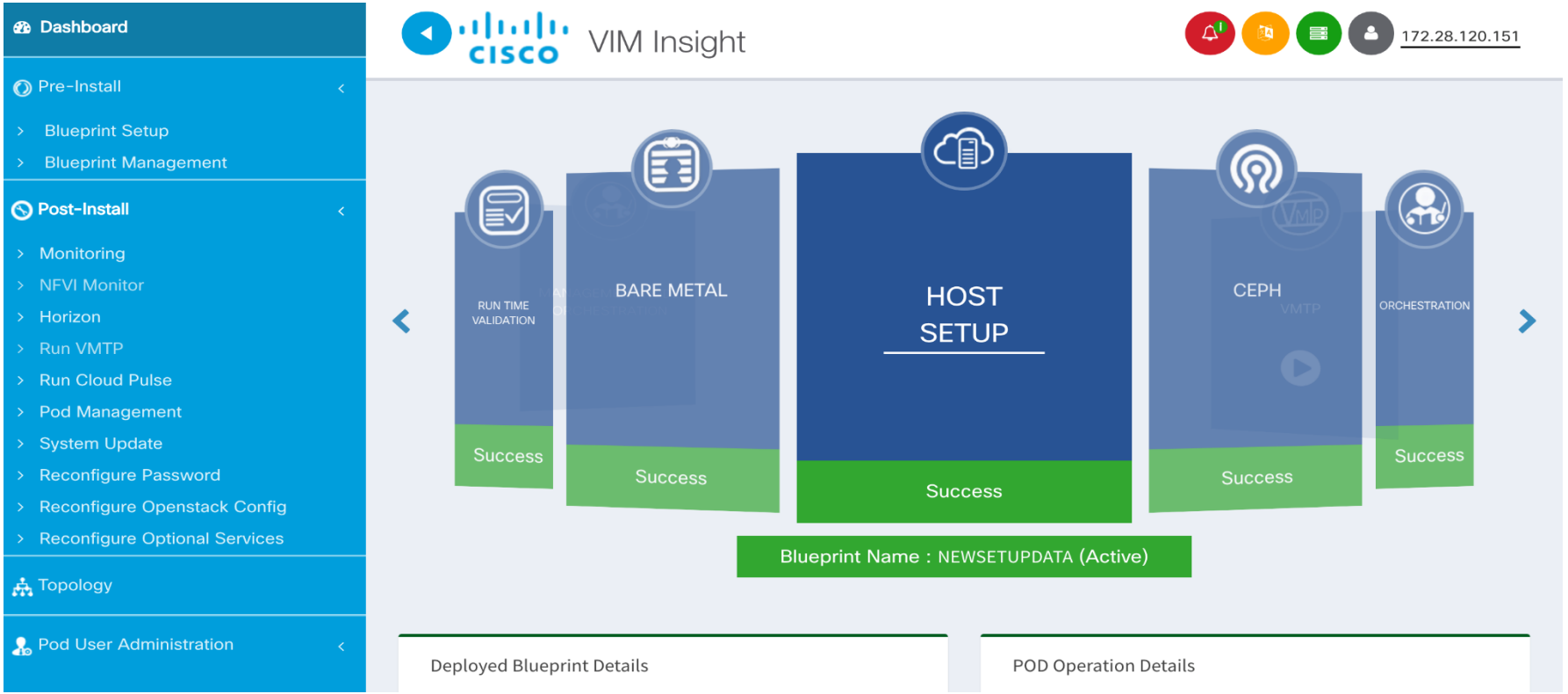
Unified Management – Pod Blueprint



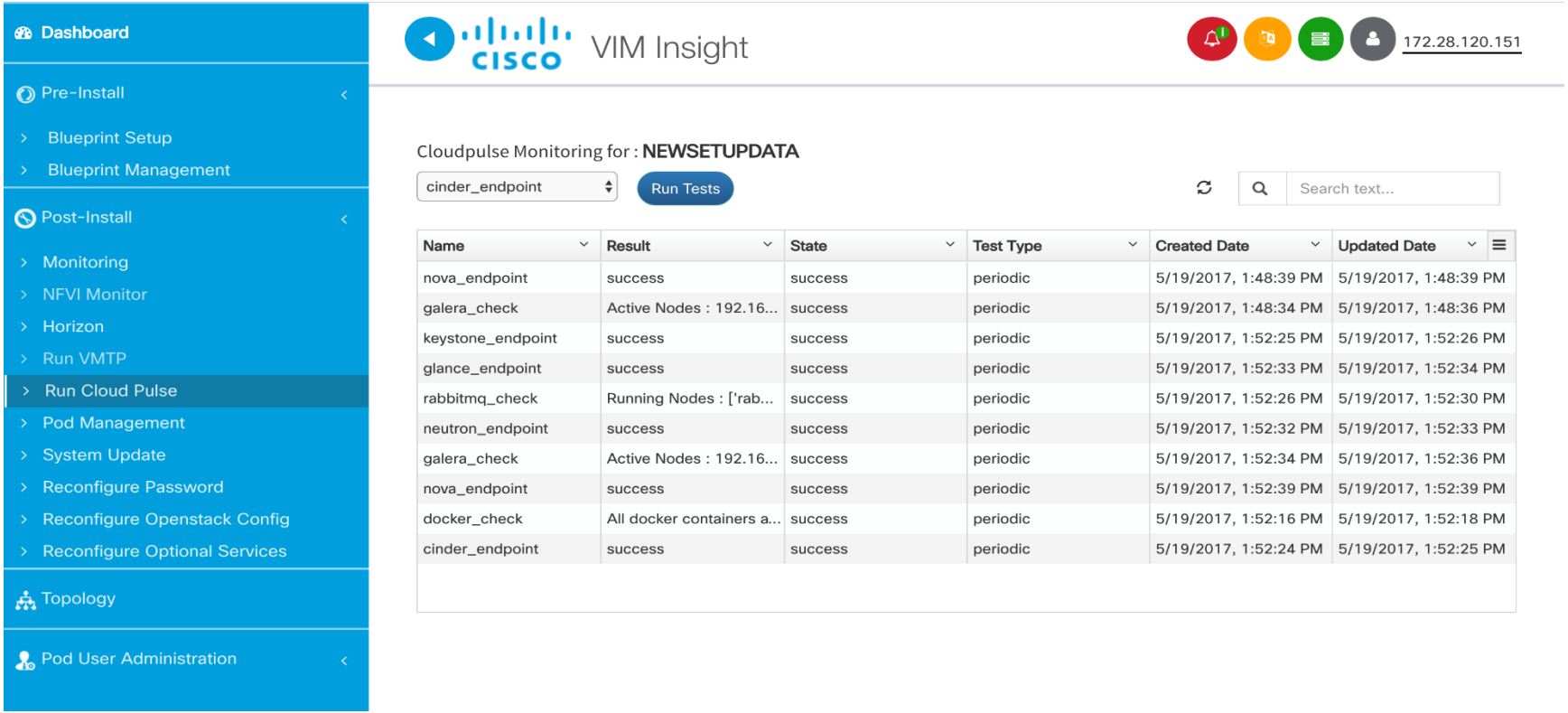
Unified Management – Installation



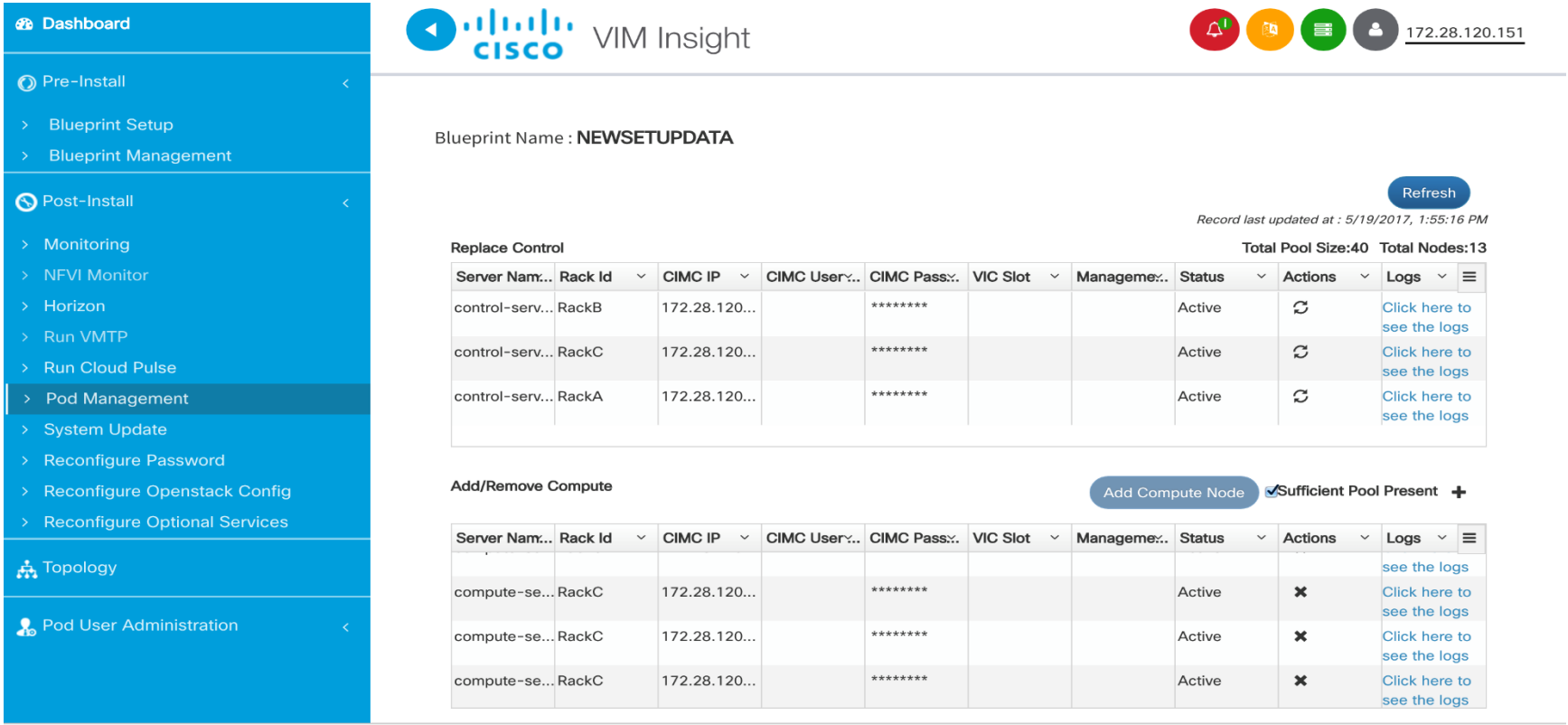
Unified Management – Installation



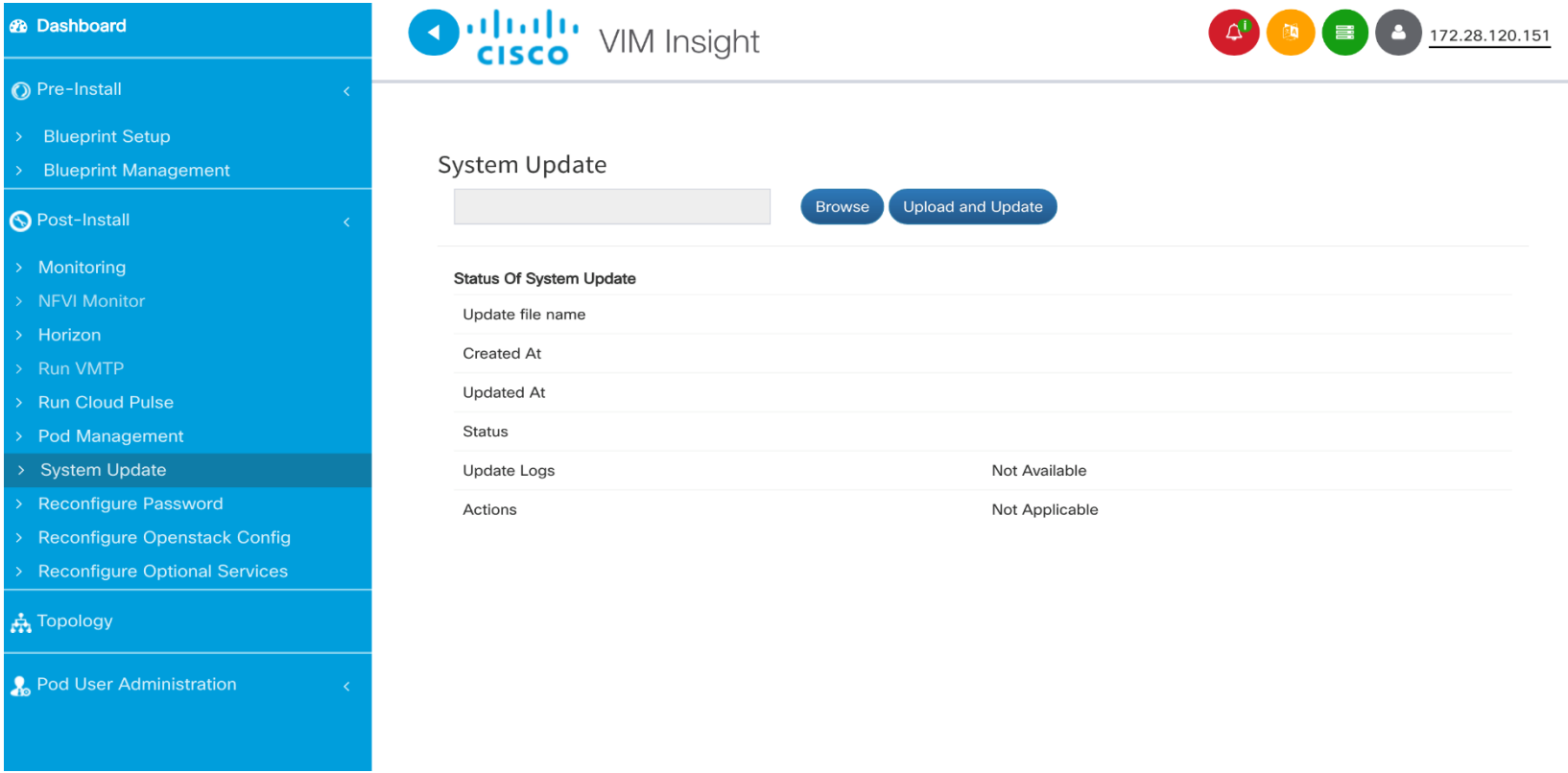
Unified Management – CloudPulse



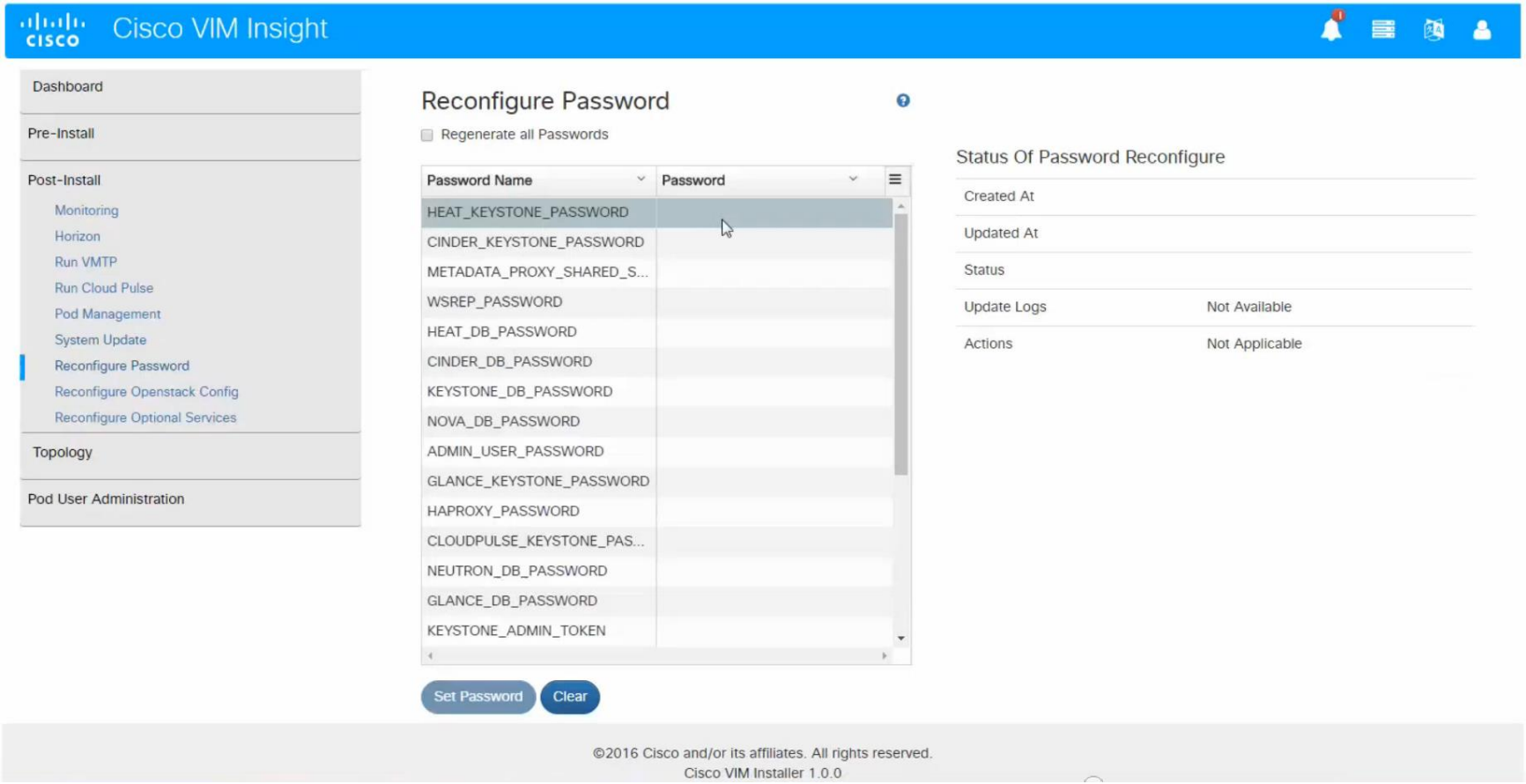
