Advances in Service Provider Architectures

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April 16, 2014

Agenda

- Key SP Industry Trends and Initiatives
- Factors behind the SP SDN Evolution
- Cisco Service Provider Strategy
  - APIs/Protocols
  - Simplification and Automation
  - NFV
- Solutions
  - WAN Controller
  - Virtualized Network Services
  - CML
- Summary

House Keeping Notes – Wednesday April 16, 2014

Thank you for attending Cisco Connect Toronto 2014, here are a few housekeeping notes to ensure we all enjoy the session today.

- Please ensure your cellphones are set on silent to ensure no one is disturbed during the session
- Please hold all questions until the end of these session to ensure all material is covered

Complete Your Paper Session Evaluation – Wednesday April 16

Give us your feedback and you could win 1 of 2 fabulous prizes in a random draw.

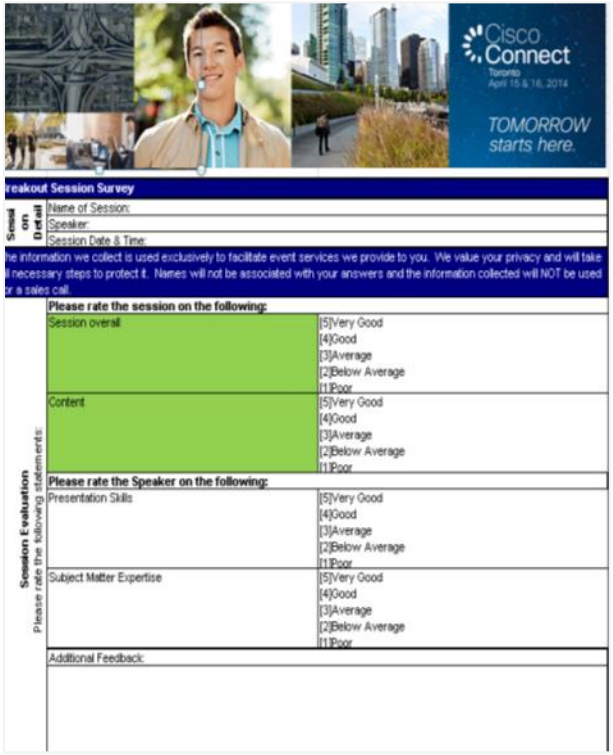
Complete and return your paper evaluation form to the Room Attendant at the end of the session.

Winners will be announced today at the end of the session. *You must be present to win!*

Please visit the Concierge desk to pick up your prize redemption slip.

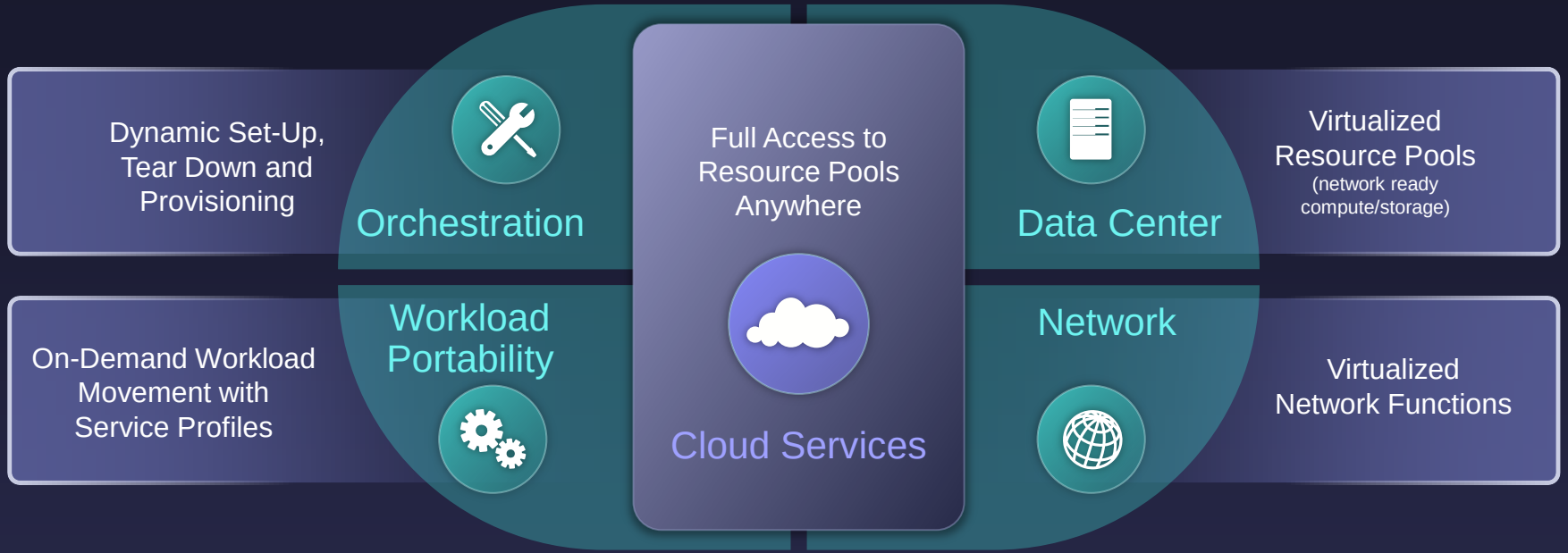
plantronics

Visit them at BOOTH# 407



The Mission: Service Provider Business Transformation

Cost Reduction and Agility Delivers Profits



AUTOMATION, VIRTUALIZATION AND ORCHESTRATION ARE REQUIRED

Service Provide Partner Examples: TCO and Service Velocity

"Supplier Domain Program 2.0. Transformative initiative. Utilizing NFV and SDN. With these advances, AT&T plans to increase the value of its network by: **Driving improved time-to-revenue**; Providing cost-performance leadership; Enabling new growth services and apps; Ensuring world-class, industry leading security, performance and reliability; and Facilitating new business and revenue models."

"**Faster time to market**, Elasticity, Redundancy, Independence from hardware" says Axel Clauberg, VP/CTO Deutsche Telekom

"To deploy router, security, voice, it take **3 truck rolls – not sustainable**" says Verizon executive

"The main promise of NFV is to benefit from commodity pricing of IT hardware, reduced power consumption and moving to a much **faster service delivery** method based on downloading software appliances as opposed to installing new hardware appliances," says Paul Veitch, chief network strategist at British Telecom"

Key SP Industry Initiatives (1)

SDN, OpenFlow, Open Daylight

"…In the SDN architecture, the **control and data planes** are decoupled, network intelligence and state are **logically centralized**, and the underlying **network infrastructure is abstracted** from the applications…"

https://www.opennetworking.org/images/stories/downloads/white-papers/wp-sdn-newnorm.pdf

"Open protocol that specifies **interactions between de-coupled control and data planes**……..open standard that enables researchers to run experimental protocols in campus networks. Provides standard hook for researchers to run experiments, without exposing internal working of vendor devices……"

http://www.openflow.org/wp/learnmore/

Open source project formed by industry leaders and others under the Linux Foundation. "…OpenDaylight's mission is to facilitate a **community-led, industry-supported open source framework**, including code and architecture, to accelerate and advance a **common, robust Software-Defined Networking platform**…"

http://www.opendaylight.org/

Key SP Industry Initiatives (2)

SON, Openstack, Open vSwitch

Self-Organizing Network (SON): ….Automation of some network planning, configuration and optimisation processes via the use of SON functions can help the network operator to reduce OPEX by reducing manual involvement in such tasks.

http://www.3gpp.org

Open source software for building public and private Clouds; includes **Compute (Nova)**, **Networking (Neutron)** and **Storage (Swift)** services.

http://www.openstack.org

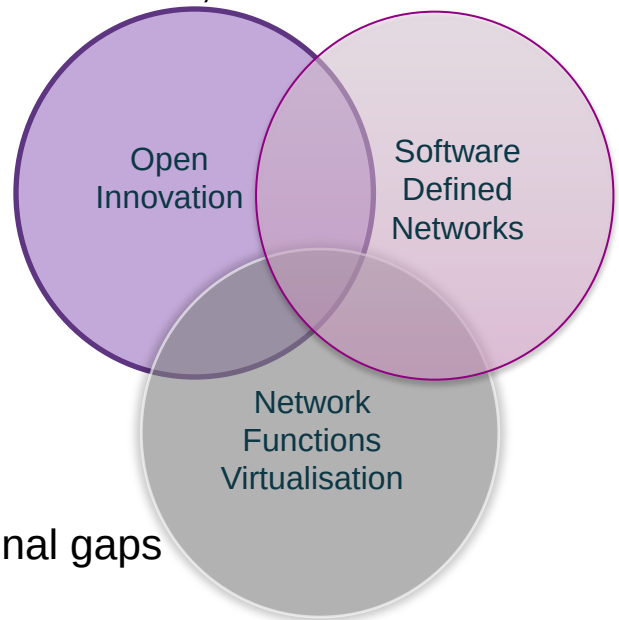
"Open vSwitch (OVS) is a production quality open source software switch designed to be used as a vswitch in **virtualized server environments**…….Open vSwitch supports standard management interfaces (e.g. sFlow, NetFlow, IPFIX, RSPAN, CLI), and is open to programmatic extension and control using **OpenFlow and the OVSDB management protocol"**

http://openvswitch.org

Key SP Industry Initiatives (3)

NFV (Network Functions Virtualisation)

- NFV Initiative
  - Initiative announced at *"SDN and OpenFlow World Congress"*, Darmstadt, Oct 2012
  - Industry Specification Group (ISG) group within ETSI
  - Initiative should be a 2 year effort from January 2013
- Use of cloud technology to support network functions
  - Management, Control and Data plane components
- Not technically related to SDN
- Role of NFV ISG
  - "Call to Arms"
  - Use cases, architecture and terminology, highlighting of functional gaps
  - Development by appropriate SDOs



Extract from "Network Functions Virtualisation – Introductory White Paper

Open & Modular Architectural Principles

Converged and Integrated Network

- De-layered, IP and Optical are one, bits over wavelengths, no L1-L2-L3 dependencies

Programmable

- Multi-levels: Device, controller, orchestration

Common End to End Orchestration

- Instantaneous self-service provisioning, excellent user experience, real-time analytics

Standards based and Open Source

- Ability for SP to innovate using open source building blocks

Physical and Virtual Elements

- Combination of virtual and physical services

Cloud-era Economics

- Service flexibility, fast innovation,agile implementation,reduced complexity, lower cost

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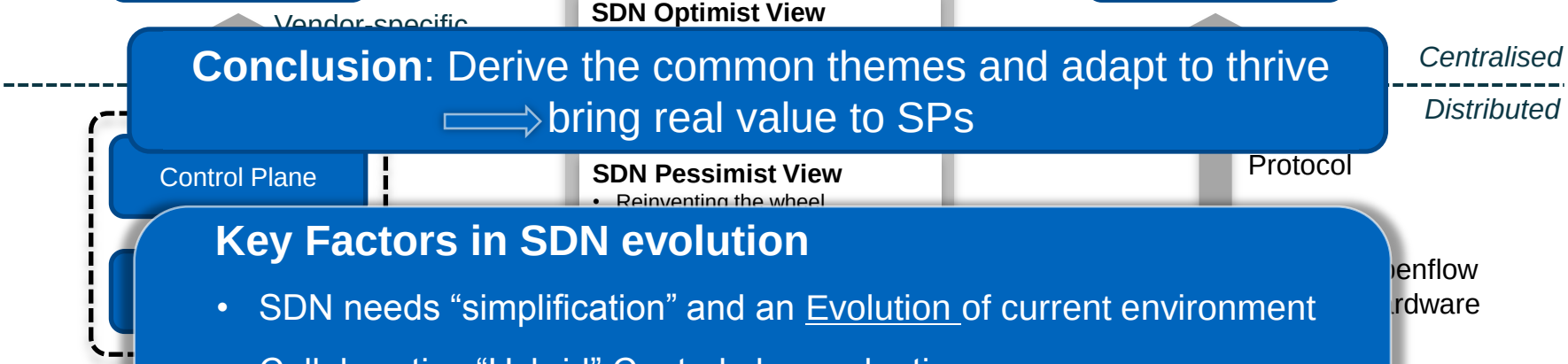
The SDN Proposal

The "purist" viewpoint

In Service Provider, formal definition of SDN will NOT meet market demands and risks being the next "Great Hype"

Conclusion: Derive the common themes and adapt to thrive ⇒ bring real value to SPs



Key Factors in SDN evolution

- SDN needs "simplification" and an Evolution of current environment
- Collaborative "Hybrid" Control plane adoption
- Abstraction layers and Programmability via API's/Protocols
- Use case driven based on SDN models

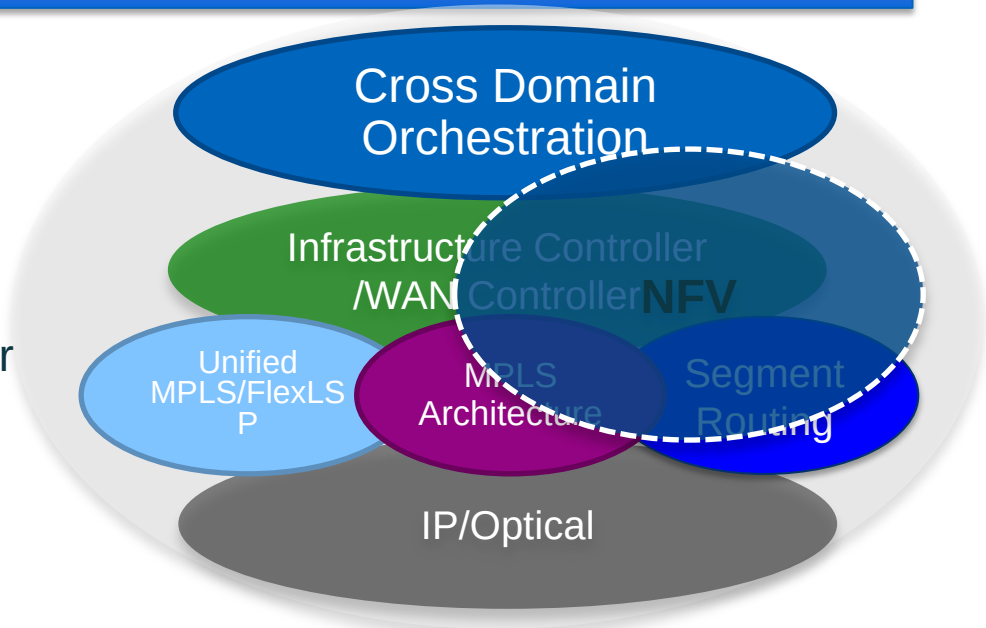
"…In t
netwo
underlying network infrastructure is abstracted from the applications…"

SDN Network Evolution

Network “simplification” with integration of Cloud and SDN techniques

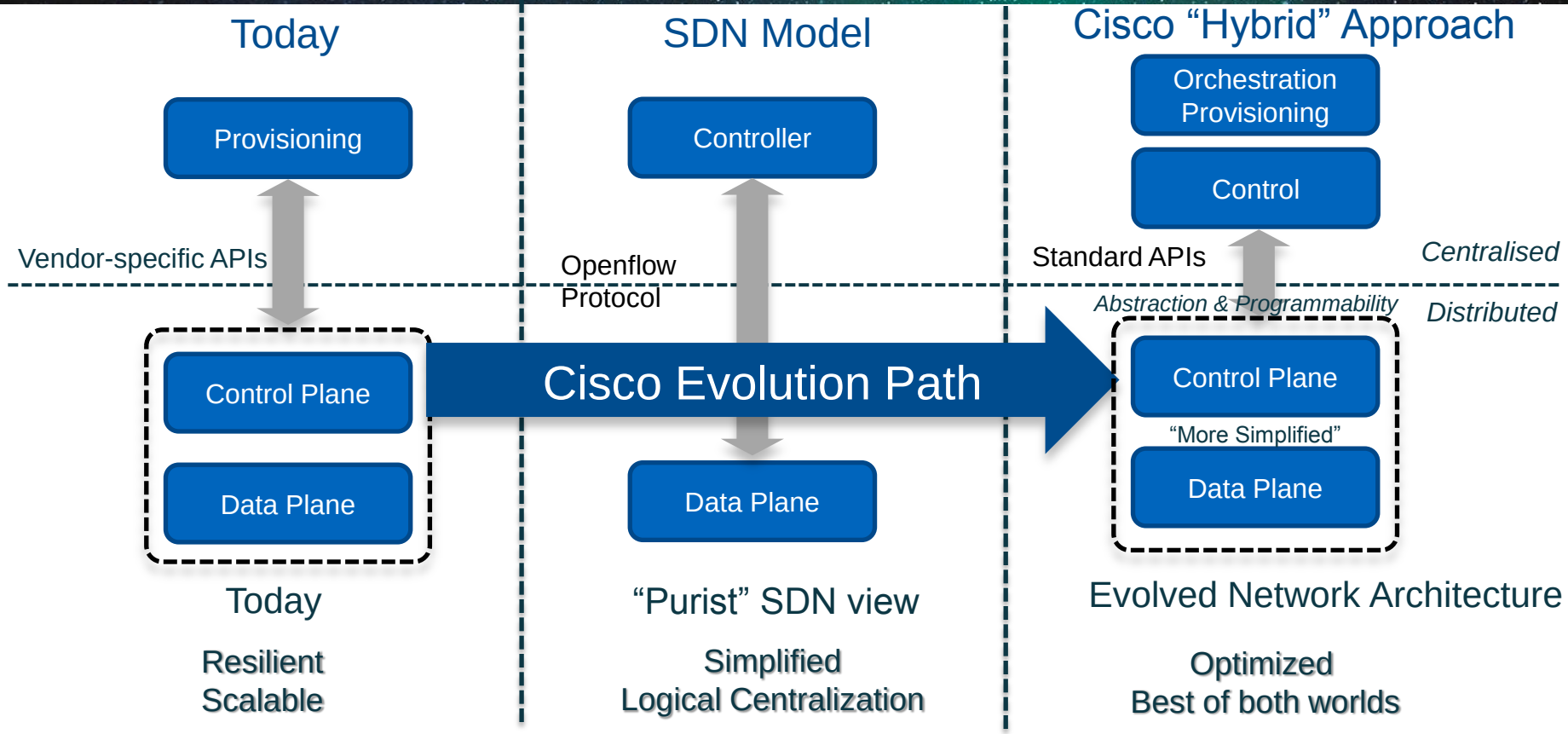
Combining Advancements from Multiple Technology Areas

