Empowering New Services with Cisco SDN/NFV and ESP portfolio

Khoo Boo Leng – GSP ASEAN Cross Architecture

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Enterprise Business Services Evolution
As Enterprises Move to Cloud, They Demand Same Networking Services from the Cloud as In Their DC

Before 2012: Enterprises want low cost compute and storage from the cloud

- A few non-mission-critical applications in the public cloud
- Low complexity
- Enterprises want lowest cost for compute and storage

Amazon with lots of server scale has advantage

Before 2012: Enterprises want low cost compute and storage from the cloud

Less than 0.5% Workload in Cloud

Implications:

Now: Enterprises want networking services from their cloud

- More of the enterprise apps are in the cloud
- Mission-critical apps in the cloud
- Complexity, security, scaling
- Enterprises want to extend their network to the cloud

More than 3% Workload in Cloud

Implications:

Service providers with network have the advantage
Service Providers’ Unique NaaS Advantage: Their Network Infrastructure

Amazon: Basic NaaS

- No visibility into SP network

Implications:
- Best effort
- Limited SLA – performance, reliability, & availability
- Rudimentary security

Service Provider: Differentiated NaaS

- Visibility
- SLA – performance, reliability, & availability
- Application Visibility
- Robust security
SDN & NFV Trend Overview

**NFV-driven**
- Caching, DNS/DHCP, load balancing, TAS, PCRF, PCEF/DPI
- Fixed AAA, BRAS, core content processing and delivery
- Real-time/convergent charging (RTC, OCS)
- IMS components: CSCF, MGCF, MRFC, SIP servers
- Mobile packet core: MME, PGW, SMSC, ePDG, ANDSF, HSS/UDC
- Core routing functions: Diameter, OSPF, RIPv2, BGP, IS-IS

**CSP SDN-driven**
- Traffic steering in the core: Gi interface and ISP DMZ LAN
- Traffic management and transport: optical, IP RAN, backhaul (RNC, eNodeB)
- Content delivery networks (CDN): caching, transcoding, adaptive streaming, video optimisation
- Access functions: access gateways, edge routers and switches
- Mobile RAN: software defined radio, multi-RAN, HetNets

**Timeline**
- 2014
- 2015
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021
- 2022
- 2023

**Increasing spend from CSPs**
SDN & NFV Application Trend Overview

Deployment Timing for NFV Use Cases

- Business vE-CPE: 64% (2015-2016), 27% (2017 or later), 9% (Won't deploy/don't know)
- Service chaining: 36% (2015-2016), 45% (2017 or later), 18% (Won't deploy/don't know)
- vNPaaS: 32% (2015-2016), 45% (2017 or later), 23% (Won't deploy/don't know)
- vPE: 27% (2015-2016), 50% (2017 or later), 23% (Won't deploy/don't know)
- Mobile core, vEPC: 23% (2015-2016), 45% (2017 or later), 32% (Won't deploy/don't know)
- Consumer home environment: 23% (2015-2016), 41% (2017 or later), 36% (Won't deploy/don't know)
- vIMS core: 16% (2015-2016), 59% (2017 or later), 23% (Won't deploy/don't know)
- vCDNs: 18% (2015-2016), 27% (2017 or later), 55% (Won't deploy/don't know)
- GLAN: 14% (2015-2016), 41% (2017 or later), 45% (Won't deploy/don't know)
- vRAN: 9% (2015-2016), 55% (2017 or later), 36% (Won't deploy/don't know)
- Consumer fixed access: 9% (2015-2016), 45% (2017 or later), 45% (Won't deploy/don't know)
- vBNG: 5% (2015-2016), 64% (2017 or later), 32% (Won't deploy/don't know)

Most Important NFV Use Cases for Revenue Generation

- Business vE-CPE: 77% (Important)
- vNPaaS: 41% (Important)
- Consumer home environment: 32% (Important)
- Service chaining: 32% (Important)
- GLAN: 18% (Important)
- Mobile core, vEPC: 14% (Important)
- vCDNs: 14% (Important)
- vIMS core: 14% (Important)
- vRAN: 14% (Important)
- vBNG: 5% (Important)
- vRAN: 0% (Not important)