Unified Management – Pod Management



Unified Management – SW Updates

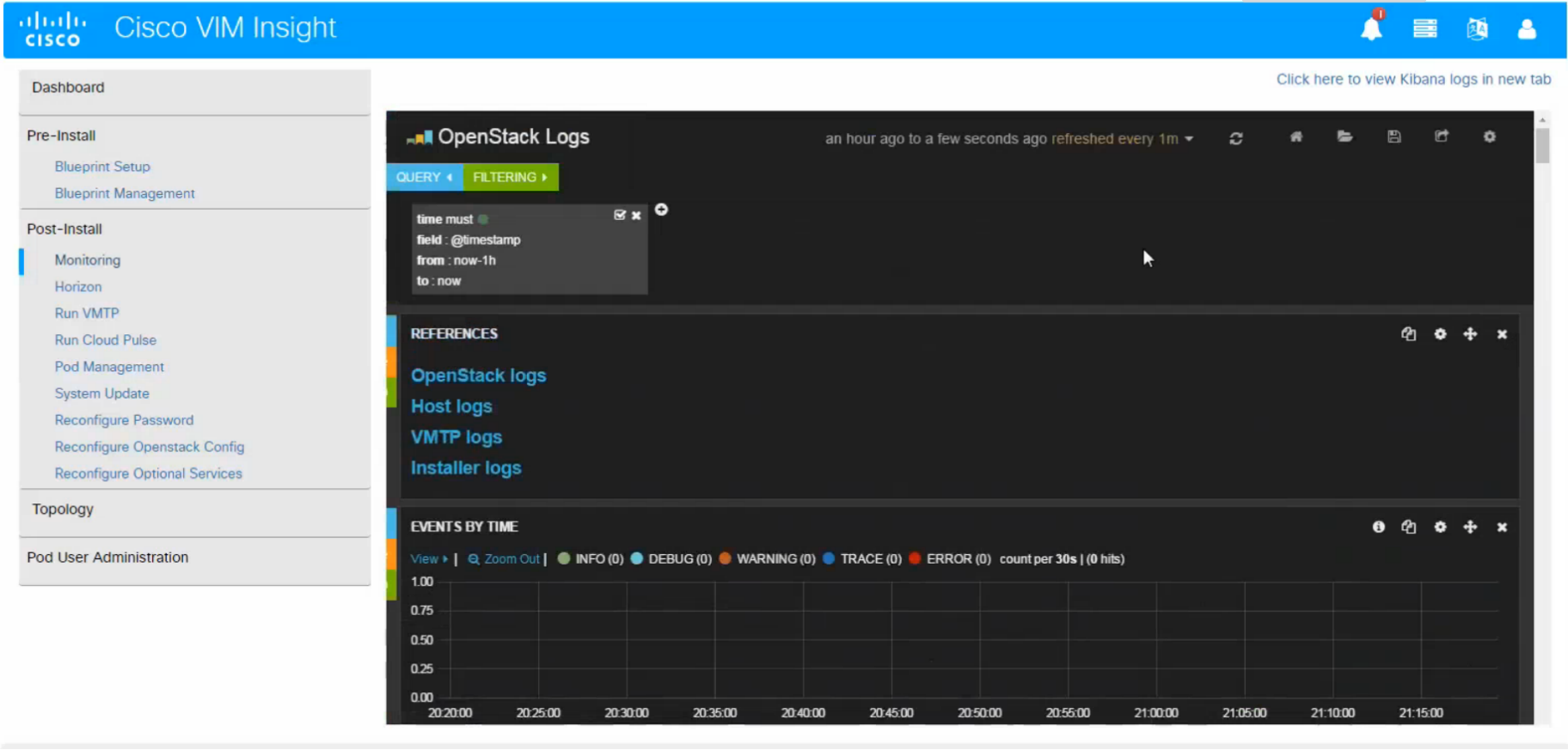


Password Management



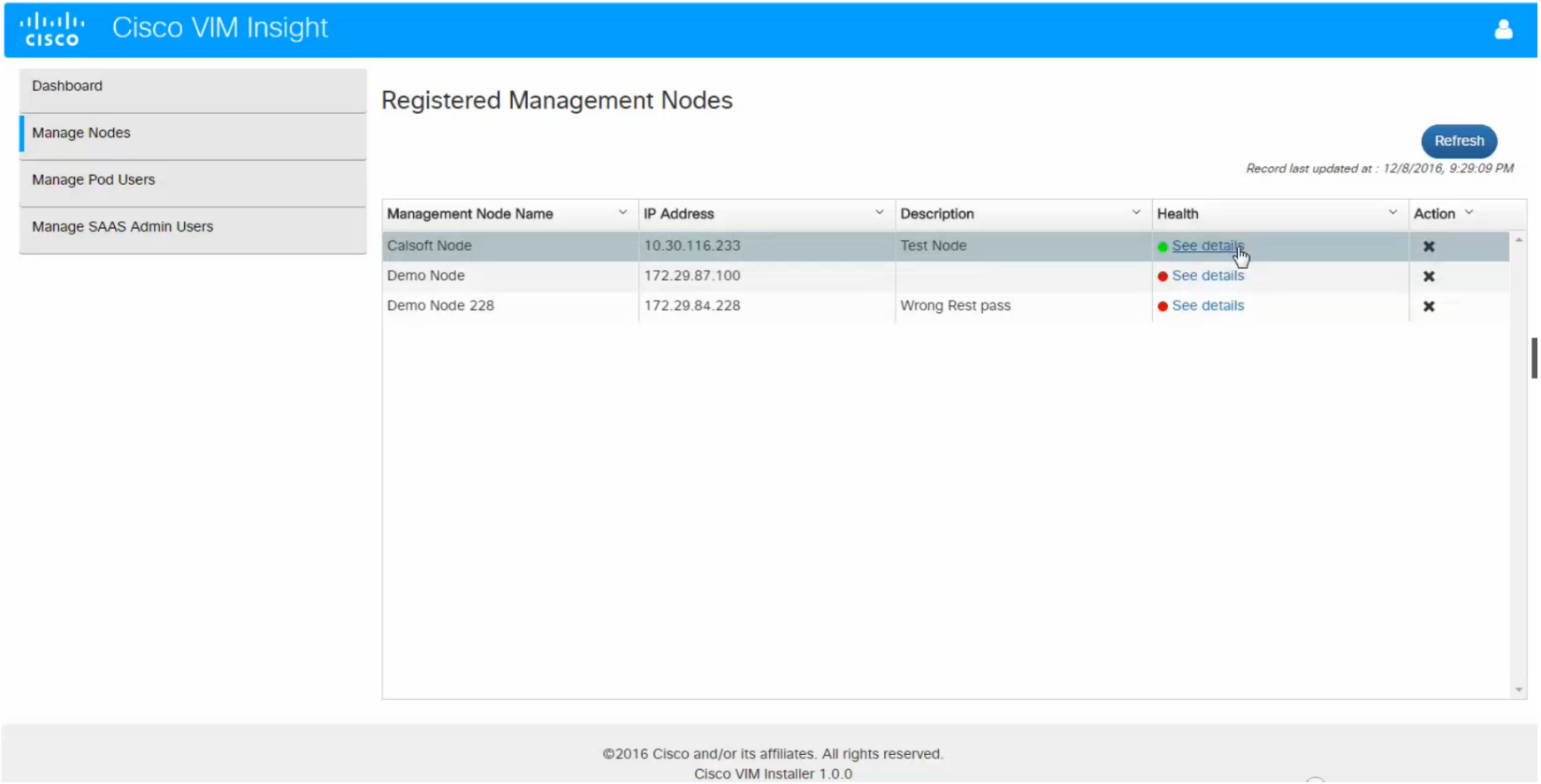
Logging Visualization

Verifications/
Monitoring/
Operations



Multi-Pod Management

Multi-Site, Multi-POD with RBAC



Monitoring & Assurance