- IP+Optical Multi-Layer Optimization
- Unified MPLS/Flex LSP
- Segment Routing
- Infrastructure Controller/WAN Orchestrator
- IP/MPLS and Cloud Integration/NFV (Network Functions Virtualisation)
- Cross Domain Orchestration



MPLS with SDN Technology Enablers

The Overall Cisco SP SDN Evolution Overview



Specific Requirements per Domain

Use-Case based approach

Service Providers

Network utilization

Service performance

Faster provisioning

Network Monetisation

Business Agility

Data Center / Cloud

Virtual overlays

Workload placement

Provisioning

Secure XaaS Multi-Tenancy

Academia

Partitioning

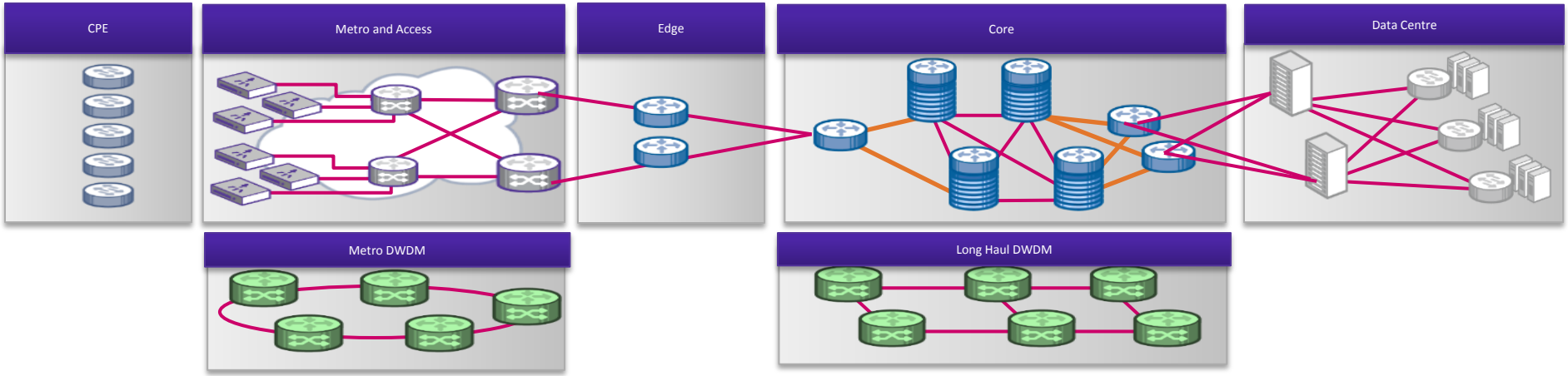
CP development

General n/w research

Experimentation

Diverse Environments
Hugely Different Requirements

Drilling into the Service Provider SDN use cases



CPE	Agg and access Infrastructure	Edge	Core Infrastructure	Data Centre
NFV	Automated set-up	NFV	Bandwidth calendaring	Virtualized n/w
Services	Analytics collections	Services	Demand engineering / PCE	Virtual 2 virtual n/w interconnect
Provisioning	Service definition	Provisioning	Single/multi layer optimization	Service chaining appliances
Analytics	Optimization	Analytics	Analytics collection	Analytics collection

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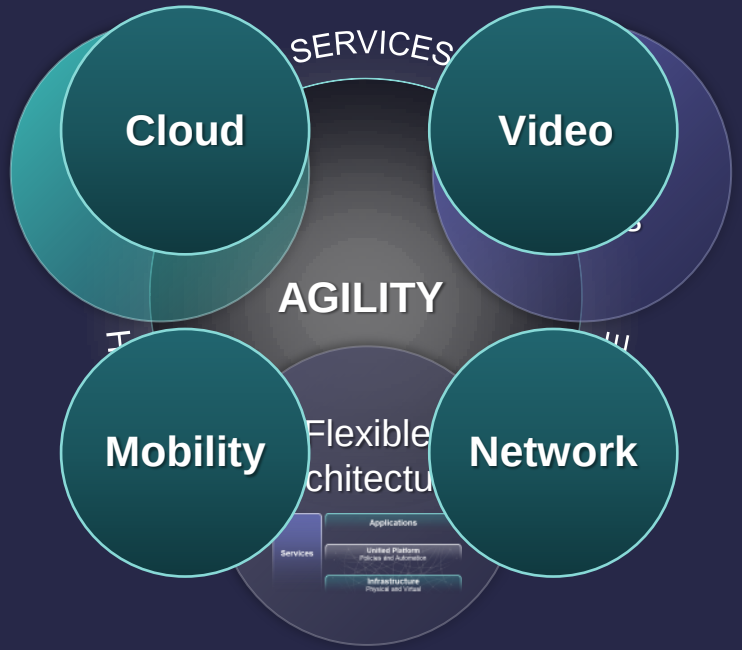
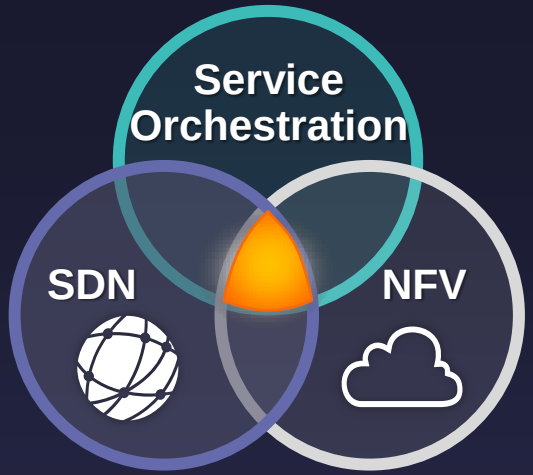
Cisco Strategy for Service Providers

- Revenue
- OpEx Reduction
- Agility



Focused on Accelerating Service Provider Revenue Growth

Towards an Automated Service Centric Platform



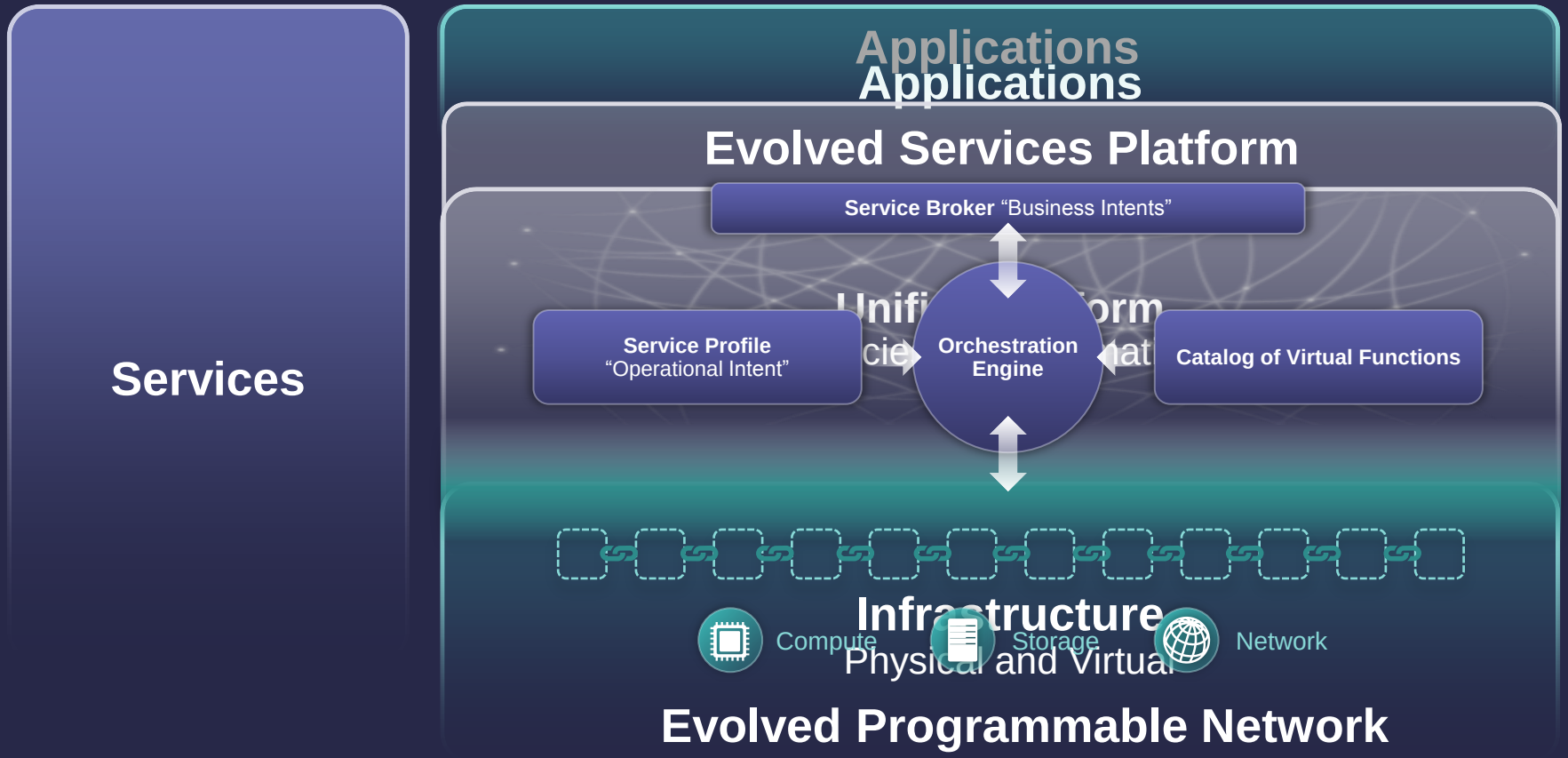
Service Orchestration
Automation, provisioning and interworking of physical and virtual resources

SDN
Separation of control & data plane for programmatic networking

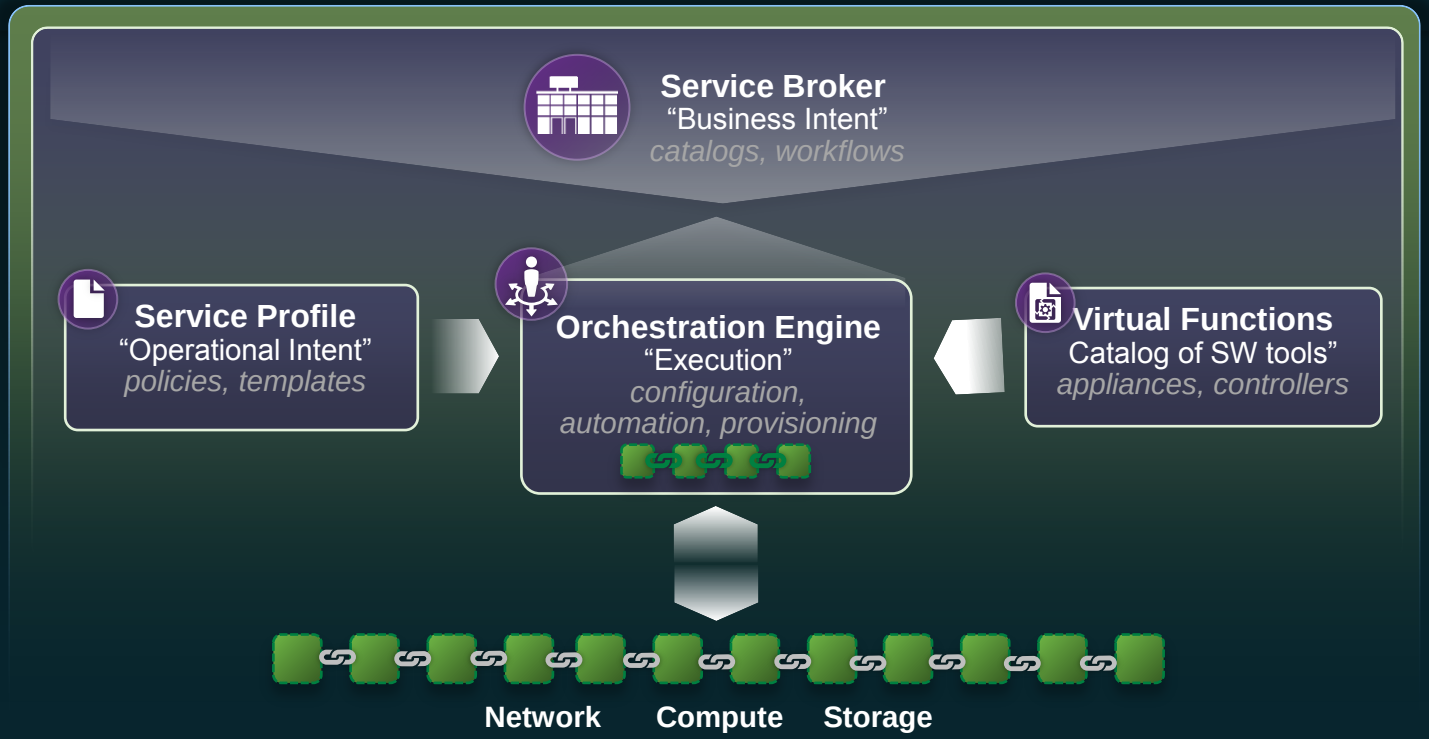
NFV
Network functions and software running on any open standards-based hardware

Cisco Is Executing on Plan to Integrate All Three

Built on Foundation of Cisco ONE SP Architecture



Cisco Evolved Services Platform



OPEN

Multi-vendor and based on open standards & API

EXTENSIBLE

Comprehensive modular capabilities spanning entire SP architecture—cloud, video, mobile and fixed

ELASTIC

Seamlessly and dynamically scale services and resources whenever and wherever needed.

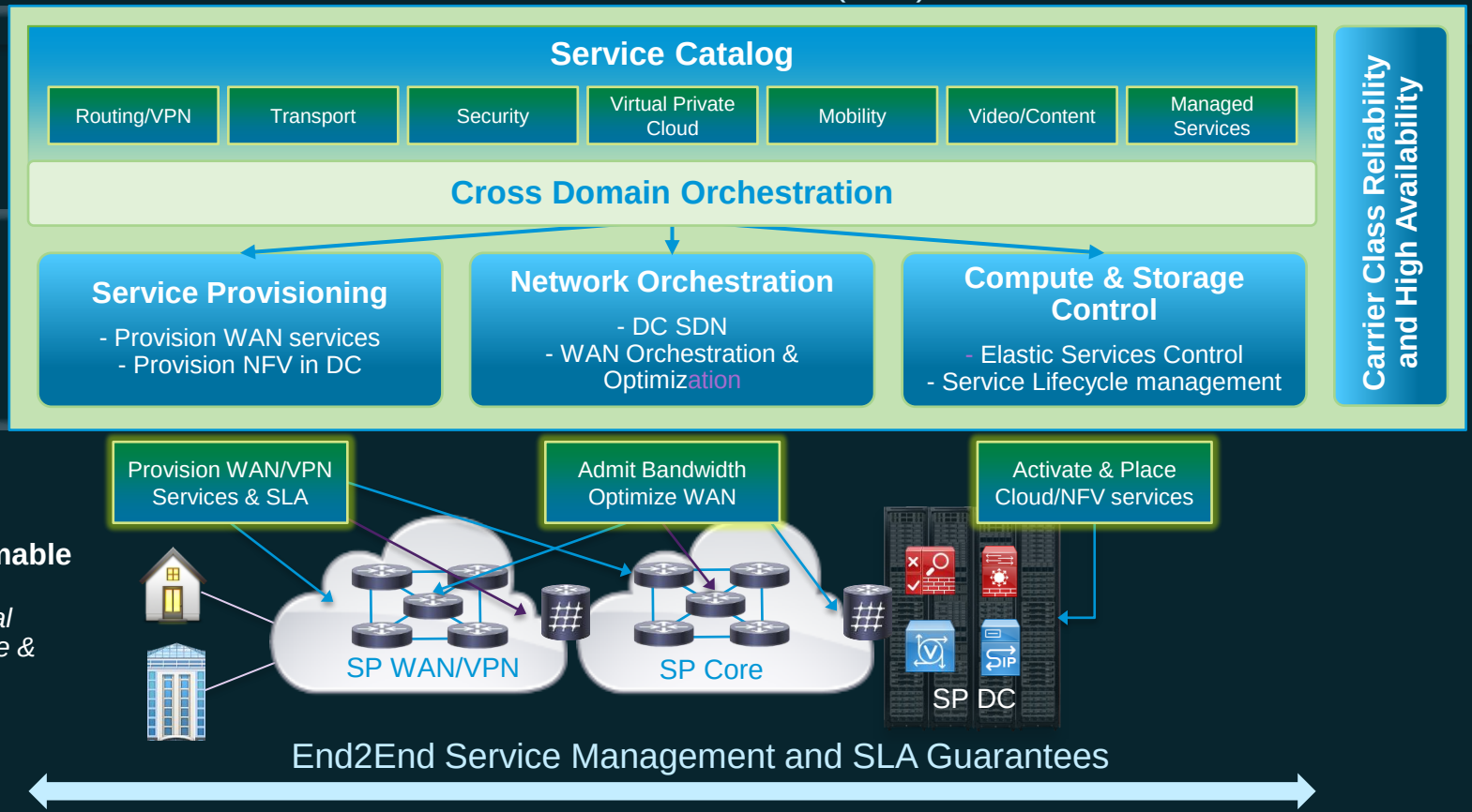
End to End Architecture for Service Orchestration