Percent of Respondents
SDN & NFV
Overview
SDN Address Network Transformation

Simplify
• Network Abstraction
• Packet Optical Convergence
• Centralized Intelligence

Automate
• ML-SDN
• Network Virtualization
• Autonomous Networking
• WAN Automation

Innovate
• Cross-domain service orchestration
• Flow through Provisioning
• Customer Self Service

OPEN NETWORK FOUNDATION
SDN Key Components

Northbound API
Applications Interface to Program the Network Element

OpenFlow Controller
Central Administration point for Network Element. Ex: POX, cisco XNC

OpenFlow Protocol
Mechanism for OpenFlow Controller to communicate with OpenFlow Agent

OF Agent
Runs on Network Element, receives instructions from Controller and Programs Flow tables
Brings out two models:
Reactive – as packets come in
Proactive – pre program
Service Provider “Network Control Plane” Architecture

- Hybrid Control Plane → Existing distributed control plane + centralized CP function
  - Distributed Components – Functions tightly coupled to data plane
  - Centralized Components – Functions where abstraction is required
- Fully Centralized Control Plane → Where architecturally feasible and required for scale
SDN Protocol & API – High Level View

- Model driven, end-to-end service lifecycle and customer experience focus
- Seamless integration with existing and future OSS/BSS environment
- Loosely-coupled and modular architecture leveraging open APIs and standard protocols
- Orchestration across Multi-domain & multi-layer provides centralized policy and services across entire network
NFV Benefits

- Reduction of network elements to manage & deploy
- Service Elasticity
- Operational efficiencies through virtualization
- Reduced complexity for High Availability
- Automated network operations
- Capex reduction by deployment of standard x86-based servers
- Deployment of best-of-breed
- OPEX decrease by reduction of branch visits
Network Virtualization Rules

- CPU
- Variable CPU / FPGA / NPU
- Distributed: Lots CPUs + NPUs
- Distributed: CPUs + Lots of NPUs
- Centralized: CPU + NPU
- SSL/BSS, subsystem and N/W control
- Wireless GWs
- Wireline GWs
- Backbone, Metro and DC switching
- Appliances (L4-L7)
- Distributed: CPUs + Lots of NPUs
- Centralized: CPU or SoC
- Business CPE
- Home CPE
- Low
- High
- CPU Reqs
Virtualization vs Appliance

{10tps, 10Kbps} {10tps, 5Kbps} {10tps, 3Kbps}

Cost vs Time

{30tps, 10Kbps} {30tps, 5Kbps} {30tps, 3Kbps}

{Average TPS per session, Average throughput per session}
NFV vision
The Architectural Components

- Real: High capacity plumbing and high performance gateways
- Virtualized: CPU intensive functions, low – mid range packet processing functions
- Interaction required between the real and virtual network functions via orchestration
- All use cases ➔ Compute + VNFs + DC virtualization + Orchestration / Redirection use cases ➔ Re-direction + Policy Server + WAN Overlay

Wide Area Network

Data Centre

Orchestration (NFVO)

Virtualised Network Functions (VNFs)

Policy Server

Classification + Redirection Function

Compute + Virtualization Technology (NFVI) + Service Chaining

Customer Premises and / or PoP

Network Overlays

CISCO
NfV Use Case: Virtualized SP / Applications / subsystems

- NFV transition well underway
  - Custom / Specialized h/w → Commercial off the Shelf (COTS) → Today: Virtualized solutions
- Examples: OSS/BSS, IMS, network control, video/collaboration, wireless/wifi, security application
- Onboarding can be an issue due to age and complexity of some OSS/BSS systems
NfV Use Case: Virtualized Edge Gateways

