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
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.

Visit them at BOOTH# 407
The Mission: Service Provider Business Transformation
Cost Reduction and Agility Delivers Profits

AUTOMATION, VIRTUALIZATION AND ORCHESTRATION ARE REQUIRED

Dynamic Set-Up, Tear Down and Provisioning
On-Demand Workload Movement with Service Profiles

Orchestration
Workload Portability

Full Access to Resource Pools Anywhere

Data Center

Virtualized Resource Pools (network ready compute/storage)

Network

Virtualized Network Functions

Cloud Services

Workload Portability

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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.

“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

“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.”
“...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...”


“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/
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

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
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
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 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...”
SDN Network Evolution
Network “simplification” with integration of Cloud and SDN techniques

- 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
The Overall Cisco SP SDN Evolution Overview

Today

- Provisioning
- Control Plane
- Data Plane

Vendor-specific APIs

SDN Model

- Controller
- Openflow Protocol
- Data Plane

"Purist" SDN view
- Resilient
- Scalable
- Simplified
- Logical Centralization

Cisco "Hybrid" Approach

- Orchestration Provisioning
- Control
- Standard APIs
- Abstraction & Programmability
- Centralised
- Distributed
- "More Simplified"
- Data Plane

Evolved Network Architecture

- Control Plane
- Optimized
- Best of both worlds
Specific Requirements per Domain
Use-Case based approach

- **Service Providers**
  - Network utilization
  - Service performance
  - Faster provisioning
  - Network Monetisation

- **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
- NFV
- Services
- Provisioning
- Analytics

### Agg and access Infrastructure
- Automated set-up
- Analytics collections
- Service definition
- Optimization

### Edge
- NFV
- Services
- Provisioning
- Analytics

### Core Infrastructure
- Bandwidth calendaring
- Demand engineering / PCE
- Single/multi layer optimization
- Analytics collection

### Data Centre
- Virtualized n/w
- Virtual 2 virtual n/w interconnect
- Service chaining appliances
- Analytics collection

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Cisco Strategy for Service Providers

Focused on Accelerating Service Provider Revenue Growth
Towards an Automated Service Centric Platform

Service Orchestration
Automated, 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

Service Broker
“Business Intent”
catalogs, workflows

Service Profile
“Operational Intent”
policies, templates

Orchestration Engine
“Execution”
configuration, automation, provisioning

Virtual Functions
Catalog of SW tools”
appliances, controllers

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.

OPEN
Multi-vendor and based on open standards & API

Network  Compute  Storage
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

Service Catalog
- Routing/VPN
- Transport
- Security
- Virtual Private Cloud
- Mobility
- Video/Content
- Managed Services

Cross Domain Orchestration

Service Provisioning
- Provision WAN services
- Provision NFV in DC

Network Orchestration
- DC SDN
- WAN Orchestration & Optimization

Compute & Storage Control
- Elastic Services Control
- Service Lifecycle management

End2End Service Management and SLA Guarantees
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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
<table>
<thead>
<tr>
<th>Management</th>
<th>Workflow Management, Network Configuration &amp; <strong>Device Models</strong>, ..</th>
<th>Network Models - Interfaces (OMI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orchestration</td>
<td><strong>L2-Segments</strong>, <strong>L3-Segments</strong>, Service-Chains Multi-Domain (WAN, LAN, DC)</td>
<td>OpenStack, Neutron API</td>
</tr>
<tr>
<td>Network Services</td>
<td><strong>Topology, Positioning, Analytics</strong> Multi-Layer <strong>Path Control</strong>, Demand Eng.</td>
<td><strong>Positioning (ALTO)</strong> Path Control (PCE)</td>
</tr>
<tr>
<td>Control</td>
<td><strong>Routing</strong>, Policy, Discovery, VPN, AAA/Logging, Switching, Addressing ,</td>
<td>Interface to the Routing System (I2RS)</td>
</tr>
<tr>
<td>Forwarding</td>
<td>L2/L3 <strong>Forwarding Control</strong>, Interfaces, Tunnels, enhanced QoS, ..</td>
<td>OpenFlow Protocol</td>
</tr>
<tr>
<td>Device/Transport</td>
<td>Device configuration, Life-Cycle Management, Monitoring, HA, ..</td>
<td>Network Functions Virtualization (NFV)</td>
</tr>
</tbody>
</table>
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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

Autonomic Management

Traditional interactions (e.g., routing)

Autonomic interactions

Device OS

Autonomic Process

Device OS

Autonomic Process

reporting

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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)
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

Many network functions are suitable for virtualization but not all. Each functional component of the network needs to be evaluated.
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, n/w acceleration / integrated memory
  Programmable in high level languages

All based on CMOS technology
All subject to Moore’s Law
X86 Based Virtualization

**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

- CPU
- Variable CPU / FPGA / NPU
  - Distributed: Lots CPUs + NPUs
  - Distributed: CPUs + Lots of NPUs