Evolved Services Platform (ESP)

"Business Intent"
Catalogs, workflows

"Execution"
configuration, Automation, provisioning

Evolved Programmable Network
Physical & Virtual Network, Compute & Storage



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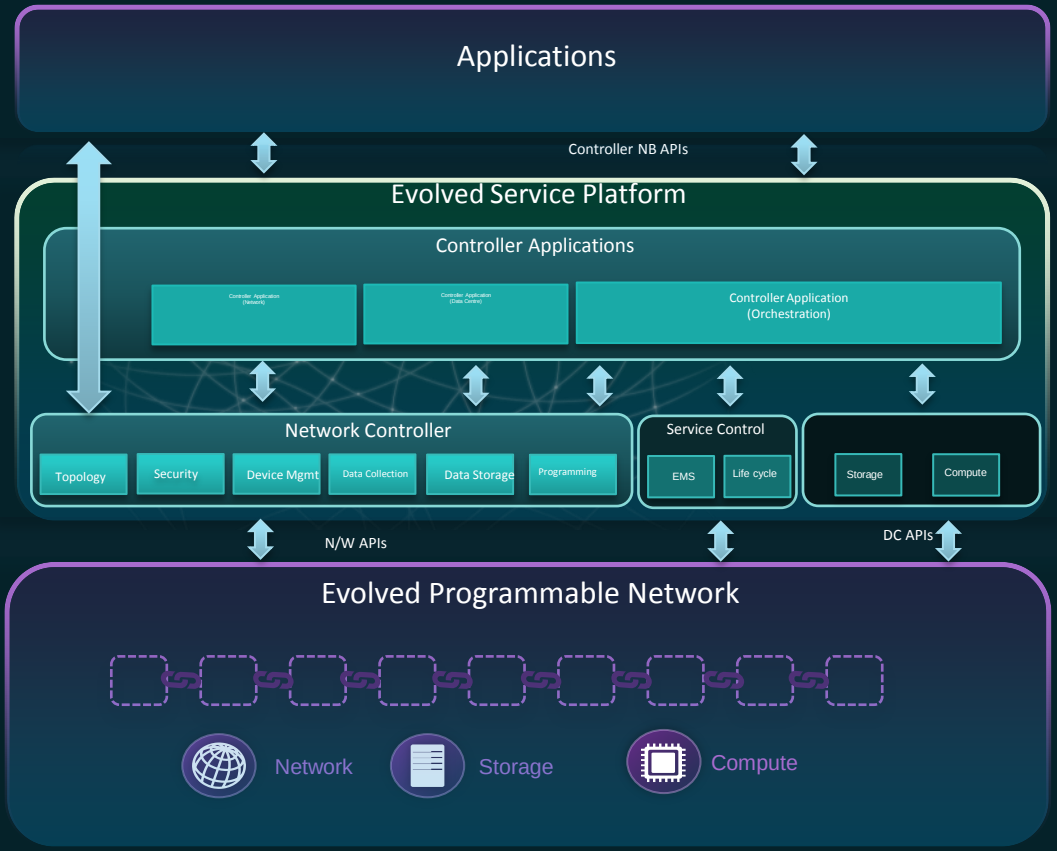
APIs – Strategic vision

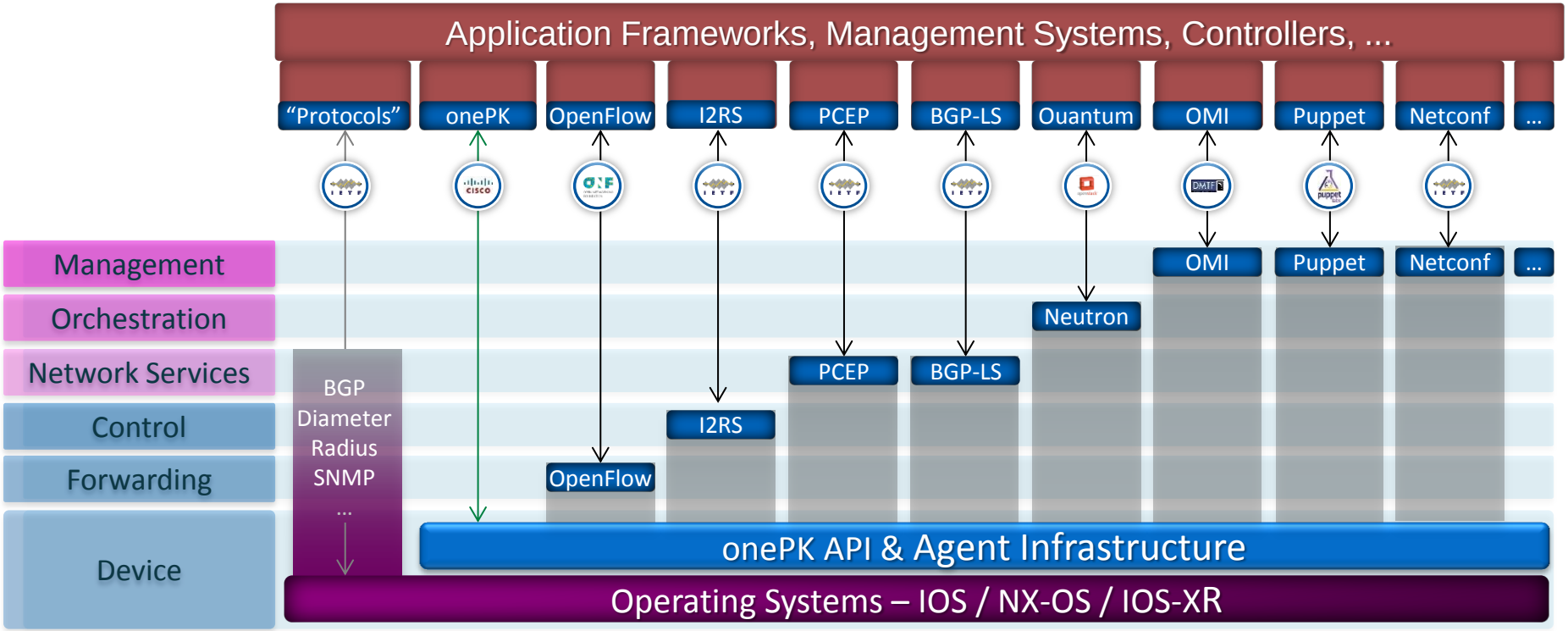
- Full duplex APIs at all levels
- Device Level APIs / protocols
  - No one API / protocol satisfies all requirements
  - Infrastructure controller platform to devices
  - Hidden from controller applications and applications
- ESP NB APIs
  - REST/JAVA based APIs
  - Auto-generated by ODL from network models
- Controller applications
  - Application specific
  - REST based APIs
  - Published open APIs



APIs and Agents
Industry Examples

Management	Workflow Management, Network Configuration & Device Models, ..	DMTF	Network Models - Interfaces (OMI)
Orchestration	L2-Segments, L3-Segments, Service-Chains Multi-Domain (WAN, LAN, DC)	openstack	OpenStack, Neutron API
Network Services	Topology, Positioning, Analytics Multi-Layer Path Control, Demand Eng.	IETF	Positioning (ALTO) Path Control (PCE)
Control	Routing, Policy, Discovery, VPN, AAA/Logging, Switching, Addressing ,	IETF	Interface to the Routing System (I2RS)
Forwarding	L2/L3 Forwarding Control, Interfaces, Tunnels, enhanced QoS, ..	ONF OPEN NETWORKING FOUNDATION	OpenFlow Protocol
Device/Transport	Device configuration, Life-Cycle Management, Monitoring, HA, ..	ETSI	Network Functions Virtualization (NFV)

APIs and Agents
Linkage to OnePK Framework



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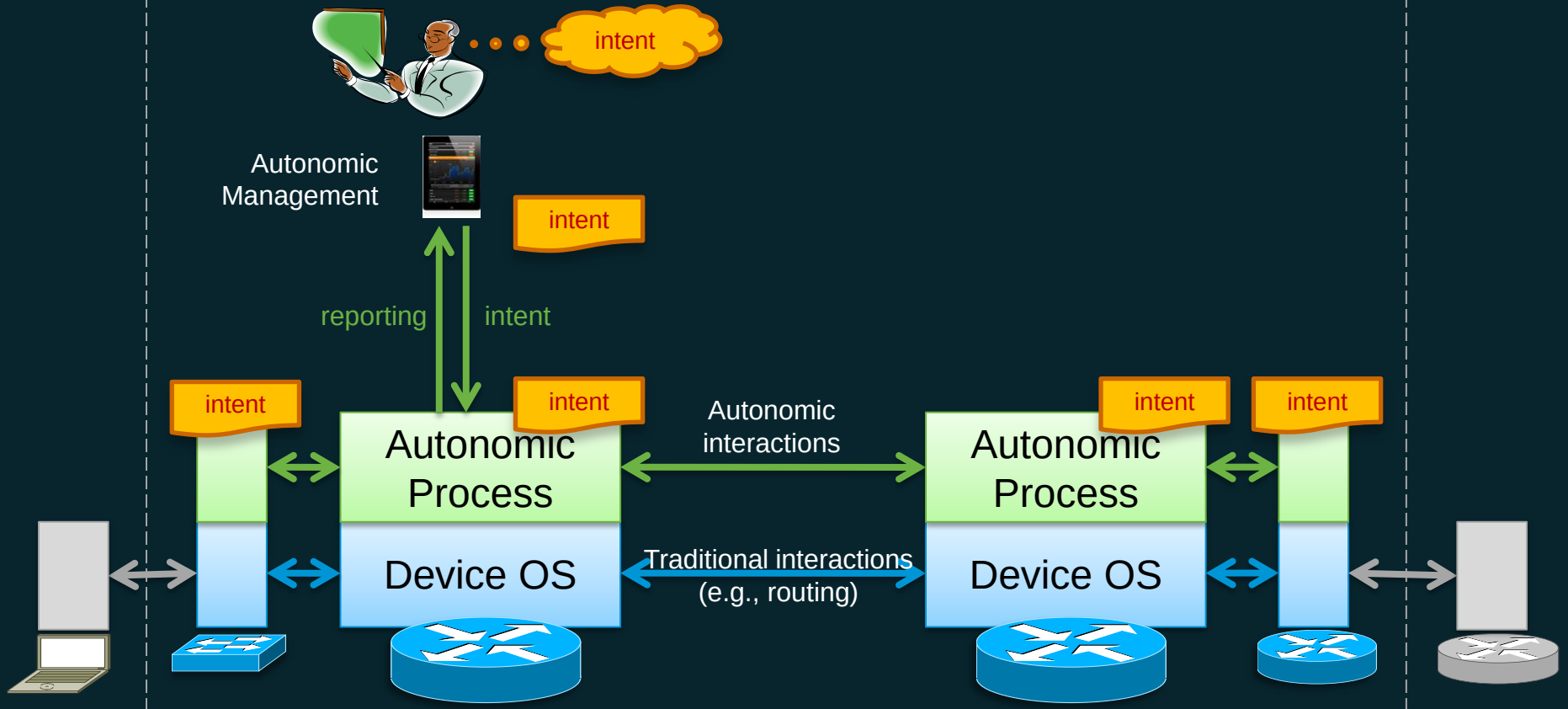
IP Optical Integration - Multi-Layer Optimization

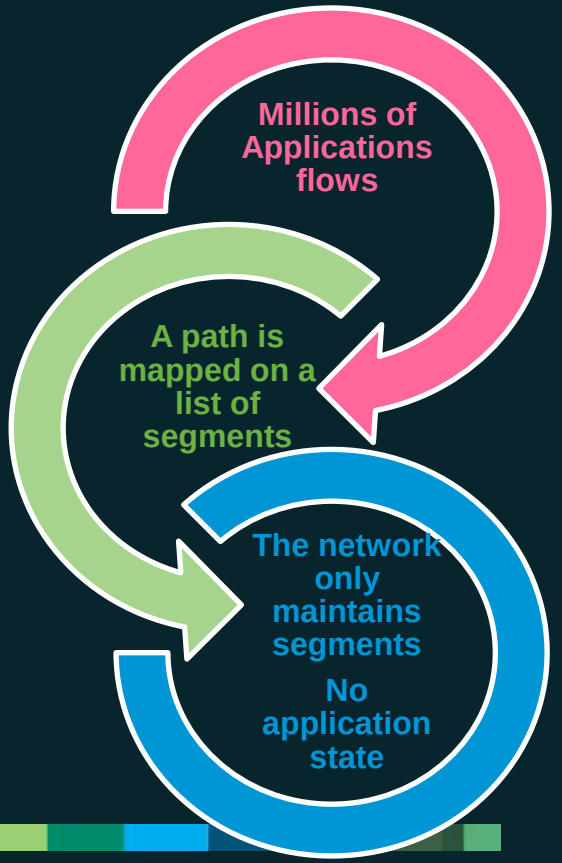
- Management and information exchange between optical and IP layers
- Dynamic optical control plane
- G-MPLS UNI between optical and IP domains
- Multi-layer optimization using Q-Wave

Simplification – Autonomics



Simplification – Segment Routing

- Application Enabled Forwarding
  - Each engineered application flow is mapped on a path
  - A path is expressed as an ordered list of segments
  - The network maintains segments
- Simple: less Protocols, less Protocol interaction, less state
  - No requirement for RSVP, LDP
- Scale: less Label Databases, less TE LSP
  - Leverage MPLS services & hardware
- Forwarding based on Labels with simple ISIS/OSPF extension
- 50msec FRR service level guarantees
- Leverage multi-services properties of MPLS



The state is no longer in the network but in the packet

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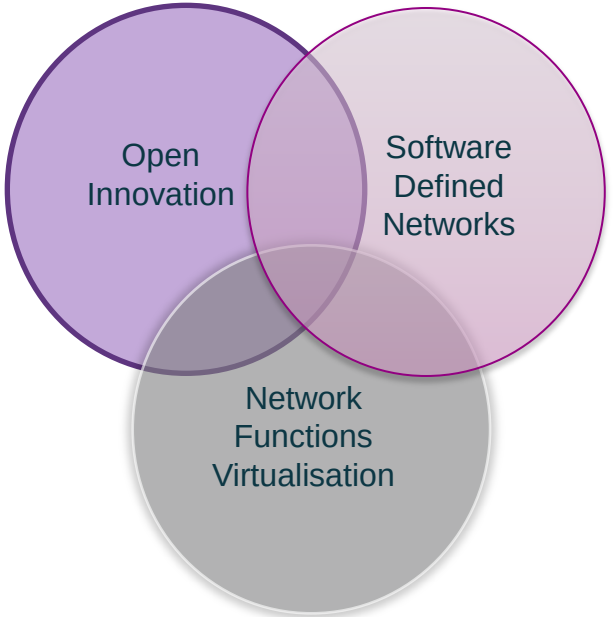
Network Functions Virtualisation

Enablers, benefits and applications

NFV = Transition of network infrastructure services to run on virtualised compute platforms – typically x86

- Enablers
  - Hypervisor and cloud computing technology
  - Improving x86 h/w performance
  - Optimised packet processing and coding techniques
  - Network industry standardising on Ethernet
  - SDN based orchestration
- Value Proposition
  - Shorter innovation cycle
  - Improved service agility
  - Reduction in CAPEX and OPEX
- ETSI based standardization



Extract from ”Network Functions Virtualisation – Introductory White Paper

Network Functions Virtualisation

Terminology

- NF: A Network Function (NF) is a building block within an operator´s network infrastructure, which has well defined external interfaces and a well defined functional behaviour. In practical terms a Network Function is today often a network node.
- VNF: A Virtual Network Function (VNF) provides exactly the same functional behaviour and interfaces as the equivalent Network Function, but is deployed in a virtualised environment.
- NFVI: The NFV-Infrastructure (NFVI) is the totality of all hardware and software components which build up the environment in which VNF are deployed, managed and executed.
- NFVO: The NFV-Orchestrator (NFVO) is a software to operate, manage and automate the distributed NFV Infrastructure. The Orchestrator has control and visibility of all VNF running inside the NFV-Infra.
- VIM: The Virtualised Infrastructure Manager manages the NFVI components and specialist VIMs are permitted (e.g. compute and n/w)

Virtual Network Function (VNF)

Evaluating the applicability of virtualization

Many network functions are suitable for virtualization but not all. Each functional component of the network needs to be evaluated

- **Physical, Environment and Functional Requirements**
  - interface count, interface size, interface type, system design requirements, specialist N/W functions
- **Performance Requirements**
  - L1-L3 packet performance, CPU processing, fabric capacity
- **Infrastructure versus Service function**
  - Will virtualization fit the network architecture principles
- **Elasticity of the service**
- **Economics and economy-of-scale**
  - Onboarding, CapEX and OpEx