- vPE, vBNG/BRAS, vS/PGW, vCMTS

- Wide range of gateway architectures deployed
  - Regionalized: High subscriber / high capacity dedicated devices
  - Distributed: Gateway functionality integrated into metro infrastructure

- Cisco is complementing existing h/w gateway solutions with virtualized solutions
  - Pure virtualized solution based on CSR1000v
  - Splitting the subscriber control plane function from the data plane function
Virtualized Managed Services

- Ethernet Based Backhaul
- Service Decoupled from Hardware
- Dynamic Service Insertion
- Orchestration / Automation – low touch
- Reduced OPEX
Nfv Infrastructure Orchestration & Implementation
Cisco NFV Architecture Mapped to ETSI NFV Framework

- Modular architecture that conforms to ETSI NFV framework
- Model driven design for declarative NFV orchestration
- Supports Cisco and 3rd party VNF Managers
- Supports Cisco and 3rd party DC SDN Controllers
- Supports Cisco and 3rd party VNFs
X-Domain Orchestration
End to End Orchestration of Elastic Services
Addressing Cross Domain Service Enablement
Different problems that need to be solved in each domain

Cross Domain Orchestration

CPE/Access Control

Multi-layer WAN SDN

Data Center SDN

WAN/Transport Multilayer control, Traffic engineering, BW on Demand, etc

vCPE/NFV Automation, Control, Service Chaining, etc

Physical CPE Automation & Control
Virtual CPE Services
Evolution Of Enterprise Ethernet Services Architecture
Managed CPE Architecture Evolutions – Drivers & Motives

- Major drives – Virtualization, Programmability, SDN and Service Orchestration
- Customer motives that we are hearing behind considering this architecture
  - Reduction of truck rolls
  - Automated Provisioning
  - Better manageability of the customer premises equipment
  - Agile and on-demand service delivery
  - Ability to cross-sell and upsell more value added services on-demand
  - Consumption based pricing model
  - Reduce Total Cost of ownership (OPEX and CAPEX)
  - Faster time to revenue
  - Cloud based service delivery model
  - It is one of the initial NFV use case for some SP’s
NIDs Requirement For Adoption Of vCPE Application

• To be inline with architecture changes for Virtualized CPE deployment
  Layer 2 only access network to customer
  Layer 2 NID is positioned as demarcation device and the only device installed at customer premises

• Access network options:
  Metro BAU - Ethernet
  HSBB - Ethernet
  Ethernet in the First Mile – G.SHDSL (Ethernet)
  Wireless (3G, LTE)

• Other requirements
  Multi-queue SLG support – Layer 3 to Layer 2 (802.1p) Ethernet Priority marking
  Wireless backup – Layer 3 technology
  Ethernet Service Activation capability
vCPE – Implementation
Where it is located

**SP’s POP**
1. Co-located with PE
2. Most common vCPE model
3. One vCPE per one or multiple customers
4. L2 / L3 traffic backhauled from customer premise

**SP Central DC**
1. At central DC
2. May not be common model
3. One vCPE per one or multiple customers
4. L2 / L3 traffic backhauled from customer premise

**On Customer Premises**
1. On-premises vCPE
   Running on x86 server
2. Helps retain most attributes of present architecture
3. More scalable from performance perspective, but difficult to manage

**No where!**
1. It’s not about vCPE → it’s about solving customers business problem
2. Example – Maraki + DSC, ISR-G2 + DSC models
Managed CPE – One Size May Not Fit All

On-Premises Functionality

“Thick CPE”

“Thin CPE”

L2 NID + cloud NfV

Simpler L3 CPE + cloud NfV

L3 CPE + x86 on premise + cloud NfV

L3 “classic” (ISR, MSE, ASA, etc) + cloud NfV

$
vCPE: IP Addressing & Routing Consideration

- IP Address assignment for hosts done by vCPE
  - vCPE has to redirect DHCP requests to the DHCP server
  - Could be offered out of the vCPE using integrated DHCP Server
  - Optional: customer operates a Router (with optional customer configured NAT)
- Traffic destined for the VPN tunneled to the CSR1000v, where it is routed to the destination (back to the customer premise for inter-subnet traffic)
vCPE : QoS Consideration