Monitoring & Assurance with Zenoss

Monitoring

- Health and performance monitoring – physical and logical
- POD level view of components, Physical to Virtual Co-relation
- Ability to monitor multiple NFVI pods

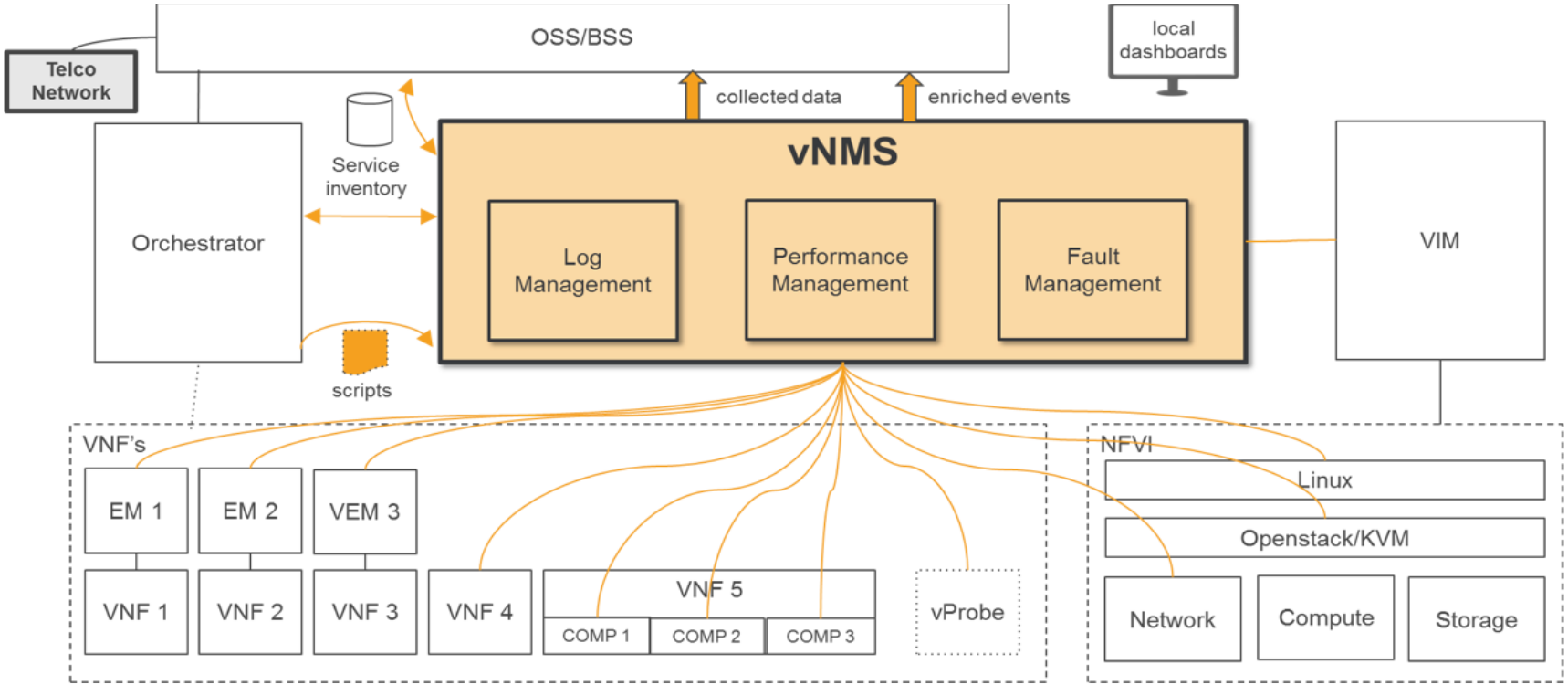
Analysis and Reporting

- Service Impact Analysis – Creates accurate models of services and their dependencies on application infrastructure
- POD capacity forecast – Alert ahead of time
- Generate reports – Device, Performance, Cisco UCS, NFVI reports

Automation

- Automate discovery and modeling – POD changes
- Automatically checks POD level health
- Integrated with CVIM installation (optional)