Building Network Equipment

- General Purpose Processors (x86, ARM, PPC)
  - Wide range of capabilities (including packet processing)
  - Evolving multi-core capability (8+ processors per die)
  - Support virtualization and easy to program

- Fixed function ASICs
  - Integrated s/w, v efficient / inflexible

- Network Processor Units (NPUs)
  - Designed for flexible packet processing
  - Multi-threaded / h/w acceleration / integrated memory
  - Programmable in high level languages

All based on CMOS technology
All subject to Moore's Law

X86 Based Virtualization Strengths and Challenges

Strengths

- High CPU processing functions
- Low-medium packet processing
- Low physical interface counts (<20)
- Low-medium interface speeds
- Ethernet interfaces (copper 10/1000/10Gbps)
- Service functions
- Functions located in the data centre

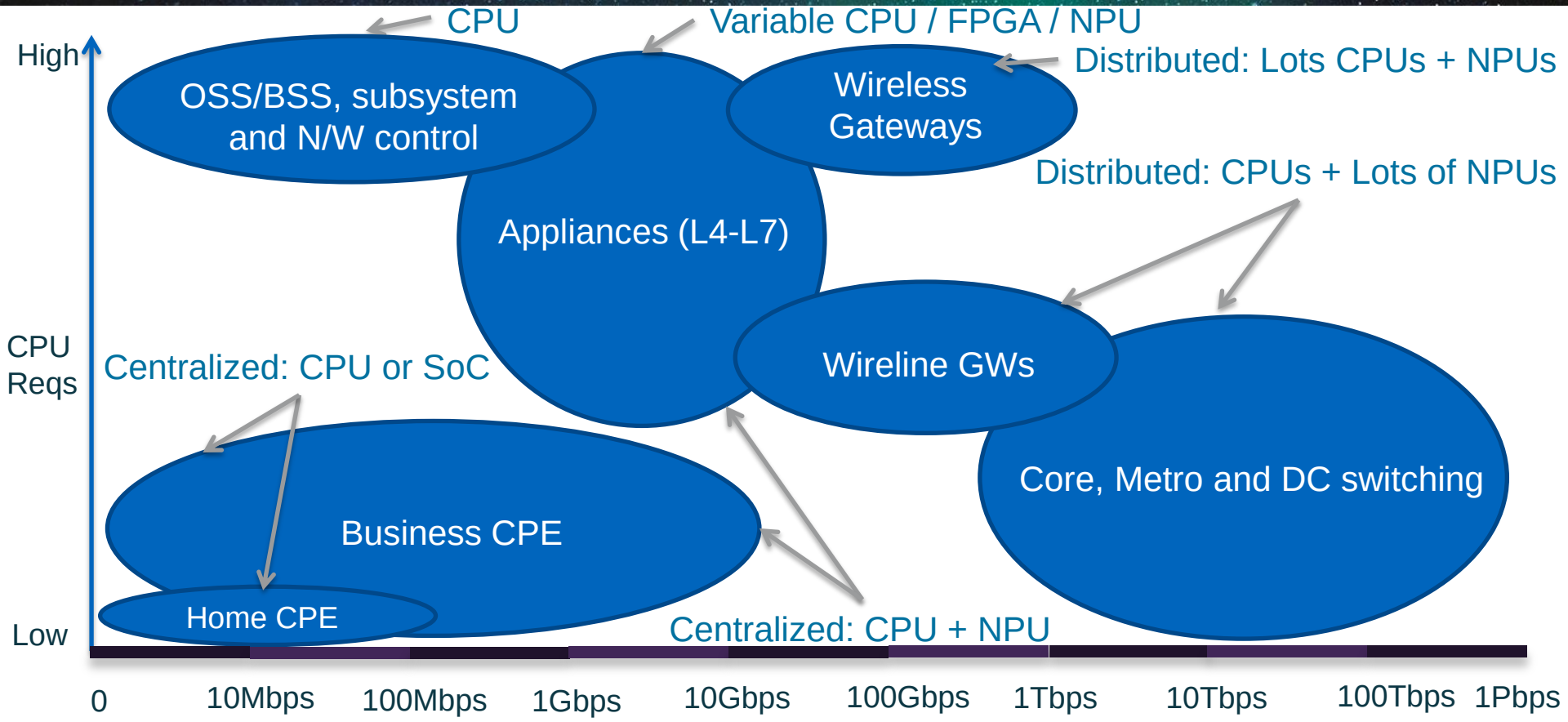
Weaknesses

- High packet processing
- Specialized SP design and h/w functionality
- High physical interface counts (>20s)
- High interface speeds (>40G)
- Diverse interfaces types
- Infrastructure functions
- Very low cost equipment

- High capacity plumbing and gateways : Custom built combination (NPU / fixed ASIC / GPP)
- Elastic service functions combined with low-medium packet processing : virtualized GPP
- CPU intensive tasks : virtualized GPP
- Very low cost components (CPE): Custom solutions (SoC, Fixed ASIC etc)

CONCLUSION : Network infrastructure will be a combination custom and GPP

Network Requirements and today's approaches



Cisco NFV Components

VNF: Cisco VNF Offering

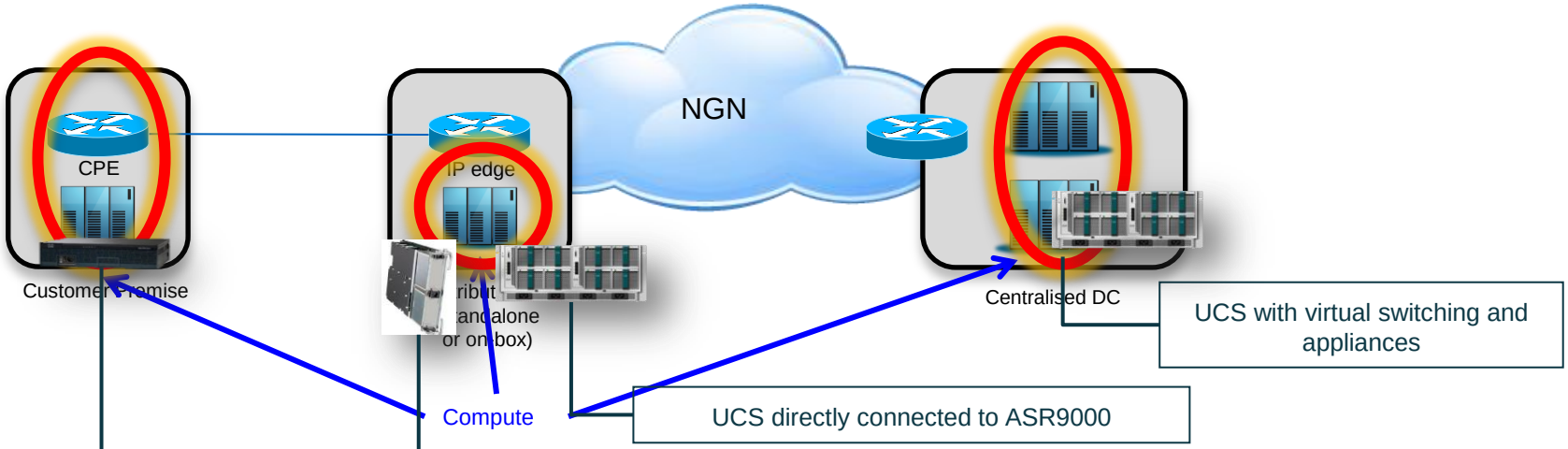
FCS Now	FCS Now	FCS Aug.'13	FCS Q1 '14	FCS Q4 '14	Target 2H'14
CSR1000v	Classic vIOS	IOS-XR Virtual Route Reflector (32bit)	STAR-OS (QvPC-SI)	STAR-OS (QvPC-DI)	IOS-XR Virtual Route Reflector (64bit)
vmware	kvm	kvm	Vmware/kvm	Vmware/kvm	kvm
FCS Now	**FCS 2H13**	**FCS Now**	**FCS Now**	**FCS 1H14**	**FCS Now**
Virtual L2 Switch Nexus 1000v	VIRL	Quantum WAN Orchestration (Cariden)	Identity Services Engine	NS-OS (PCE)	Quantum Policy Suite (PCRF, Subs Mgr)
kvm/HV	kvm/HV	kvm	Vmware/kvm	kvm	vmware
FCS Now	**FCS Now**	**FCS Now**	**FCS Now**	**FCS Now**	**FCS Now**
Firewall ASA 1000v	vESA Email Security (Ironport)	vWSA Web Security (Ironport)	Network Analysis Module	Wide Area App Services	Firewall vSG
vmware	vmware	vmware	kvm	kvm	vmware

1Q2014	PoC Now	PoC Now	1Q2014
DDoS – Prevail Arbor	Loadbalancer (VPP)	NX-OS (Nexus)	DDoS – Prevail Arbor
kvm	kvm/bare	kvm	kvm
Source Fire	**PoC Now**	**FCS1Q14**	**Not Committed**
vIPS, vNGFW, vAnti-X	4-6 Softwire Concentrator (VPP)	Radware Defense Pro	DDoS – TMS Arbor
kvm	kvm	kvm	kvm
OPENWAVE HTTP Se…s, We… 3rd Party 1H2014	**FCS 1Q14**	**FCS 2Q14**	**Not Committed**
	vPE (VPP)	Firewall vASA	WSA/ESA (Ironport)
	kvm	kvm	kvm

Goal is to be hypervisor agnostic. Specific hypervisors references above are to clarify what's currently available/planned.

Cisco NFV Components

NFVI Compute: Cisco Compute Portfolio

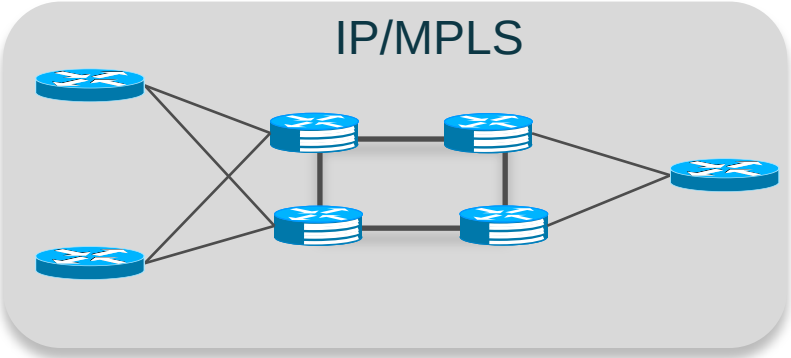


- Compute offers the flexibility to be located at multiple point in the network depending on requirements
  - Centralised
  - Distributed
  - Remote

Cisco NFV Components

NFVI: Virtual Network Overlays

Virtualised WAN



L2 and L3 Virtualised WAN

L2 VPN options

- E-line, E-LAN, E-Tree

L3/L3VPN options

- MPLS L3VPN/Vrf Lite, Global IP

Virtualised Data Centre

VXLAN (Virtual Extensible LAN)

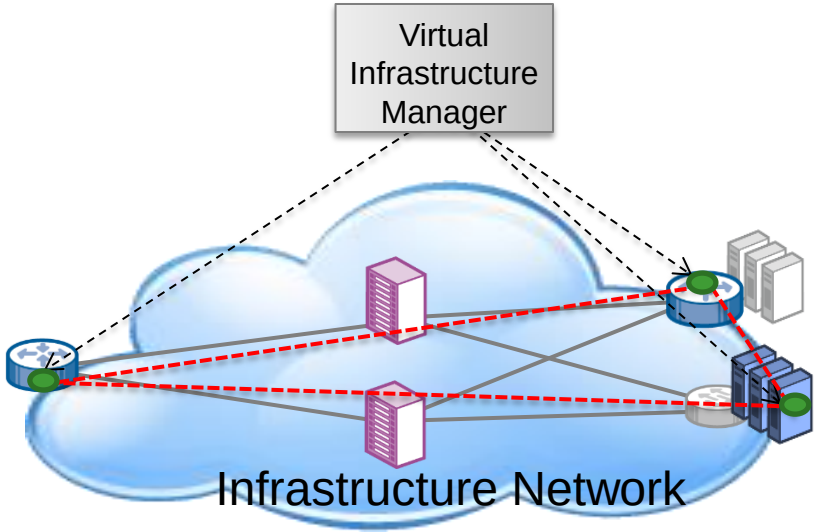
Ethernet in IP overlay network

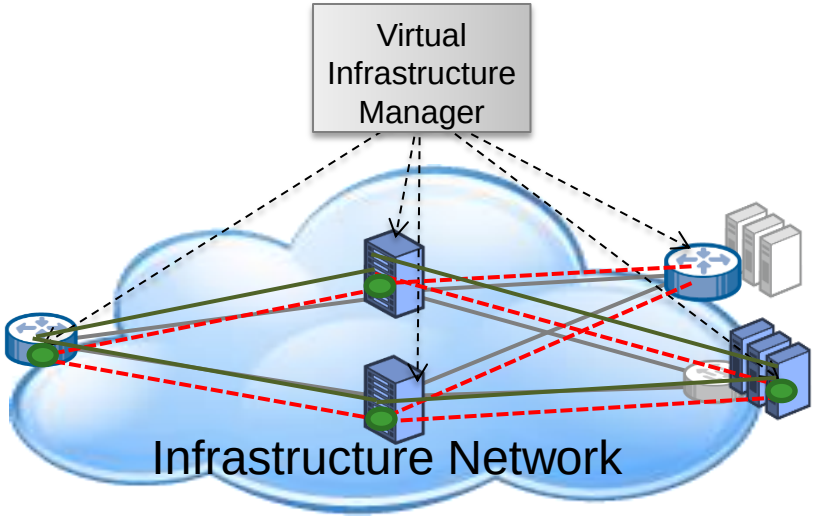
Include 24 bit VXLAN Identifier

- 16 M logical networks

Technology submitted to IETF

NFVI network - creating the virtual network partitions





Underlay and overlays

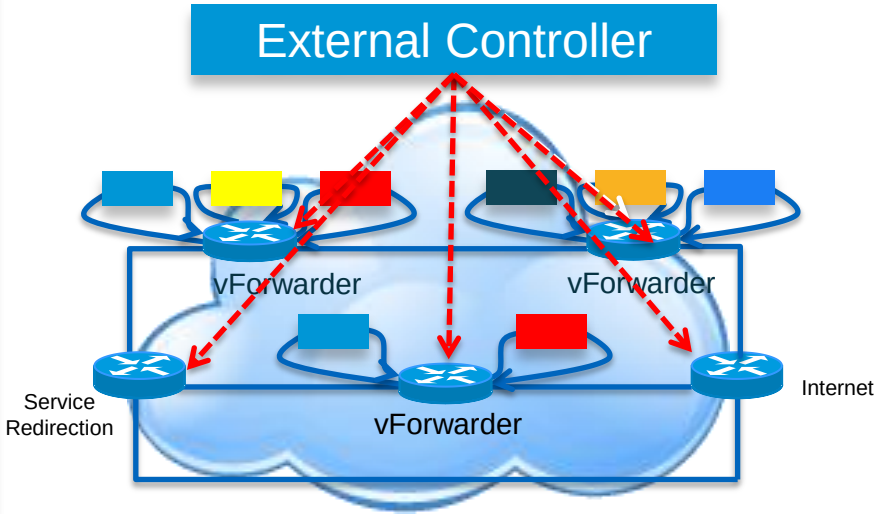
VXLAN

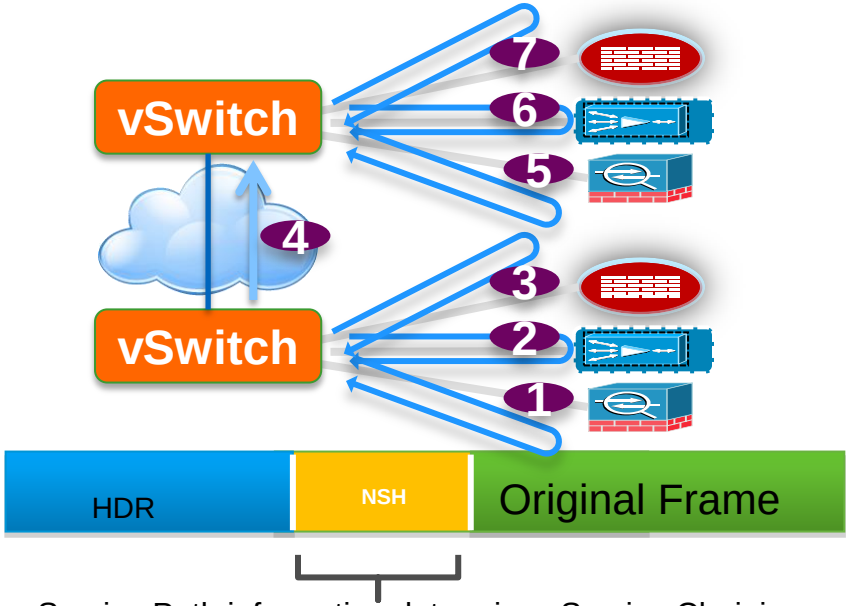
Infrastructure partitioning

Example VLANs

Functionality of virtual N/W orchestration controller application dependent on physical infrastructure and virtualization technology

NFVI network - Service Chaining or Forwarding Graphs





- Service ordering determined by real or virtual n/w structure

- Service ordering by info in user packet
- 5 drafts submitted by Cisco at Berlin IETF
- New IETF working group “Service Function Chaining (sfc)