- Wireless Gateways
- Appliances (L4-L7)
- Wireline GWs
- Core, Metro and DC switching

- OSS/BSS, subsystem and N/W control
- Centralized: CPU or SoC
- Distributed: CPU + NPU

- Business CPE
- Home CPE
- Centralized: CPU or SoC

- CPU Reqs
- Low
- High

- 0 10Mbps 100Mbps 1Gbps 10Gbps 100Gbps 1Tbps 10Tbps 100Tbps 1Pbps
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 points in the network depending on requirements
  - Centralised
  - Distributed
  - Remote

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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

Infrastructure Network

Virtual Infrastructure Manager

Underlay and overlays
VXLAN

Infrastructure partitioning
Example VLANs

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

Virtualised services on the physical router

Virtualised router and services

Virtualized branch services

Virtualized service in DC

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- Summary
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

Desktop

Visualization & Analytics

Collector & Modelling

Bandwidth Orchestration

Programming*

SNMP, CLI, NetFlow

Network Model

Collect

Model/Analyze

Action/program

Weeks

Months

* Via CLI, Scripts, NMS, etc.

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Wan Controller – qWave
From off-line to on-line

Continuous real-time state of the network

Predictive model of the network across time

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

Expose different levels of abstractions via a Northbound API

Visualization & Analytics

Bandwidth

Collector & Modelling

Programming*

Model/Analyze

Network Model

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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

---

**Diagram Description:**
- **Step 1:** ML Path Optimization App
- **Step 2:** NB API
- **Step 3:** PCEP
- **Step 4:** New Ra-Rb link is injected into IP/MPLS Topology
Z with SLA (BW, lat)

OK, use {72, 9001, 65}

ABCOPZ meets SLA. I account the BW.
I encode the path as nodal segment to C, adj segment to O, nodal segment to Z.

shortest-path 65 straight to Z
provides the requested SLA.
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 OpenDaylight + WAN Orchestration on Demand Bandwidth Scheduling

Benefits:
- Performance & Scalability On-Demand
- New Portal = Simple, Intuitive, Automated
- New Services = Revenue Opportunities
- Multi-Vendor & Open Architecture
- Based Upon Open Source (No Lock-in)
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**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

Virtual Systems Operations Center (vSOC)

- REST APIs
  - Cluster Controller
  - Service Catalog
- Catalog based GUI
  - Service Policy Manager & DB
  - Performance / Fault Monitoring

vSOC Infrastructure (Orchestration, Event Notification & Messaging)

- IP Address Management
  - DHCP
  - DNS
- Routing Control
  - DC Edge
  - Service Routing
- Services Configuration
- VM Control & Elasticity Management

Elastic network services

Elastic tenant Workloads/VMs

Server 1

- vPEF
- Tenant 1: VNF 1
- Tenant 2: NNF 1

Server 2

- vPEF
- Tenant 1: VNF 2
- Tenant 2: VNF 3

Server 3

- vPEF
- Tenant 1: VM 1
- Tenant 2: VM 1

Multiprotocol Label Switching (MPLS), GRE, L2TPv3, VXLAN

Multi-Protocol Label Switching (MPLS)
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

BGP MPLS VPNs extended into the DC

WAN Controller
Collector & modelling
Programming

Cloud Controller (vSOC)

DC WAN Gateway

Server
vPEF

VRF1

Tenant 1 VM

Tenant 1 VM

Tenant 2 VM

Tenant 2 VM

Tenant 3 VM

SP WAN

SP Data Center

DC Fabric
Virtualized Network Services – Mozart

Use-case: VPC and NFV Service Chaining

WAN Controller
Collector & modelling
Programming

Cloud Controller (vSOC)

Service Chaining through multiple Virtualised Network Functions

DC WAN Gateway

SP WAN

SP Data Center

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END USER PORTAL

Simple, Intuitive UX

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

Spin Up New Services in Minutes
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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

<table>
<thead>
<tr>
<th>IOS-XR</th>
<th>NX-OS</th>
<th>IOS-XE</th>
<th>IOS</th>
<th>Servers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtualized in</td>
<td>Virtualized</td>
<td>Virtualized in</td>
<td>Virtualized in</td>
<td>Such as vPagent, Jump-Host, Others</td>
</tr>
<tr>
<td>XRVR</td>
<td>vNXOS</td>
<td>CSR1000v / Ultra</td>
<td>viOS</td>
<td>(Available)</td>
</tr>
<tr>
<td>(Available)</td>
<td>(Under Test)</td>
<td>(4GB/4CPU only)</td>
<td>(Available)</td>
<td>(Available)</td>
</tr>
</tbody>
</table>
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
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

1. VM Maestro
2. Topology Graph
3. Router Configurations
4. Topology Views
5. Topology Graph with Router Configurations
6. Services
7. OpenStack
8. Virtual Machines / Switches

A1-Console: 17000
A1-Aux: 17001
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