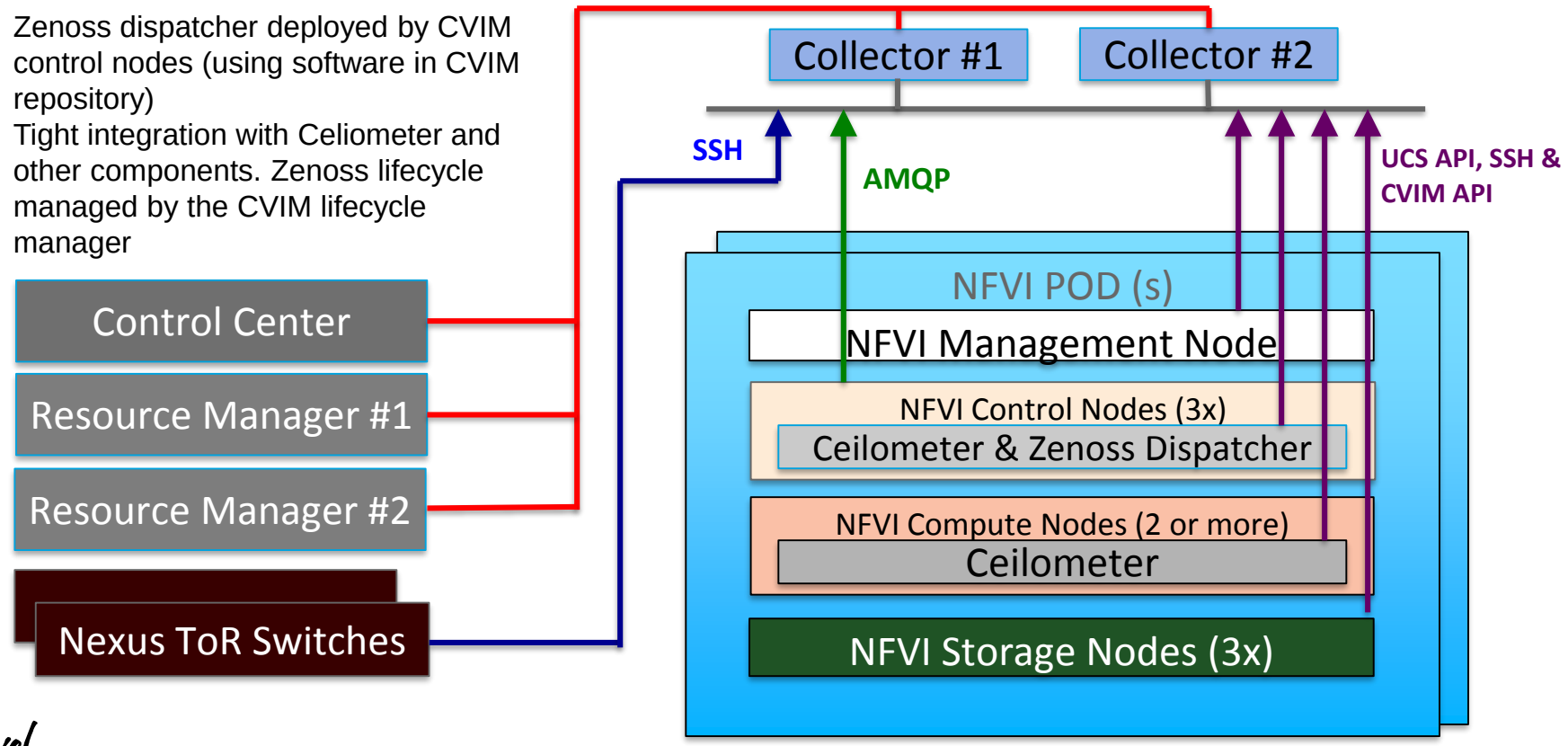
NFV Assurance Integration Points



vNMS : Virtual Network Monitoring System

Cisco VIM Integration with Zenoss

- Zenoss dispatcher deployed by CVIM control nodes (using software in CVIM repository)
- Tight integration with Celiometer and other components. Zenoss lifecycle managed by the CVIM lifecycle manager



SDN Integrations

Cisco VIM Integration with Cisco ACI

Cisco VIM 2.2 – ACI Integration

Cisco VIM 2.2 integrates ACI using OpFlex ML2 plugin to provide the market leading SDN solution for Cisco NFVI

Integrating ACI with Cisco VIM

- Allows dynamic creation of networking constructs to be driven directly from OpenStack requirements
- Provides additional visibility within the ACI APIC down to the level of the individual virtual machine (VM) instance

Cisco VIM 2.2 deploys ACI OpFlex plugin in "Unified" mode with ML2:

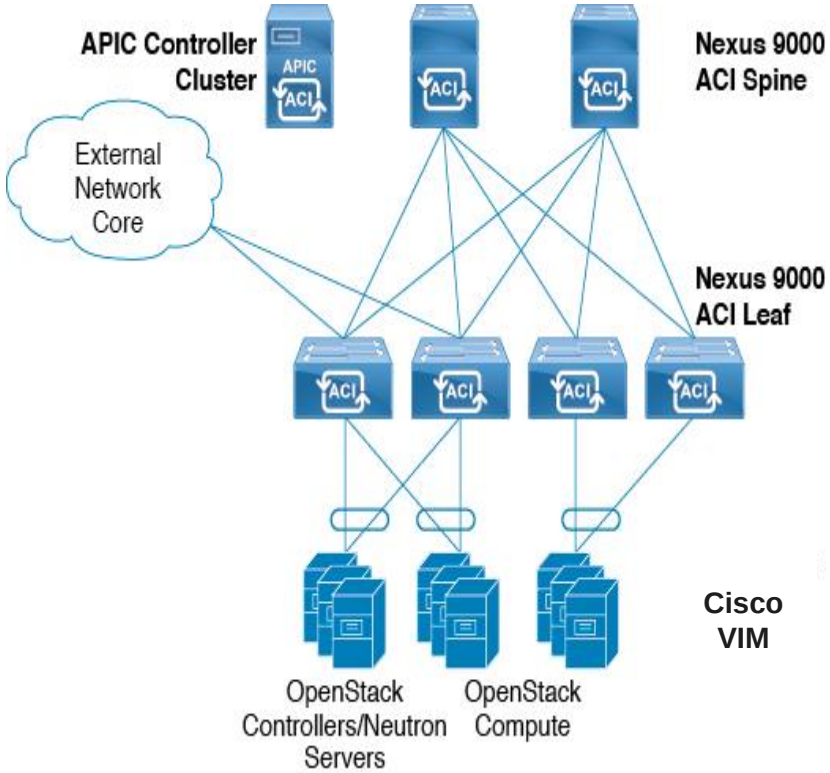
- Modular Layer 2 (ML2) mode – Standard Neutron API is used to create networks

Future: Group Based Policy (GBP) mode – New API is provided to describe, create and deploy applications as policy groups

Cisco VIM with ACI – Architecture

A typical architecture of ACI fabric with Cisco VIM deployment consists of

- Nexus 9000 Spine/Leaf topology
- APIC cluster
- Cisco VIM Pod – Controller, Compute and Storage Servers
- An ACI External Routed Network connection