Cisco NFV use case

vCPE for Business Environment

Service appliances in the branch and DC

Today

Virtualised services on the physical router

Cloud Connector available

Virtualised router and services

Under investigation

Virtualized branch services

Systems Work underway

Virtualized service in DC

Systems Work underway

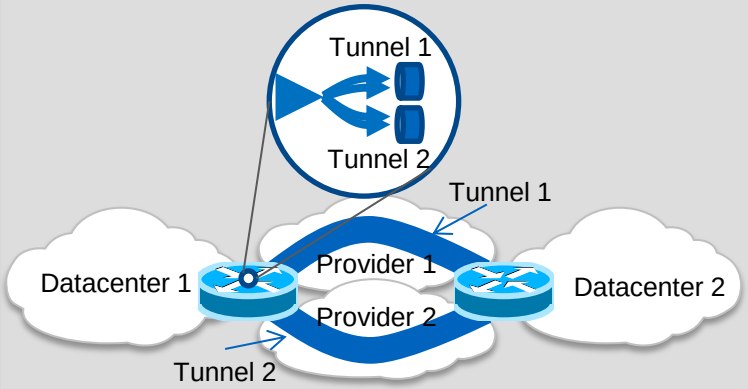
Agenda

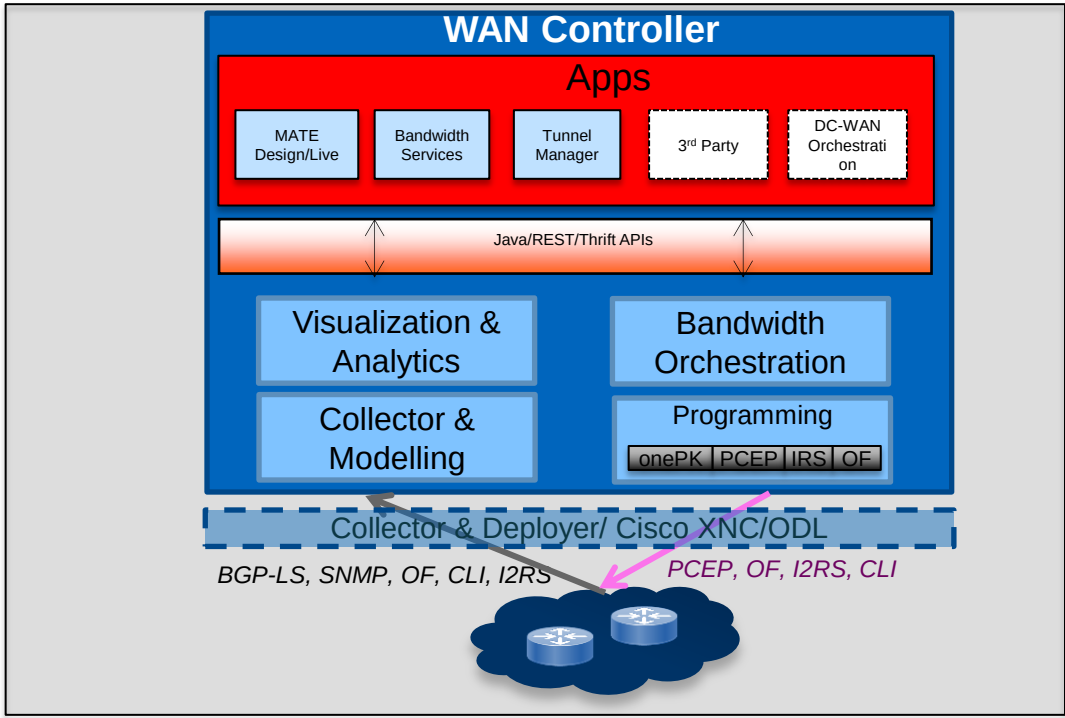
- Key SP Industry Trends and Initiatives
- Factors behind the SP SDN Evolution
- Cisco Service Provider Strategy
  - APIs/Protocols
  - Controllers
  - Simplification and Automation
  - NFV
- Solutions
  - WAN Controller
  - Virtualized Network Services
  - CML
- Summary

WAN Controller - qWave
Use-Case: Path Computation/Bandwidth Scheduling via WAN controller

Deployments typically combine Device-APIs, device delivered Network-APIs, and controller delivered Network APIs for a particular solution

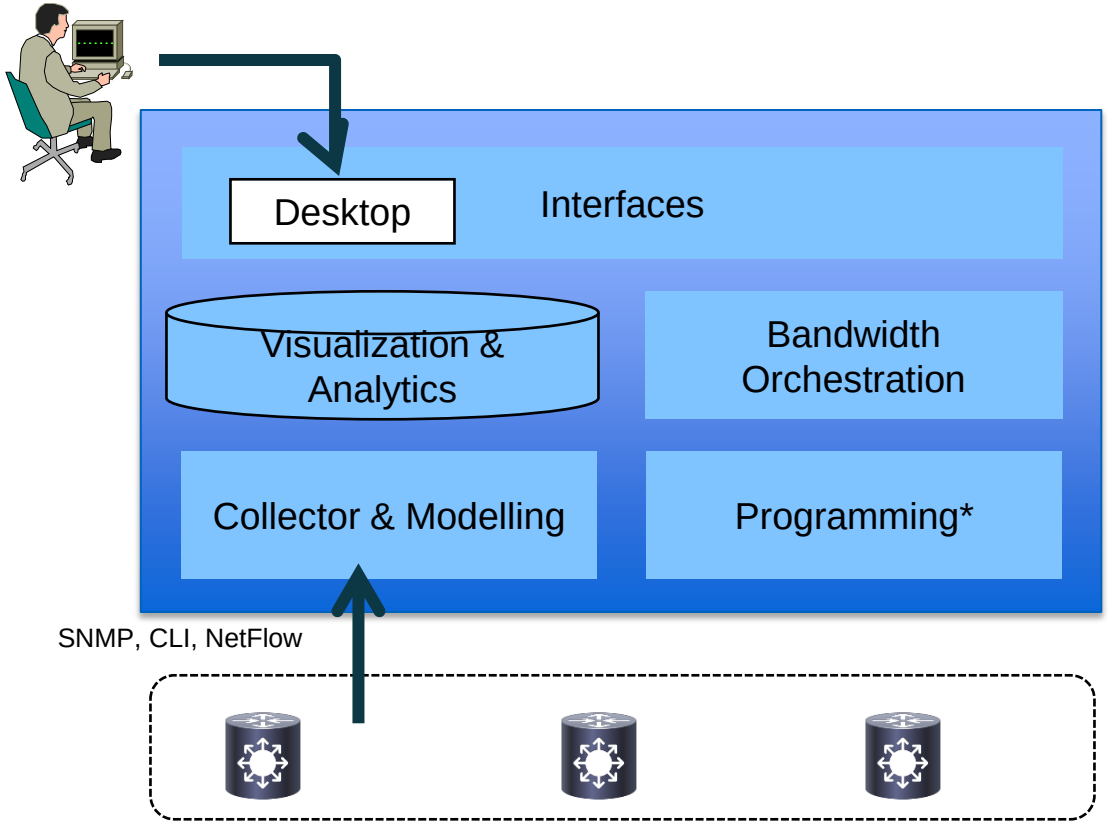
Example: Data-Center Interconnect across two providers with granular traffic forwarding control

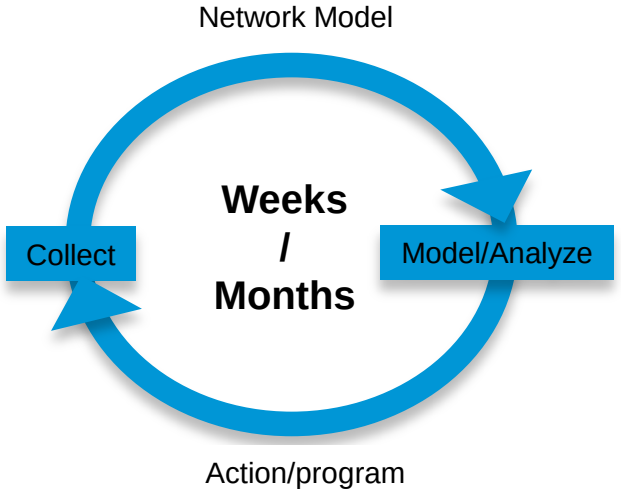




Wan Controller – qWave

Initially off-line planning





* Via CLI, Scripts, NMS, etc.

Wan Controller – qWave

From off-line to on-line

Continuous real-time state of the network

Predictive model of the network across time

Visualization &

Bandwidth

Mechanisms to program the network to get it to the desired state

Model/Analyze

Collector & Modelling

Programming*

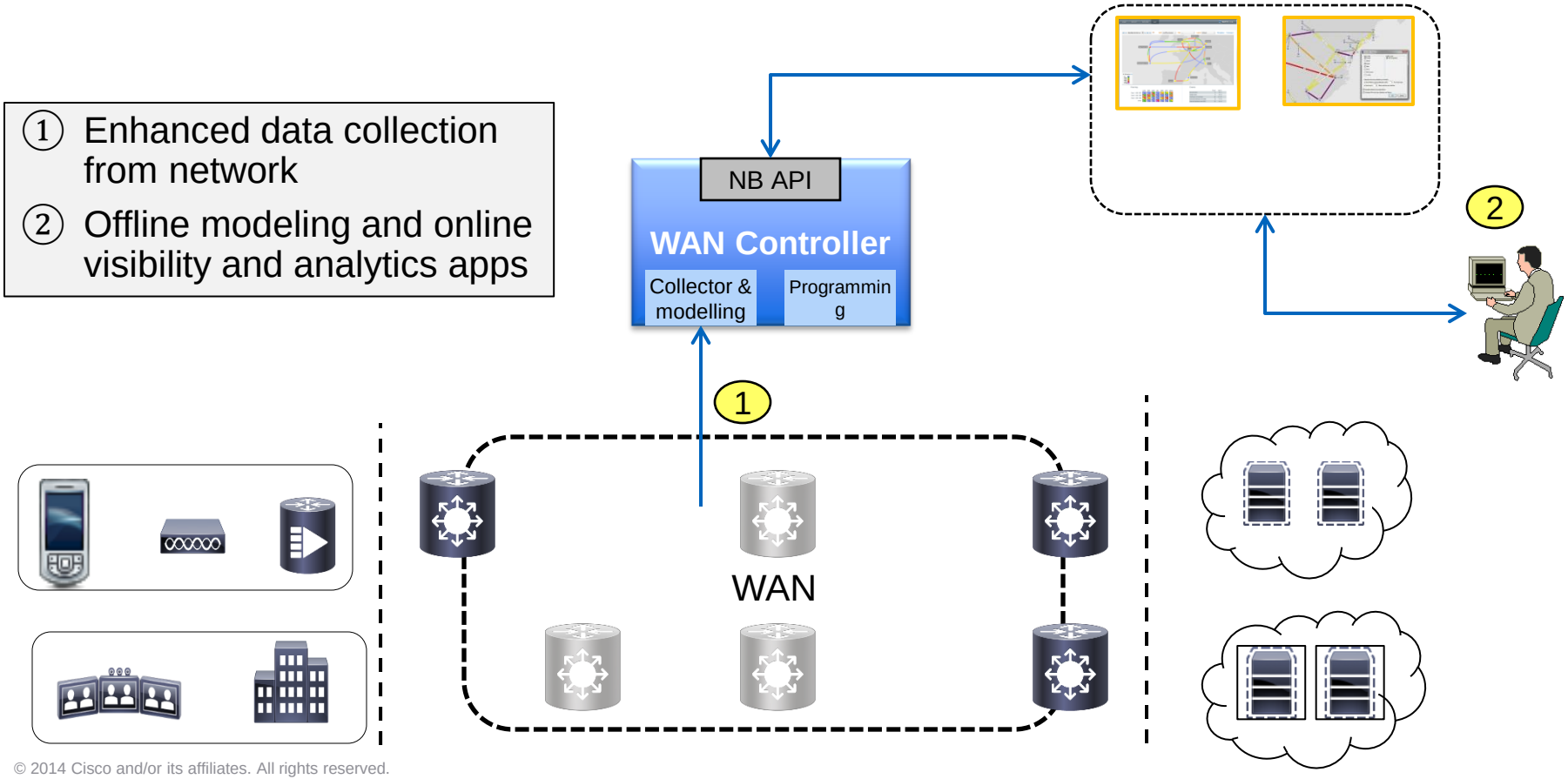
Expose different levels of abstractions via a Northbound API

WAN Controller – qWave

Visibility/Analytics/Modeling Scheduling

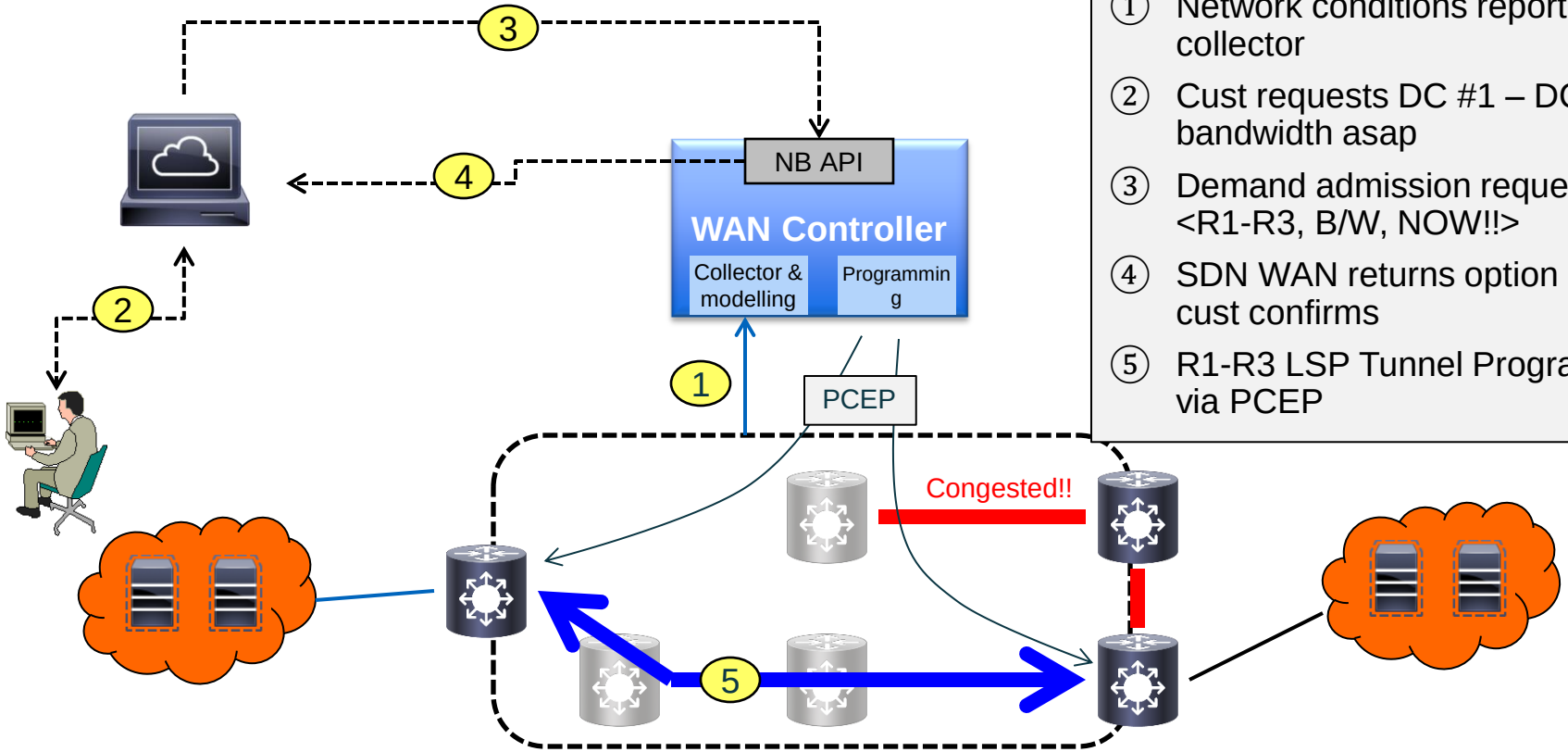
① Enhanced data collection from network

② Offline modeling and online visibility and analytics apps



WAN Controller qWave

Bandwidth Scheduling (On-Demand)