- CPE-lite or NID: L2-Cos for traffic coming from the hosts into the L2 tunnel
- Marking / re-marking of IEEE 802.1q bits according to the Metro Ethernet COS scheme
- TM have to re-mark the MPLS EXP bits at the EPE for MPLS Pw Upstream transport
- vCPE: downstream L3 QoS, either for core-facing traffic or for traffic returning to the customer premise
vCPE: Security Consideration

- Securing CPE-lite – L2 Security
  - Deploying limited physical ports,
  - Port security: Limiting MAC address tables / timers
  - BPDU Guard
  - L2 ACLs
  - ARP inspection
  - Option 82

- DDoS prevention and Broadcast Storm Suppression at the Metro Aggregation
- Traffic filtered by L3 in the vCPE
Virtual Branch High-Level Architecture Building Blocks

Interface to orchestrate, automate, and manage day 1, 2, N (REST, NETCONF, SNMP)

Decoupled and elastically provisioned network services (AVC, FW/IPS, IPAM, Routing, WAN Opt, etc)

Provide container host for VNFs and abstract hardware (KVM, ESXi, Xen, Hyper-V)

General Linux OS for platform support, deploy to generic COTS HW (UCS), and leverage purpose built (CSX, 4K, etc.)
ISR4K with integrated UCS E-Series Server

+ All-in-One Integration
+ On-Demand Services
+ Common Server Management Tools
+ Vendor Agnostic
+ Small Footprint

+ Rugged Core Network Platform with dedicated hardware
+ 7-Year Hardware Lifecycle
+ One Support Contract
+ Integrated WAN and Ethernet Switch
+ Integrated Services
+ Redundant HW & SW (VM and IOS)
Branch Virtualization – On Premise Options

1. **Router + integrated L4-7 services**
   - E.g. ISR + UCS-E
   - Router performs transport functions (Routing, ACL, NAT, SNMP..)
   - Services (Firewall, WAAS..) virtualized on UCS-E
   - Optional redundancy

2. **Router + virtualized L4-7 services**
   - Router performs transport functions (Routing, ACL, NAT, SNMP..)
   - Services virtualized on external server
   - Optional redundancy
   - VNFs Could be multi-vendor (Best of breed)

3. **Fully virtualized Branch**
   - Physical router replaced by x86 compute
   - Both transport and network services virtualized
   - Optional redundancy
   - VNFs could be multi-vendor (Best of breed)
Virtualizing Enterprise Branch Environments
Solution Components

1. Multiple X86 compute form factors to fit all branch profiles
   • Including operating system to manage life-cycle of virtualized functions
   • Including plug-and-play functionality for automated branch and service instantiation

2. Virtualized network functions and applications
   • Cisco VNF’s - CSR, vWAAS, vASA, vDPI (NBAR/SCE) and more
   • 3rd party VNFs and applications (non VNF)

3. Orchestration – provision VNFs, service chaining, VM life cycle management & VNF service management

4. Fit into the IWAN Architecture and defined branch golden profiles
   • Small, medium, large - w/ the appropriate services
   • Hybrid, MPLS+DIA w/IWAN services

<table>
<thead>
<tr>
<th>Priority</th>
<th>VNF</th>
<th>Function</th>
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<tbody>
<tr>
<td>1</td>
<td>CSR 1000v</td>
<td>L3-L7 integrated routing</td>
</tr>
<tr>
<td>2</td>
<td>vWaas</td>
<td>WAN optimization</td>
</tr>
<tr>
<td>3</td>
<td>Sourcefire</td>
<td>IPS/IDS</td>
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<tr>
<td>4</td>
<td>ASAv</td>
<td>Firewall</td>
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<tr>
<td>5</td>
<td>SRST</td>
<td>VoIP Call Control</td>
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<tr>
<td>6</td>
<td>Unity Cxn</td>
<td>VoIP Voicemail / AA</td>
</tr>
<tr>
<td>7</td>
<td>WSAv</td>
<td>Web security</td>
</tr>
<tr>
<td>8</td>
<td>vWLC</td>
<td>Wireless LAN controller</td>
</tr>
<tr>
<td>9</td>
<td>CUBE</td>
<td>SIP Trunking</td>
</tr>
<tr>
<td>10</td>
<td>CME</td>
<td>Call Processing</td>
</tr>
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Orchestration With NSO tail f
Orchestration describes the automated arrangement, coordination, and management of complex computer systems, middleware and services.