Cisco VIM with ACI architecture

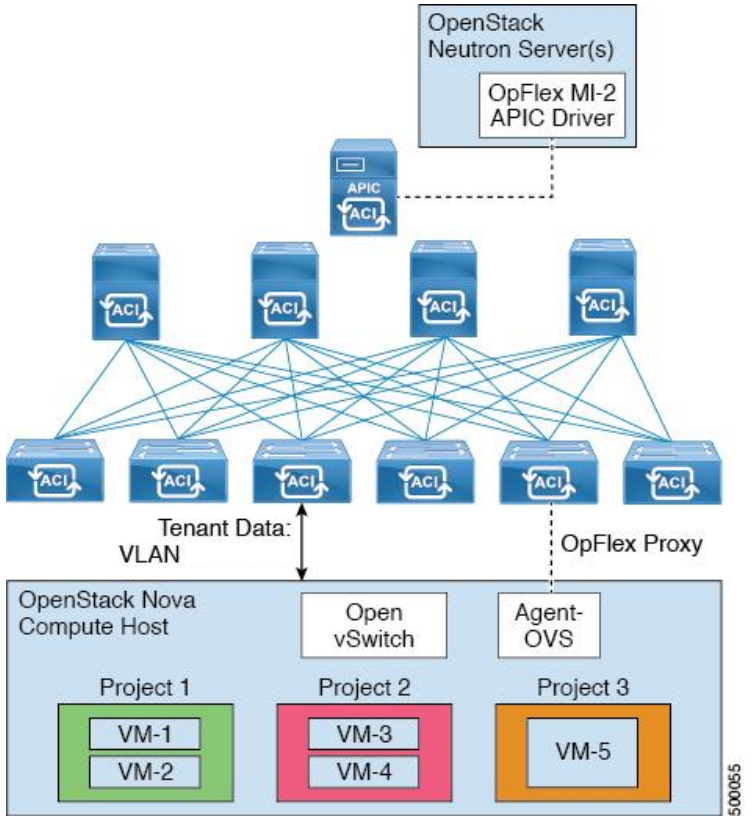
OpFlex ML2

OpFlex ML2 APIC Driver for integration into Neutron runs on the Control nodes

- Translates Neutron networking elements such as a network, subnet or router into APIC constructs within the ACI Policy Model

An OpFlex proxy runs on the ACI leaf switch

- Exchanges policy information with the Agent-OVS instance extending the ACI switch fabric and policy model into the virtual switch



ACI Integration in Cisco VIM 2.2

Cisco VIM 2.2 ACI Integration Features

- Containerized deployment of APIC services
- Fully Automated Day 0 APIC configuration
  - VLAN Pools, AEP, Physical Domain for bare metal hosts, Intf policy for LACP, PC and VPC, Network VRF and BDs, EPGs, Associate EPGs to Phys domains and AEPs
- Dynamic provisioning of provider and tenant networks
- Hardware Supported – UCS C-Series with Cisco VIC
- Virtual switch and Tenant encapsulation – OVS and VLAN
- Reconfigure option to scale up/down ACI Fabric (Leaf nodes)
- Fully supported in CVIM Unified Management GUI

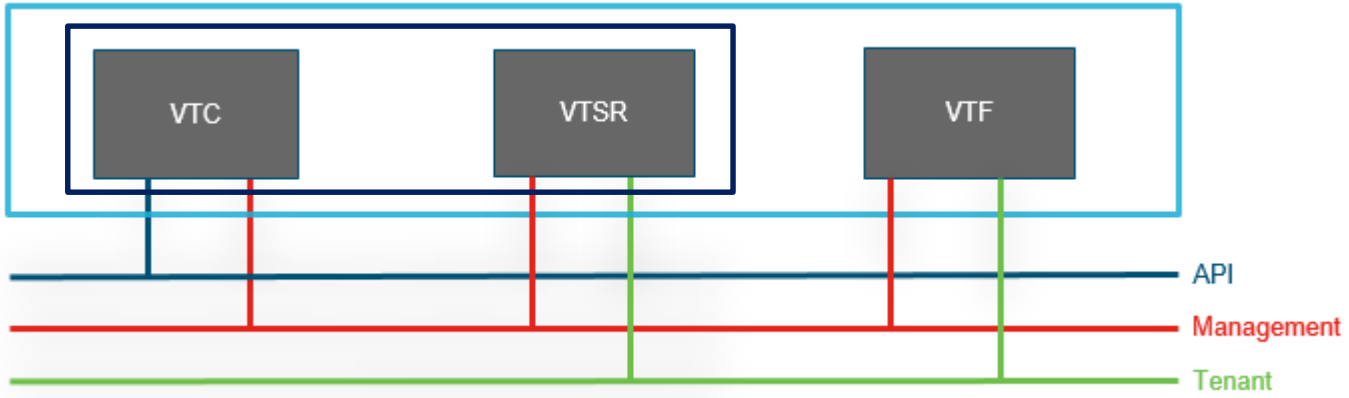
Scale Optimizations – ACI integration

In Cisco VIM 2.2 ACI Unified Plugin for OpenStack enables optimized functions for Local Layer 3 functions

- DHCP optimization with Distributed DHCP
  - The Discovery, Offer, Response, and Acknowledgement (DORA) functions that interact with the VM instances is kept local to each compute node
- Distributed Metadata on compute nodes
  - OpenStack VM's can receive instance-specific information such as instance-id, hostnames, and SSH keys from the Nova Metadata Service
- Distributed NAT
  - Distributes Source NAT and Floating IP functions for OpenStack to the Open vSwitch of the compute nodes

Cisco VIM Integration with Cisco VTS

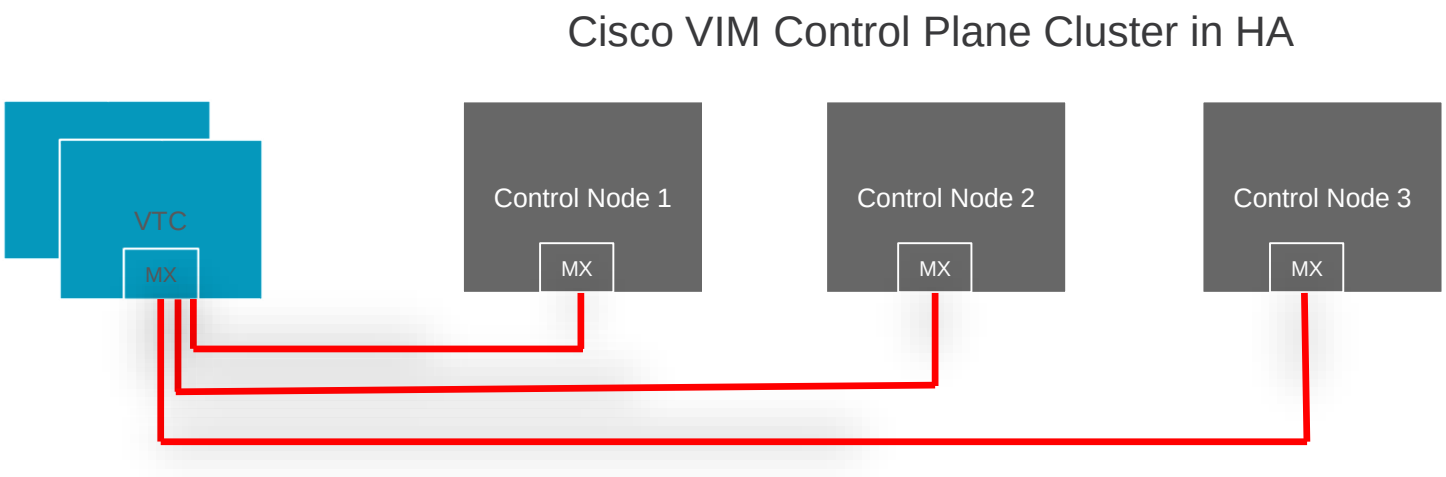
Cisco VIM – VTS Integration



- Pre-requisites for VTS Integration with Cisco VIM
  - VTC (Controller) is installed in HA mode on two external servers
  - VTSR is the BGP control-plane running in HA mode
  - VTSR script to configure loopback interface and BGP-ASN