① Network conditions reported to collector

② Cust requests DC #1 – DC #2 bandwidth asap

③ Demand admission request: <R1-R3, B/W, NOW!!>

④ SDN WAN returns option and cust confirms

⑤ R1-R3 LSP Tunnel Programmed via PCEP

WAN Controller qWave

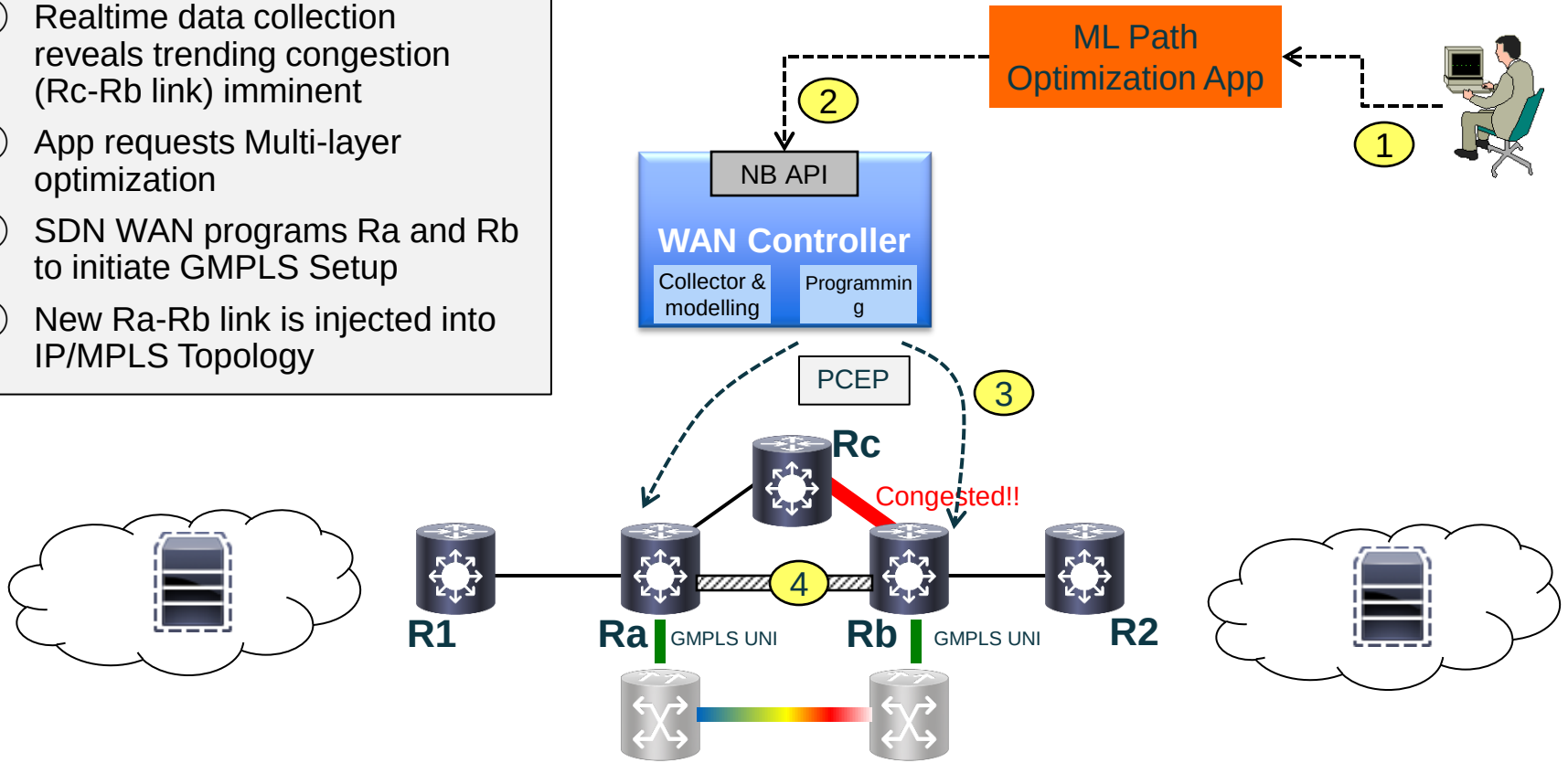
SDN WAN Triggered GMPLS Setup

① Realtime data collection reveals trending congestion (Rc-Rb link) imminent

② App requests Multi-layer optimization

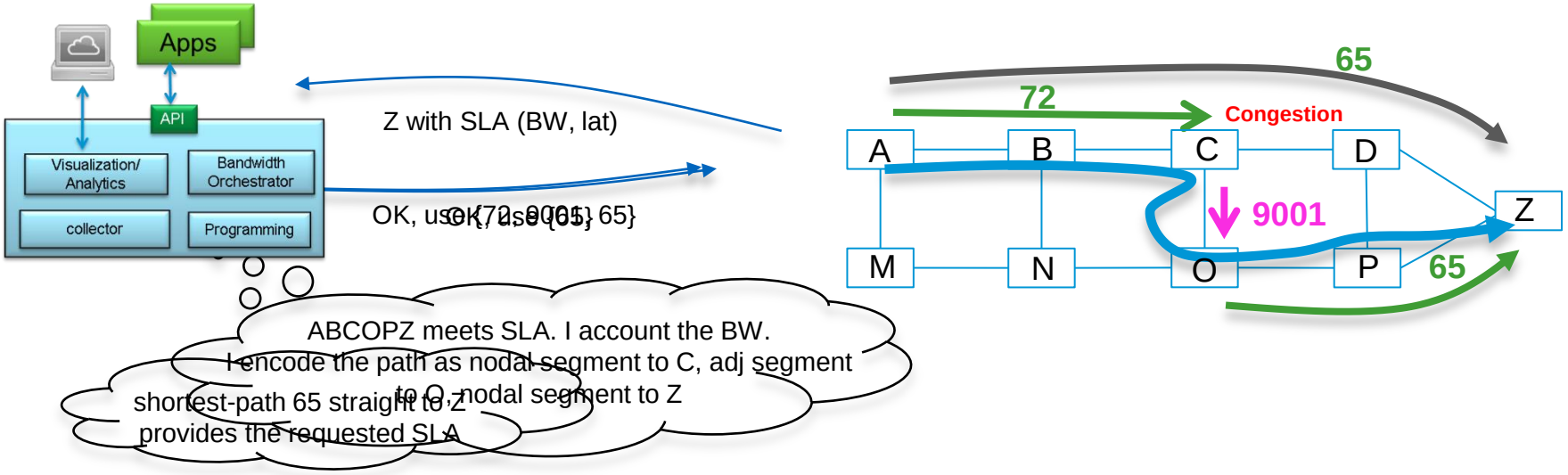
③ SDN WAN programs Ra and Rb to initiate GMPLS Setup

④ New Ra-Rb link is injected into IP/MPLS Topology



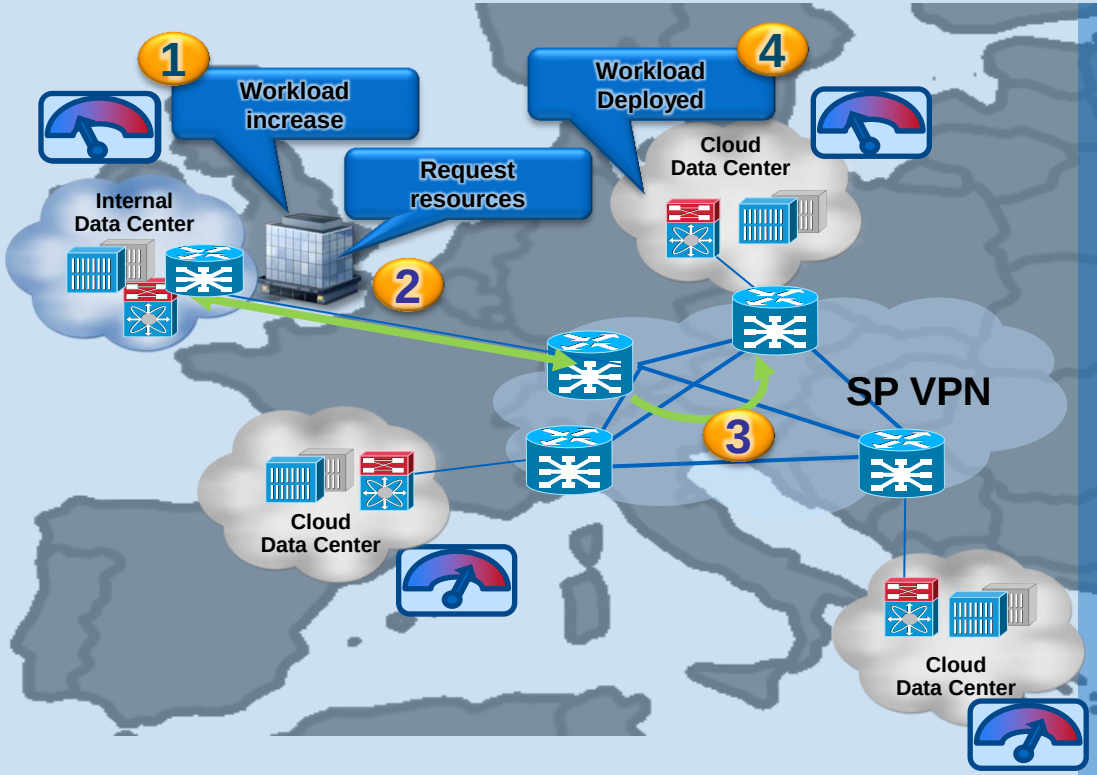
WAN Controller - qWave

Future Use-Case: Segment Routing with Centralised Control



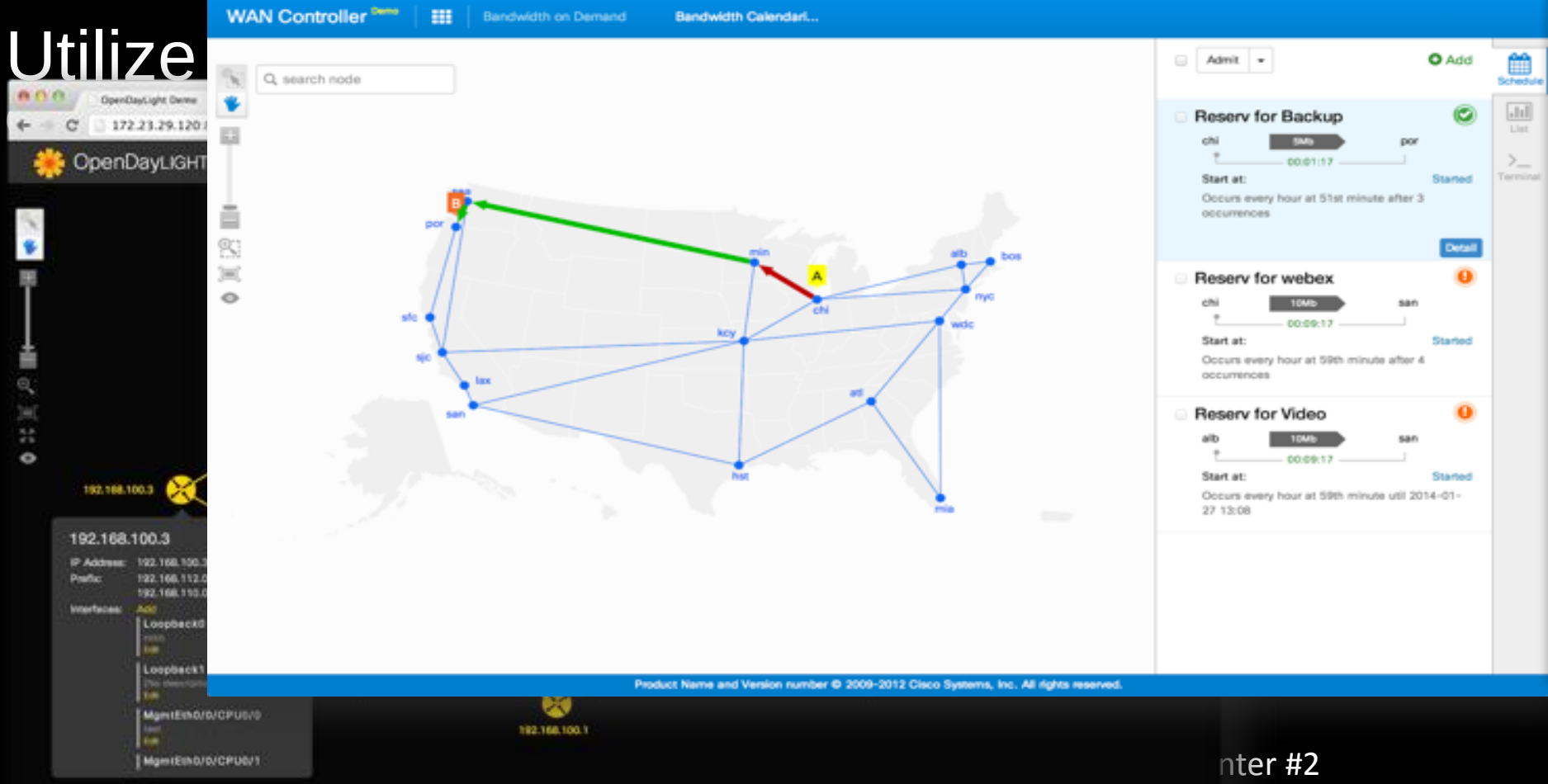
WAN Controller -qWave

Future Use-Case: WAN/DC Service Placement



1. Additional capacity needed – request Cloud resources
2. Check resource availability, performance – determine optimal location
3. Provision network tenant, virtual Compute, Storage, VPN, services
4. Virtual infrastructure and network container active

Utilize



nter #2

OPEN DAYLIGHT

Agenda

- Key SP Industry Trends and Initiatives
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- Cisco Service Provider Strategy
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  - CML
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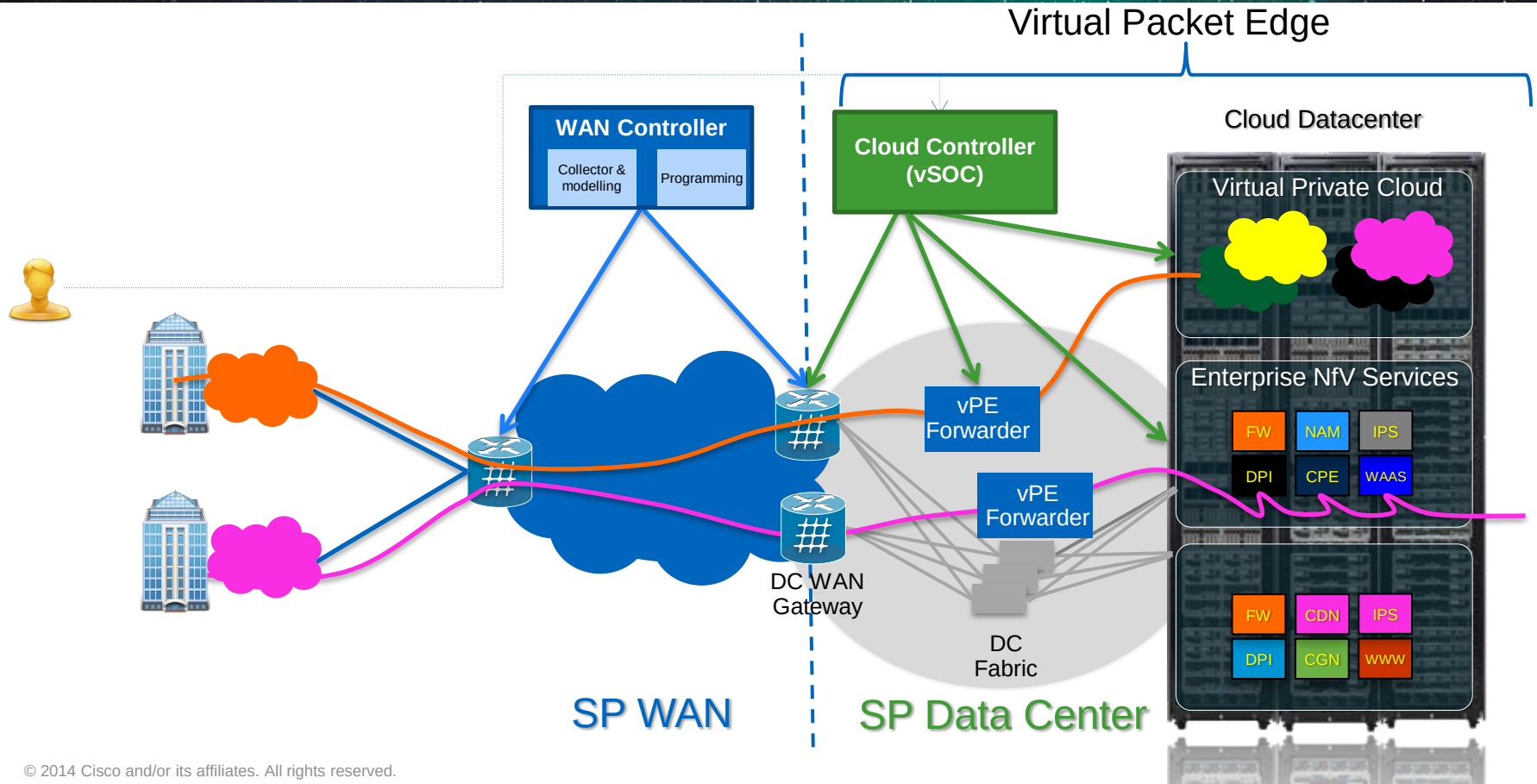
Virtualized Network Services – Mozart