Enter *Network Service Orchestration*

- Service Agnostic
- Network Agnostic
- Model Driven
No hard-coded assumptions about
- network services
- network architecture
- network devices

Instead:
Data models written in YANG (RFC 6020)

Benefits:
- Service Agility
- Service Flexibility

10x-100x improvement in TTM for new Services or Devices
NSO CLI

- Service-aware
- Network-wide
- Juniper style
- Cisco XR style
- Powertool
- Helps keep the current domain experts
- Rich editing with tab-completion for commands, static elements and dynamic instances
- History, hints, help
- Extensible with custom/external commands, wizards
NSO REST

- Relies on verbs of transport layer:
  - HTTP 1.1
  - GET: get resources
  - PUT: replace existing resource
  - POST: create resource
  - DELETE: delete resource
  - PATCH (RFC5789): modify existing resource
  - HEAD, OPTIONS
- Stateless, client-server
- Hyperlinked, just like the web
- XML or JSON as data containers
- Links to available data-stores and operations

$curl -u admin:admin -s http://localhost:8008/api
  /api/running
  /api/candidate
  /api/operations
  /api/operational
  /api/rollback
Case Study: VPN Provisioning

Business Challenge:
Fast delivery of various types of VPNs (L2 and L3) and Carrier Ethernet 2.0 services for traffic separation in a dynamic, programmatic way.

Business Outcomes with NSO:
- Automated provisioning of complex VPNs spanning 50,000+ devices from multiple vendors using network-wide, transaction-safe features
  - Juniper MX series core routers
  - Cisco for PE
  - Overture, Adtran and ADVA for CE
- Support for provisioning, updating and removing VPNs using minimal diffs
- Drastically reduced TTM
- API integration with customer self-service portal, OSS, and analytics systems

```bash
admin@ncs% set services service cust1 type eLine evc evc1 ce-vlan 888
admin@ncs% set services service cust1 type eLine evc evc1 endpoints c0 uni-interface TenGigE 0/3/0/4
admin@ncs% set services service cust1 type eLine evc evc1 endpoints c3 uni-interface TenGigE 0/3/0/1
admin@ncs%
```
Network Provisioning Compliance Tool

Benefits with NSO:

- Network-wide CLI & Web UI
- Fine-grained, deep transaction-safe configuration changes with rollback across atomic change sets
- Engineers use NSO as a power-tool for new automated, paper free MOP process
  - Compliance
  - Technical review
  - Execution – with rollback
  - Post change compliance – with rollback
  - Service validation – with rollback
- Audit, Compliance and Reporting
  - Device groups to keep HA pairs in sync
- Backup and history
  - NSO export to offline database

Automation of IP service provisioning in mobile transport
Architecture Implement Approach
SDN/NfV Architecture Framework
Exploration Phase 1 (Network Optimisation)

Cross Domain Orchestrator (RFS)

Service Catalog
Portal

Service Provider
OSS Service Provider
Existing Portal/Catalog

Customer-Facing Service

Cross-Domain Orchestration

Modular Components

Open Architecture

Open Daylight

Virtual Physical
Evolved Programmable Network

Compute
Storage
Network

Cisco or Third Party
WAN Controller – WAE For Network Optimization

Description: SDN controller (WAN-Orchestrator) to compute dynamic/explicit path across the WAN to guarantee customer SLA (Bandwidth, Packet lost, Jitter, Backup…)