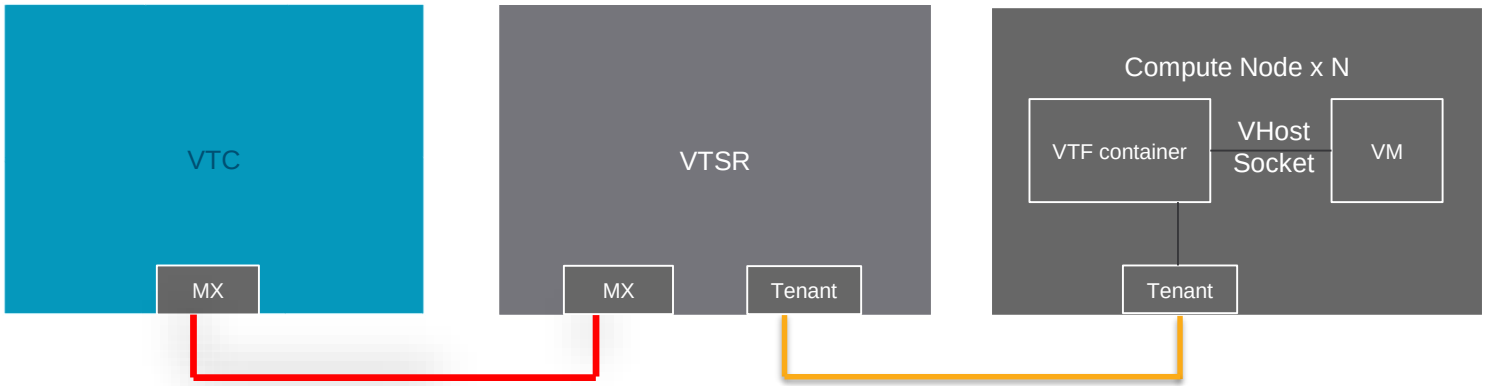
Cisco VIM – VTS Control Components

- Cisco VIM will install VTS plugin on all 3 control nodes
- Control node will send network information to VTC over MX network



Cisco VIM – VTF VHOST Forwarder

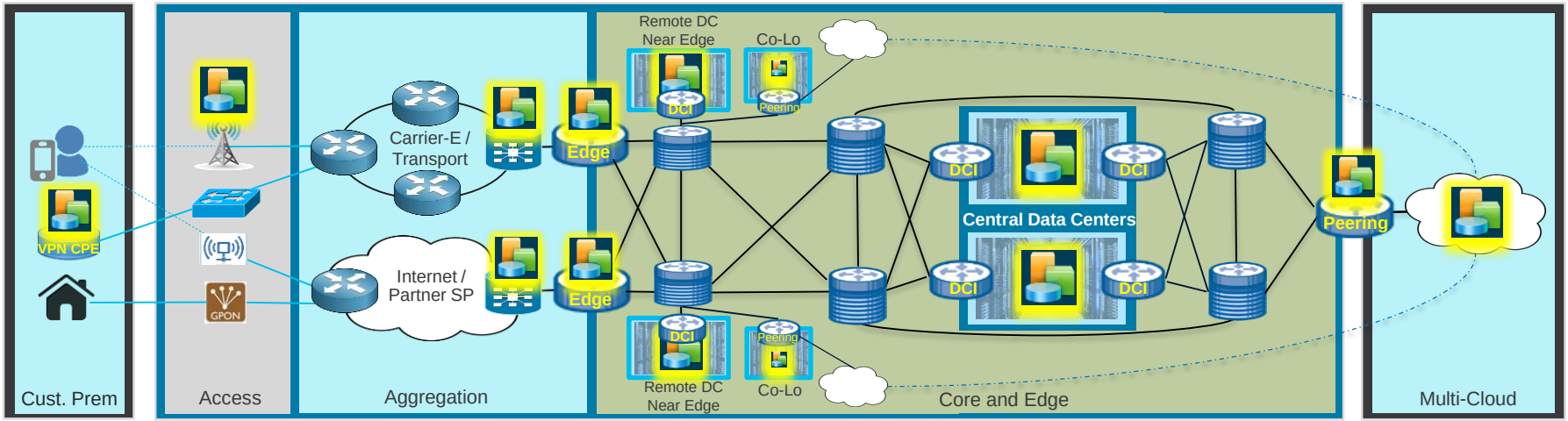
- Cisco VIM will install VTF VHOST on all compute and control nodes
- VTSR control plane will use tenant network to program VTF vswitch



Where are we headed?

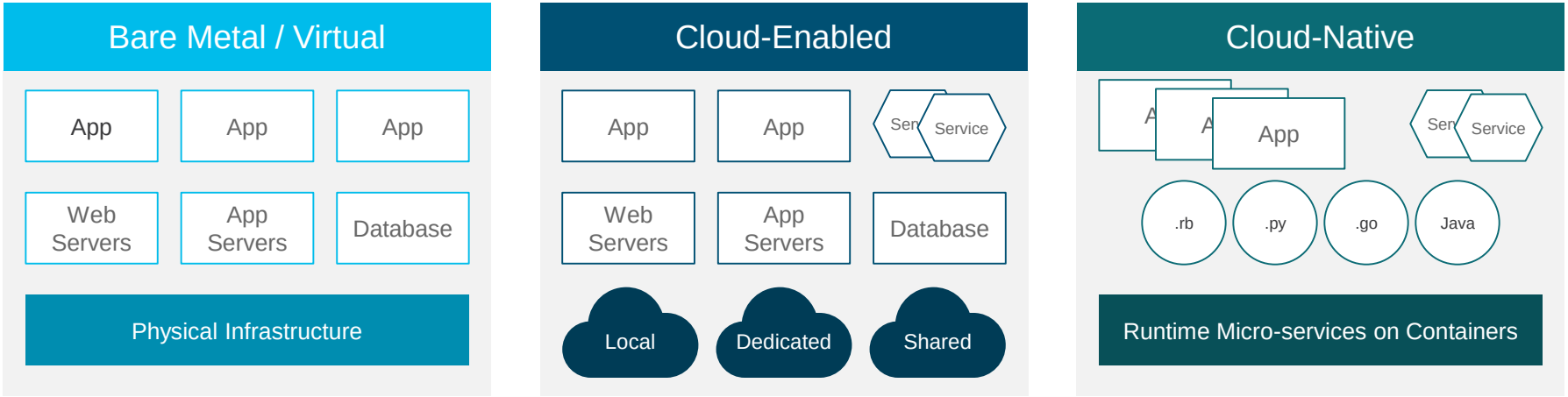
Distributed NFV with Edge Cloud & CO Transformation

Cust Prem	Access	CO	Remote DCs	Central DCs	Co-Lo / Peering	Cloud Hosted
vBranch, Analytics	Nothing is seen today…	vBNG, vOLT, vCMTS, vPE Biz Services (vMS), vRAN, vCDN, Analytics	VPC, SecGW, vIMS, vManaged Service, Media xCoding, cDVR, vPE, vBNG, vCMTS, vCDN, Analytics	VPC, Gi-LAN, vIMS, Biz Services (vMS), Media xCoding, cDVR, vCDN, Virtualized RR, Analytics	vMS, vCDN, vDDoS, Analytics	XaaS delivered from the Multi-Cloud
	MEC, VPC & Fog Apps	VPC & vCDN, Cloud RAN, AR/VR, IOT, Fog, location based services, Data Analytics	IOT / Fog Computing, Online Gaming, Location based Services, AR/VR, Data Analytics			