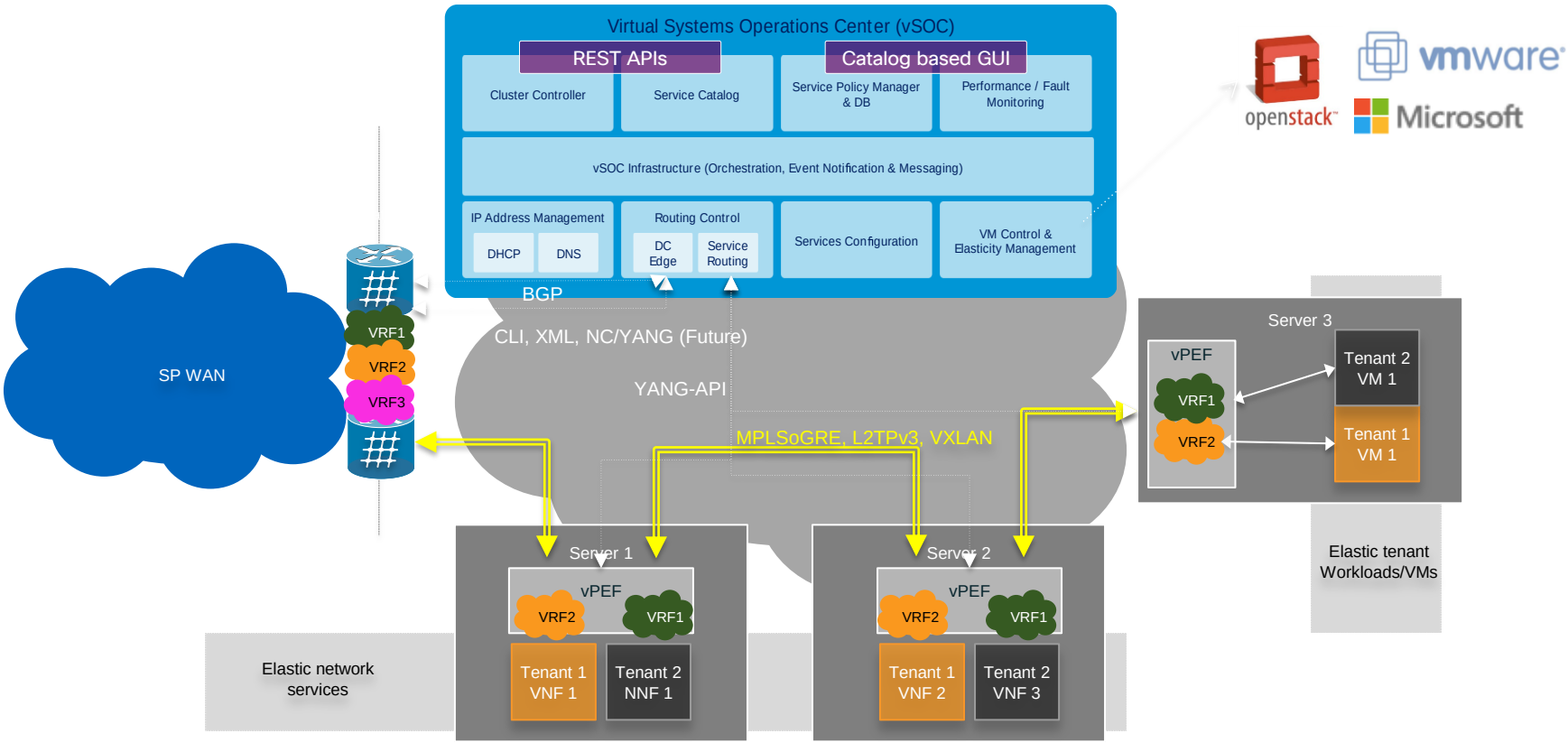
Virtualized Network Services – Mozart

Components

vSOC	Virtual Systems Operations Center (vSOC) Extensible Service Orchestrator
v-PE Forwarder	Virtual PE Forwarder (vPEF) – Light weight forwarding element per Server
VNF Services	vASA, CSR 1000 for IPsec, NAT, DPI & RaaS, GI-LAN
DC WAN Gateway	ASR9k/Nexus 7k - Physical PE (DC WAN Gateway)

Virtualized Network Services – Mozart
Cloud Orchestrator

Multi-Tenant Data Center

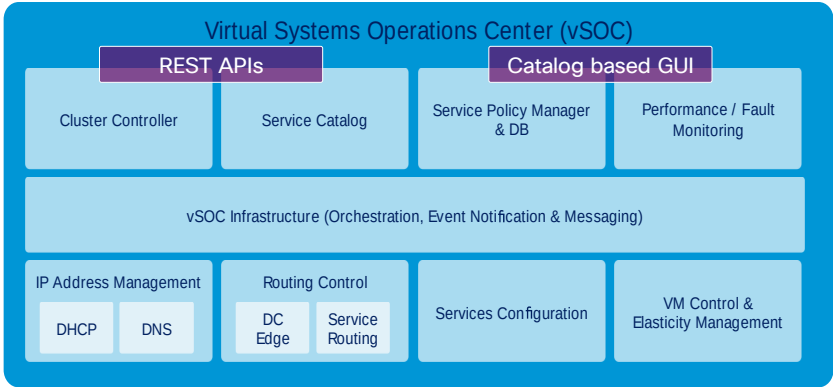


Virtualized Network Services – Mozart

vSOC – Virtual Systems Operations Center

- Management Function (north)
  - Single Pane of Glass' management interface for provider and customer using REST and Catalog based GUI
  - Customer configures tenant org and all the network elements and policies (tenant, topology, network etc.)

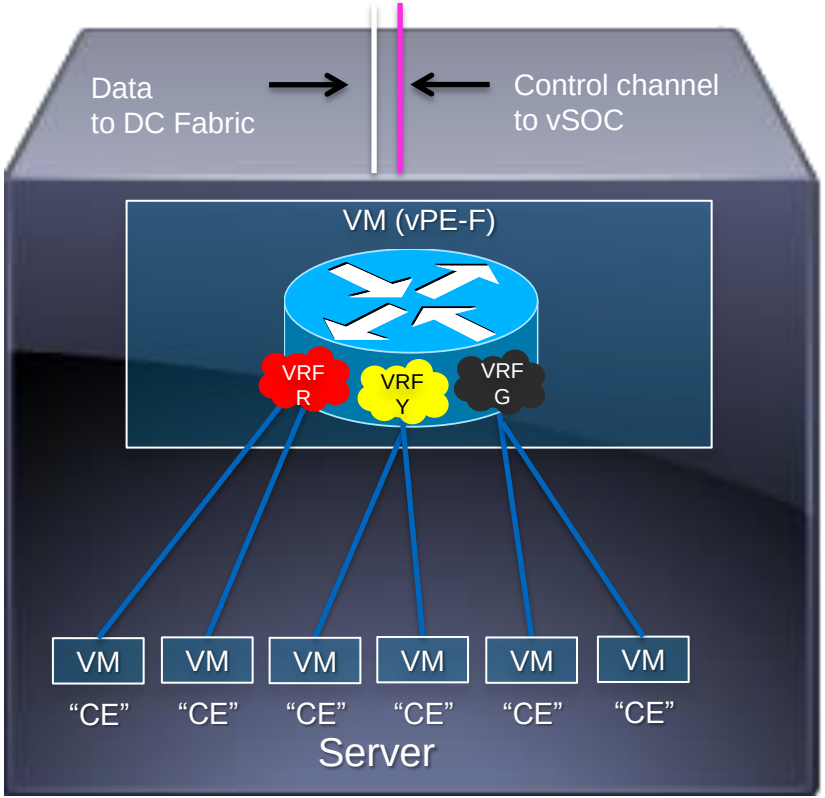
- Provisioning Function (south)
  - Communicates with vPE-F to program the forwarding tables (Yang)
  - Communicates with OpenStack to manage VM resources
  - Communicates with DCI to interwork with SP network
  - Communicates with IPAM/DHCP for IP
  - Configures service nodes
- Orchestrator Function (glue)
  - Orchestrate end-to-end flow w/ the ability to modify and extend behavior
  - Continuous health monitoring of vSOC Subsystem and Network services



Virtualized Network Services – Mozart

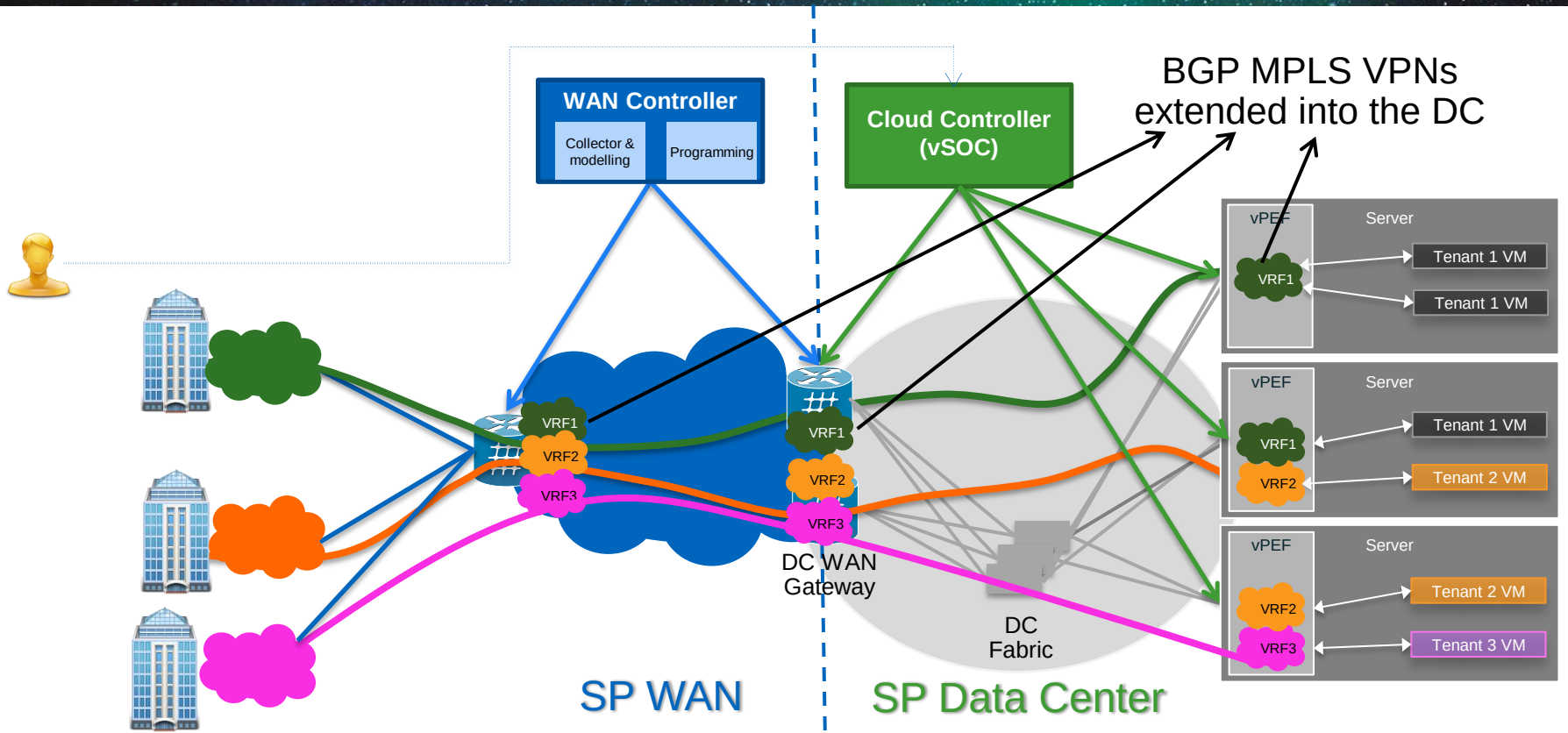
vPE in a server/vPE-F

- Light weight software forwarding plane
- Provides highly optimized forwarding in x86 environment
- Runs inside a VM in each server
- Contains a unique forwarding context per tenant
- Provides per-tenant L3, L2 and PBR forwarding
- Support for IPv4, IPv6 address families
- Provides multiple tunnel encaps (MPLS-over-GRE, L2TPv3, VXLAN (in future)
- Provides DHCP relay function
- Programmed by vSOC using YangAPI (tenancy and service chaining)



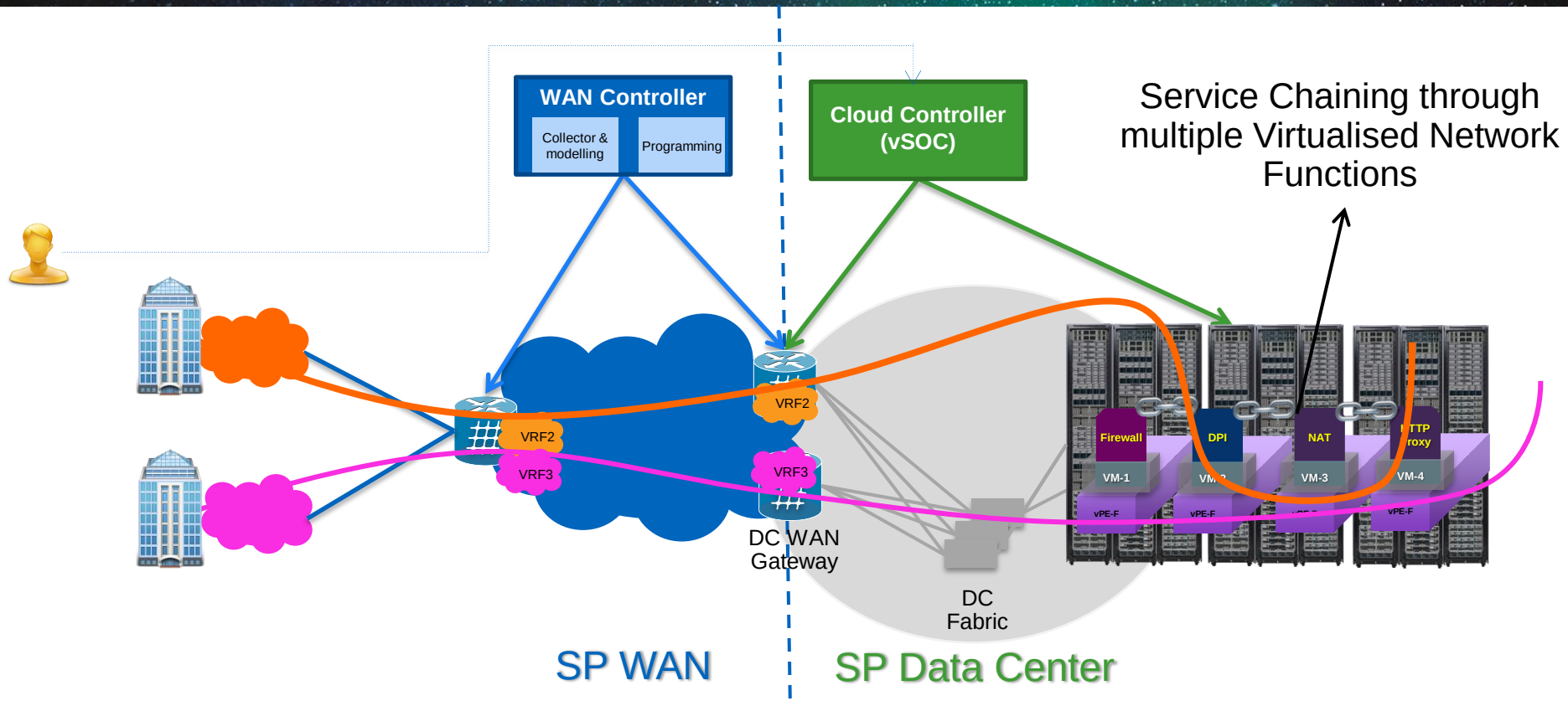
Virtualized Network Services – Mozart

Use-case: IAAS/VPC to VPN mapping



Virtualized Network Services – Mozart

Use-case: VPC and NFV Service Chaining



END USER PORTAL

Simple, Intuitive UX

Spin Up New Services in Minutes

Customizable

User-Defined SLAs, Reporting, Service Customization, Cloud Preference Options

Bundled Offerings

Pre-Packaged or Custom Creation of End Application Services & Appliances

Any Service, Any Device
Anywhere & On-Demand

Agenda

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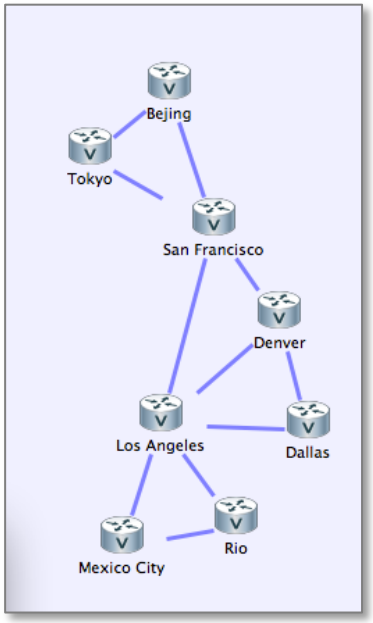
- Summary

What is Cisco Modeling Labs (CML)?

A multi-purpose extensible network virtualization and simulation platform

- Enables highly-accurate models of real-world / future networks
- Leverages ‘real’ network operating systems - build synched with platform releases
- Supports the integration of ‘real’ and virtual networks
- Allows servers, appliances, and routers to be added and removed on-demand



Why Use CML?