Business: SP to monetize the SP core, MPLS simplification

Platforms: ASR9K, CRS, NCS6000, Scapa, Quantum Wave Orchestration, 3rd party Routers (Juniper, ALU, Huawei)

SDN Elements: Open Day Light controller, BGP LS, Netflow, PCE-P, Segment Routing, NETCONF/YANG
Use Cases: Restoration & Path Re-route

**Multi-Layer Network Optimization**
Global network view | Optimization across layers
15% interface savings

**Multi-Layer Service Activation**
Months to Minutes | Simple, focused applications
Constraint-based routing

**Multi-Layer Restoration**
>40% Interface Savings | Zero Touches
Re-use stranded network assets

**Coordinated Maintenance**
Multi-layer service awareness | Months to Minutes
Hitless multi-layer re-route
Dynamic Bandwidth on Demand

- Use only what you need
- For as long as you need it.
- Incrementally pay for what you use.
- No bandwidth management required.

Business Impact:

- Market Disruption
- Increase revenue per bit.
- Increase market differentiation.
- Lower OpEx.
Segment Routing Across WAN and DC

Application requires the lowest latency path in the WAN

- WAN has cheap capacity via US with higher latency.
- Scarce, expensive capacity via Russia, with lower latency.

Customer identify the applications that require the lowest possible latency on the service catalogue, integration steers that traffic on the path via Russia.
BOD & Calendaring – Enables New Classes of Service

- Self-Service Portal
- Optimal Service Deployment
- Collect
- Deploy
- Congested!!
- Multi-Vendor Agile Infrastructure
- Enterprise Data Center

Steps:
1. Auto Collects Traffic & Topology
2. Service Request Made
3. Predictive Analysis with Network Impact and Optimization
4. Optimal Service Deployment

Cisco Evolved Programmable Network
SDN/NfV Architecture Framework
Exploration Phase 2: vCPE & vBranch

Customer-Facing Service

Cross-Domain Orchestration

Modular Components

Open Architecture

Infrastructure

Virtual Physical

Evolved Programmable Network

Cisco or Third Party

Service Catalog

Portal

Prime Fulfillment

RT-OSS (CFS)

Cross Domain Orchestrator (RFS)

Managed CPE

Meraki/Tail-f

WAN Optimization

WAE

NSO (Tail-f)

OpenDaylight

OpenStack

Service Provider

OSS Service Provider

Existing Portal/Catalog

Evolved Programmable Network

Compute

Storage

Network

Cisco or Third Party

Evolved Programmable Network

Customer-Facing Service
vCPE & vBranch Solution

Customer Orders VPN Service

Tenant Portal

SP's OSS/BSS

REST API

REST API

PnP Server

Provide Day 1 Configuration

PnP Functionality
Zero Touch Provisioning

Network Services Orchestrator (NSO)

Elastic Services Controller (ESC)

Virtual Topology Controller (VTC)/ODL

More scalable and flexible service chaining enabled with VTC & high-performance VTF

OpenStack

SMARTNID

SMARTNID Shipped to Customer Site, connected & Powered ON

Establish VPN: IPSec, IP Overlay (VXLAN, GRE, LISP), L2

CloudVPN Connectivity up

If more VNFs are needed for a Service Chain?

vWAAS

ToR

vASA

vCPE

VCPE

OVS/VTF

Server

PE

X86 Server

If more VNFs are needed for a Service Chain?
End State Architecture

Service Provider OSS Service Provider
Existing Portal/Catalog

Customer-Facing Service

RT-OSS (CFS)

Cross-Domain Orchestration

Service Catalog

Portal

Cross Domain Orchestrator (RFS)

Prime Fulfillment

Modular Components

Enterprise
Managed CPE
WAN Provisioning
WAN Optimization
Cloud
Intercloud Fabric
Network Function Virtualization
Dynamic Services Composer

Open Daylight

OpenStack

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Cisco or Third Party

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Cisco or Third Party
TOMORROW starts here.