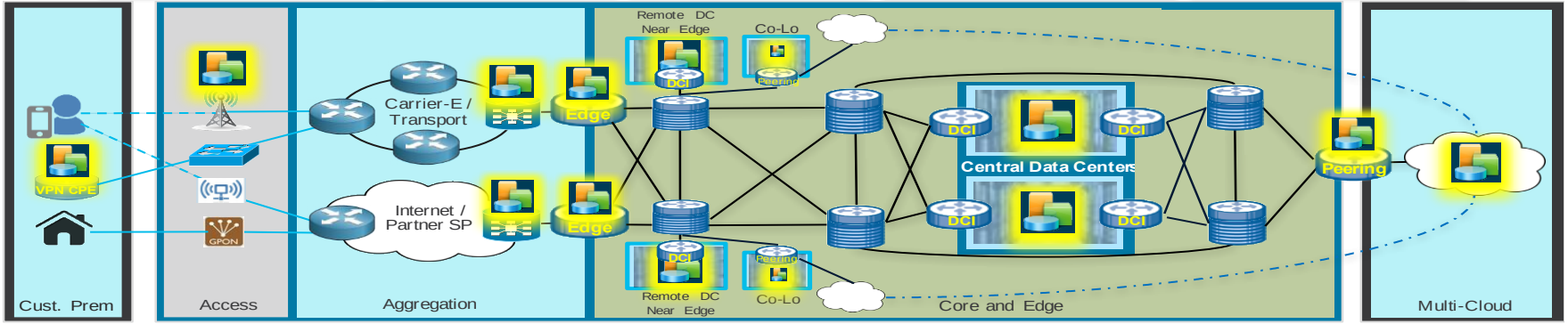
Evolution of Workloads

Application requirements changing: Cloud Native, Micro-services, Containers



Towards a Cloud Native Common Virtualization Platform

Edge Compute Latency sensitive apps (MEC, IoT, Edge Analytics)	>10s of Virtual Workloads, Production Services	>100s of Virtual workloads, Production services	>1,000s of Virtual workloads Production & Backend services	>100s of Virtual workloads Production services




Nano


Micro


Rack(s)


Multi-Rack


½ or Full Rack

Modular Cloud Orchestration Software Stack

OPENSHIFT | kubernetes | docker | KVM | openstack | BM

High Performance, Automation, Day 0 – N Lifecycle Management, HA, Consistent Networking Models, Logging, Assurance, Security

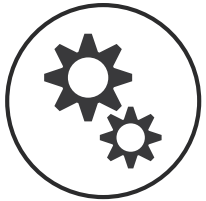
Cisco NFVI Powered by Cisco VIM

Carrier Grade NFVI Solution

Multi-Use Case Capable, Cisco & 3rd Party

Open source and standards compliant

Ease of Use with Simplified Manageability



Single Point of Accountability & Ownership

Carrier Grade Performance, HA, Scale & Security

Joint Engineering & Innovation with Partners

Integrated platform sold and supported by Cisco, powered by Intel, fully backed by Red Hat

Evolution to Cloud Native SP Virtualization solution with seamless integration with WAN to drive true realization of NFV

Complemented with best in class MANO and Industry's Broadest VNF Portfolio

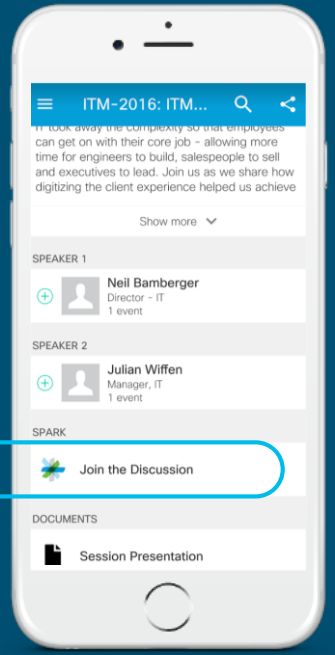
Cisco Spark

Questions?

Use Cisco Spark to communicate with the speaker after the session

How

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

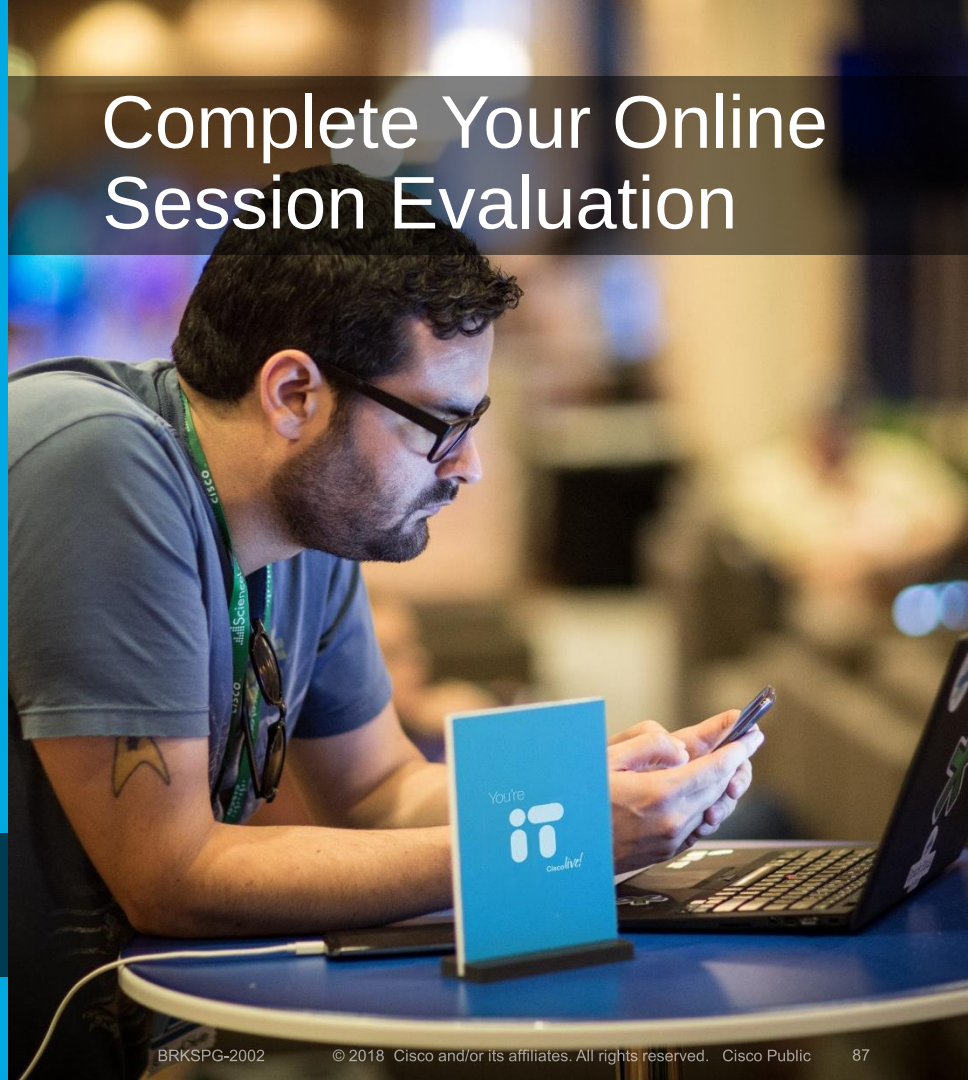


cs.co/ciscolivebot#BRKSPG-2002

Complete Your Online Session Evaluation

- Please complete your Online Session Evaluations after each session
- Complete 4 Session Evaluations & the Overall Conference Evaluation (available from Thursday) to receive your Cisco Live T-shirt
- All surveys can be completed via the Cisco Live Mobile App or the Communication Stations

Don’t forget: Cisco Live sessions will be available for viewing on-demand after the event at www.ciscolive.com/global/on-demand-library/.



Continue Your Education

- Demos in the Cisco campus
- Walk-in Self-Paced Labs
- Tech Circle
- Meet the Engineer 1:1 meetings
- Related sessions

Continue Your Education

- Demos in the Cisco campus
- Walk-in Self-Paced Labs
- Tech Circle
- Meet the Engineer 1:1 meetings
- Related sessions

Thank you


You're
Cisco live!