Technical Opportunities

- Build, test & deploy networks – virtually
- Validate and verify designs and configurations
- Rapid prototyping of new service offerings
- Reduce risk and errors through improved training

Benefits

- Lower spend on lab equipment
- Improve access to resources
- Scale resources on demand
- Decrease time to deployment for new services
- Accessible – on- or off-premise usage

CML Architecture

Virtualized Network Operating Systems

IOS-XR

Virtualized in XRVR

(Available)

NX-OS

Virtualized in vNXOS

(Under Test)

IOS-XE

Virtualized in CSR1000v / Ultra

(4GB/4CPU only)

IOS

Virtualized in vIOS

(Available)

Servers

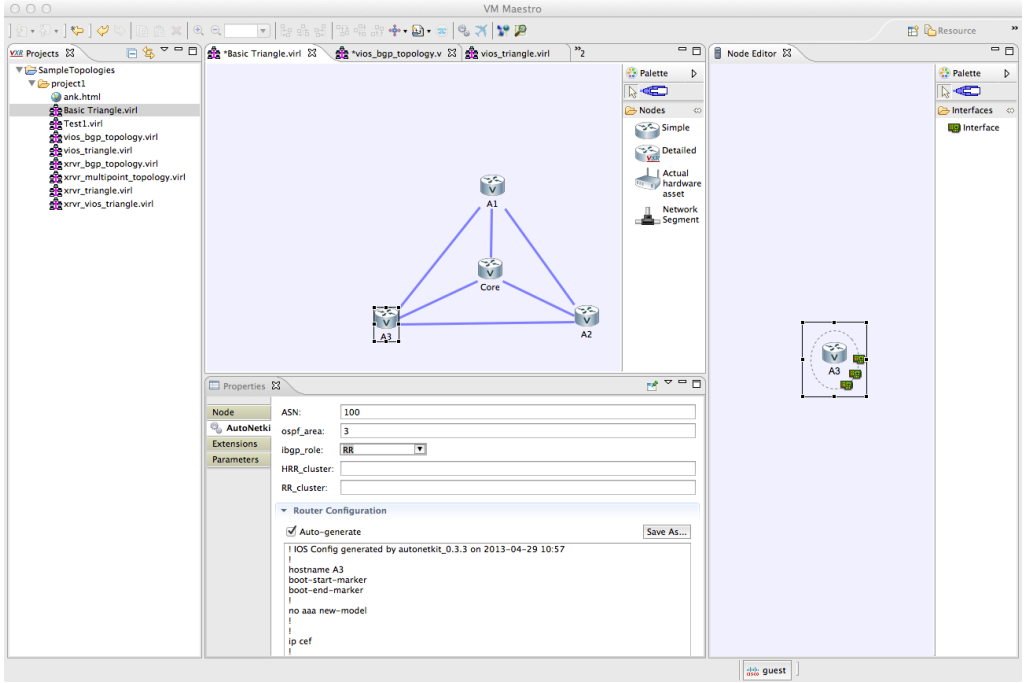
Such as vPagent, Jump-Host, Others

(Available)

CML Architecture

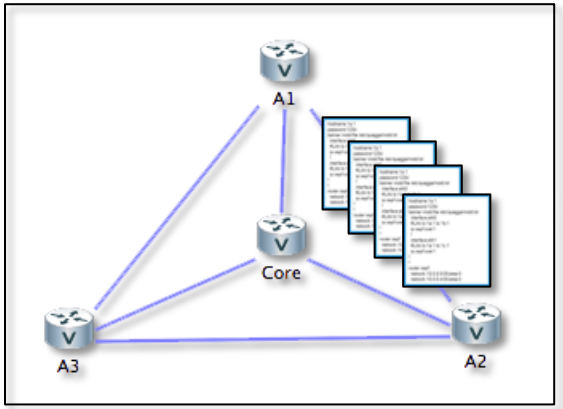
VM Maestro Network Design

- The graphical topology editing tool used by CML
- Enables definition of topology and network element attributes:
  - ✓ Routers
  - ✓ Links
  - ✓ Protocols
  - ✓ Facilities
- Supports complex (full SP) topologies
- Creates XML-based topology descriptions
- Provides simulation management and console access to virtual routers



CML Architecture
Topology Representations

- Full topology definition with configurations represented in XML
- Files are highly portable and shareable
- Integrated support for GIT repositories enables multi-user sharing, versioning

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<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
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http://cide.cisco.com/vmmaestro/schema/CML.xsd">
  <extensions>
    <entry type="String" key="management_network">flat</entry>
    <entry type="Boolean" key="AutoNetkit.enable_cdp">true</entry>
    <entry type="Boolean" key="AutoNetkit.enable_OnePK">true</entry>
    <entry type="String" key="AutoNetkit.address_family">dual_stack</entry>
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    <entry type="String" key="AutoNetkit.ipv4_infra_prefix">8</entry>
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    <entry type="String" key="AutoNetkit.ipv4_vrf_loopback_prefix">24</entry>
    <entry type="Boolean" key="AutoNetkit.enable_routing">true</entry>
    <entry type="String" key="AutoNetkit.IGP">isis</entry>
  </extensions>
  <node location="518,292" subtype="IOSv" type="SIMPLE" name="Core">
    <interface name="GigabitEthernet0/1" id="0"/>
    <interface name="GigabitEthernet0/2" id="1"/>
    <interface name="GigabitEthernet0/3" id="2"/>
  </node>
  <node location="519,172" subtype="IOSv" type="SIMPLE" name="A1">
    <interface name="GigabitEthernet0/1" id="0"/>
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    <interface name="GigabitEthernet0/3" id="2"/>
  </node>
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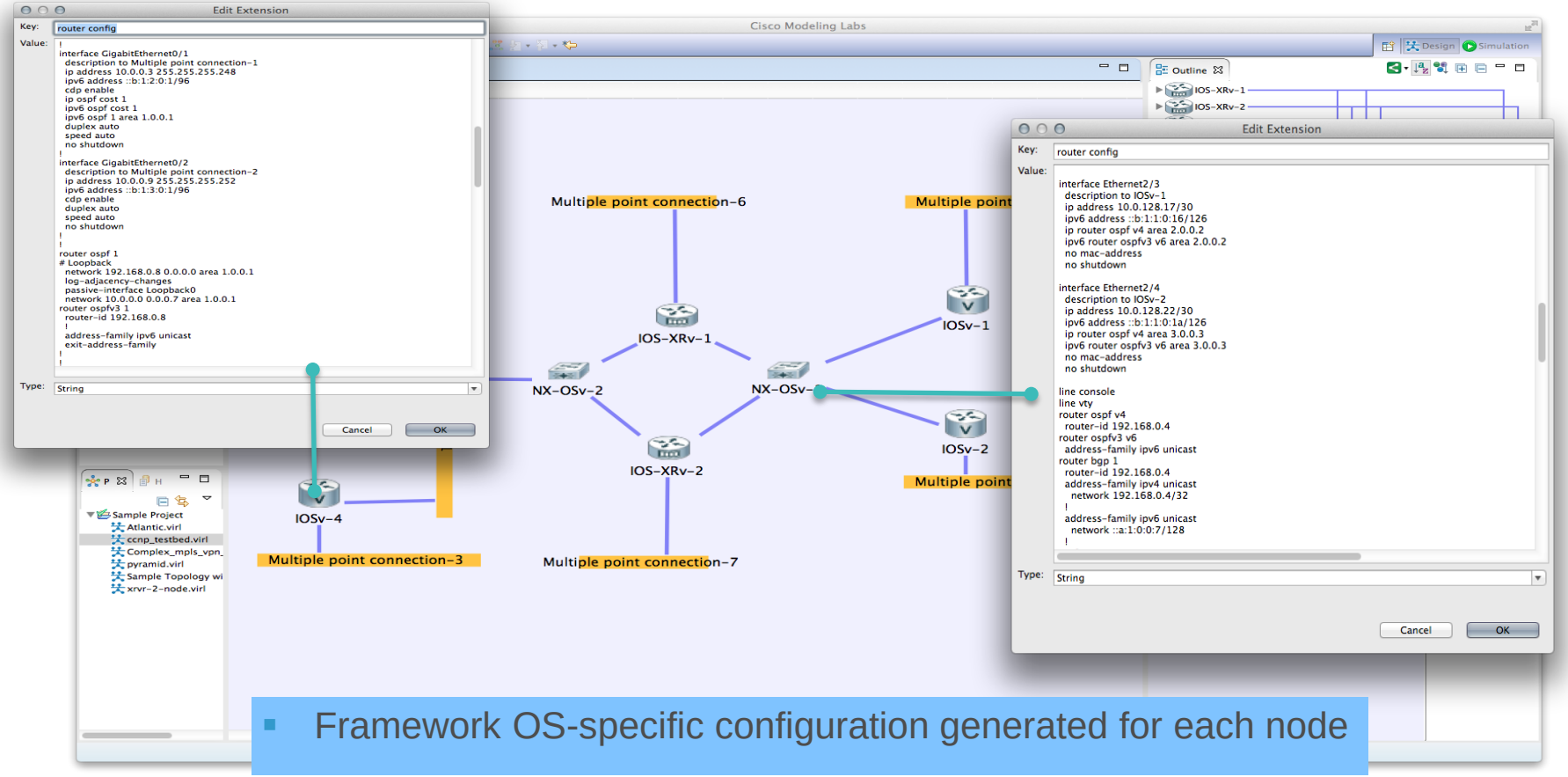
  </node>
  <node location="403,382" subtype="IOSv" type="SIMPLE" name="A2">
    <interface name="GigabitEthernet0/1" id="0"/>
    <interface name="GigabitEthernet0/2" id="1"/>
    <interface name="GigabitEthernet0/3" id="2"/>
  </node>
```

CML Architecture

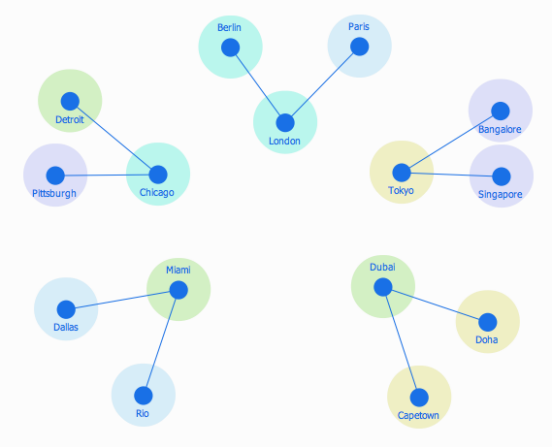
Automatic Configuration



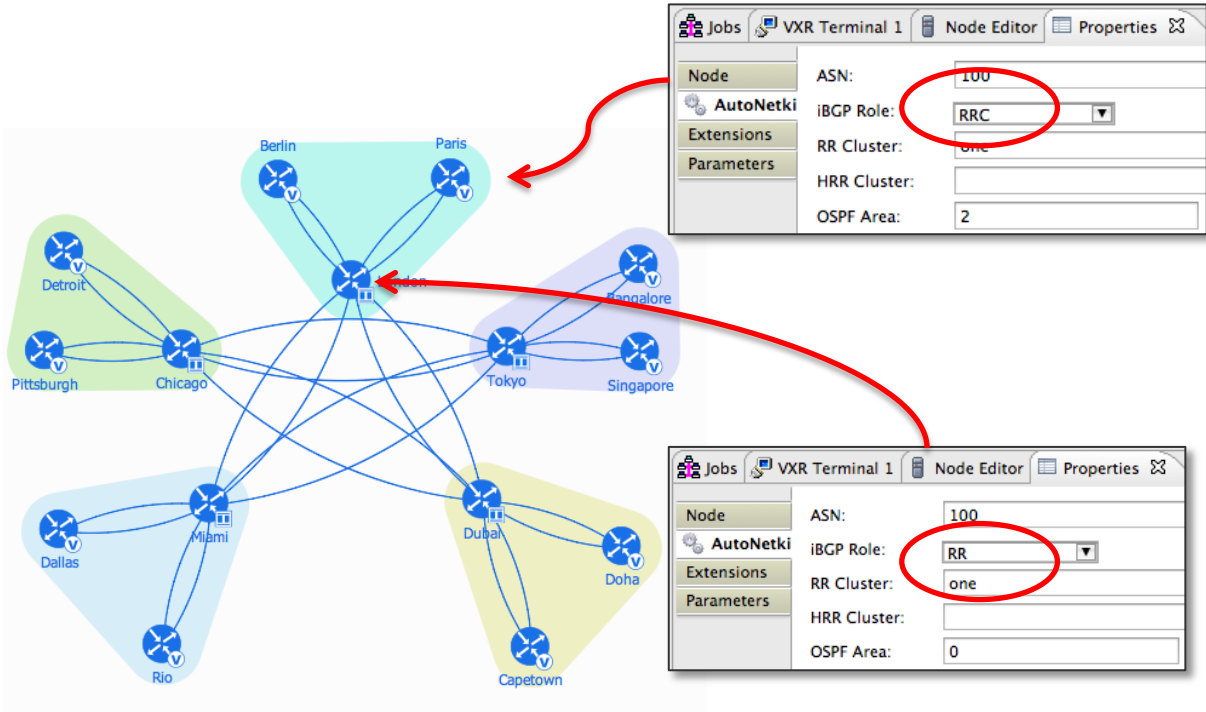
- Framework OS-specific configuration generated for each node

CML Architecture

AutoNetKit Network Visualization



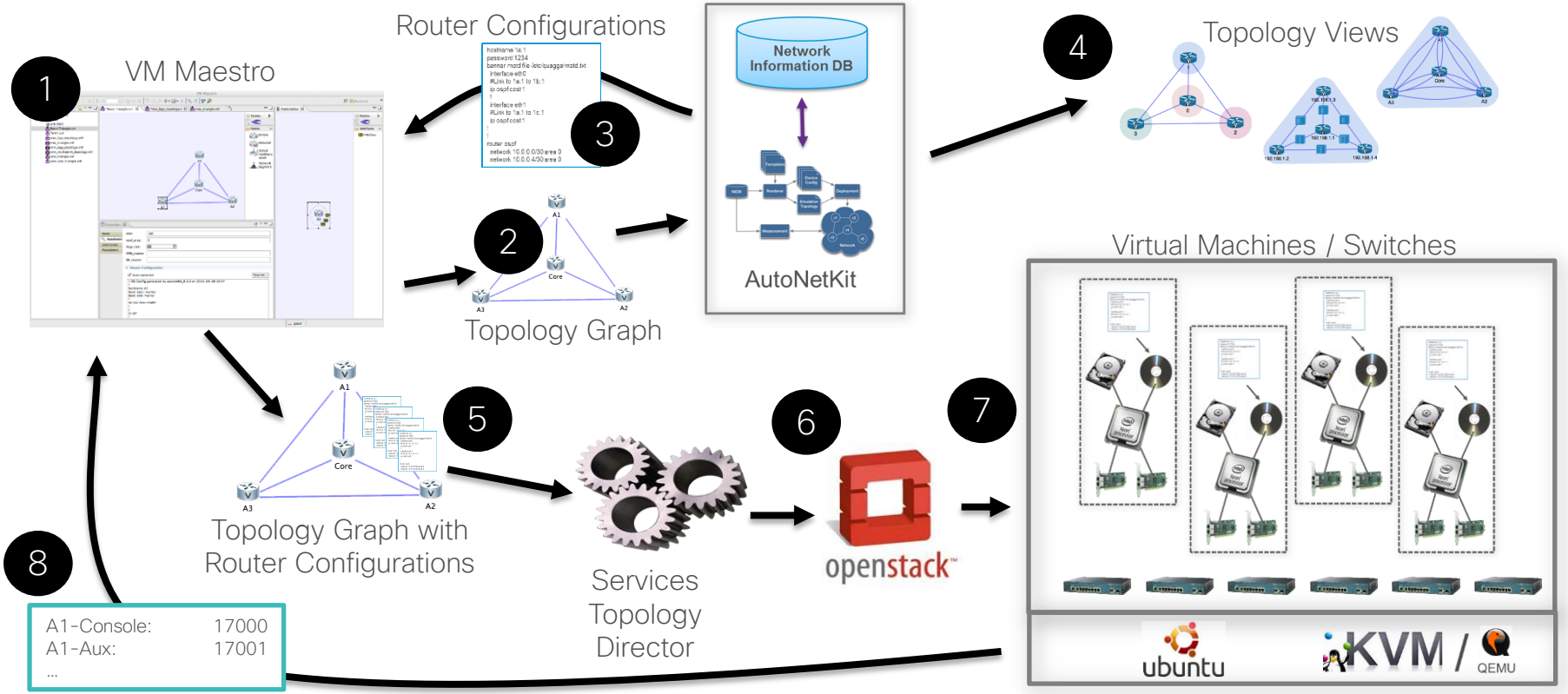
OSPF area values set on each node



BGP route-reflector clusters and AS's configured

CML Architecture

CML Work-Flow

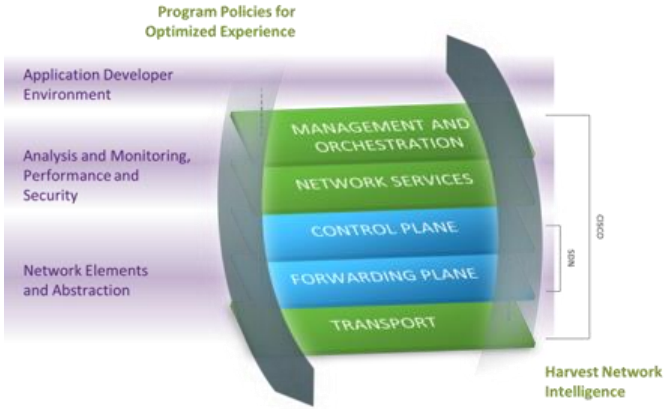





Summary

Summary

- Cisco provides an end-to-end SDN approach for SP
  - From WAN to DC
  - Cross-domain orchestration
- Evolutionary step for networking
  - Integrate with and complement the Network Control Plane
- Centered around delivering open, programmable environment for real-world use cases
  - No one-size-fits-all
  - APIs, Agents/Controllers, Network Virtualization
  - Joint evolution with industry and academia
- Technology-agnostic
  - Not predicated on a particular technology or standard
  - Draw from existing technologies and industry standard

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