White Paper

Cisco NFV Solution: Enabling Rapid Service Innovation in the Era of Virtualization

NFV Orchestration Overview

Network Function Virtualization (NFV) technology, in combination with software-defined networking (SDN), promises to help transform today's carrier networks - in how they are deployed and managed, and the way services are delivered. The ultimate goal is to enable service providers to reduce costs, increase business agility, and accelerate time to market of new services.

NFV decouples network functions from underlying hardware so they run as software images on commercial as well as purpose-built hardware. It utilizes standard virtualization technologies (compute, network, and storage) to virtualize the network functions. This reduces service providers' dependence on dedicated, specialized physical devices by allocating and utilizing the physical and virtual resources only when and where needed. In doing so, service providers can reduce overall costs by shifting more components to a common physical infrastructure while optimizing its utilization, and respond more dynamically to changing service demands.

Simple examples showing the benefit of an NFV service are a virtualized firewall or a load balancer. Instead of installing and operating a dedicated appliance to perform the network function, NFV allows operators to simply load the software image on a virtual machine (VM) on demand. In a mobile network, examples would include virtualizing the mobile packet core functions such as packet data network gateway (PGW), serving gateway (SGW), mobile management entity (MME), and so on.

NFV decouples the network function from the hardware. However, delivering services over an infrastructure that includes these virtual network functions (VNFs) requires special orchestration capabilities.

Traditional orchestration, in the broader context of service fulfillment, is the process of coordinating and aligning business and operational processes in designing, creating, and delivering a defined service. This orchestration process involves the use and management of complex systems and tools such as order, inventory, and resource management systems, configuration and provisioning tools, and operational support systems (OSSs) combined with the processes associated with these tools and systems. Orchestration solutions play a critical role for service providers by automating tasks across technologies and organizations, by integrating with business support systems (BSSs) and customer relationship management (CRM) systems orchestration, and by ultimately reducing order-to-revenue time.

NFV orchestration has unique requirements based on the need to automate the delivery of network services through the provisioning of multiple technical resources based on service intent. These requirements include:

- **The rapid configuration, provisioning, and chaining of virtual network functions** in addition to other resources required for the service. The capability of chaining several VNFs is important to create innovative and customized services.

- **Intelligent service placement:** Automating the determination and selection of a physical location to place the VNFs depending on various business and network parameters like cost, performance, and user experience. A VNF can be placed on various devices in the network - in a data center, in a network node, or even on the customer premises.
- **Dynamic and elastic scaling of services:** The orchestration process maps the instantiation of virtual network functions against the real-time demand. This capability frees up physical capacity to be used for other services. In doing so, service providers utilize their infrastructure more efficiently. Service providers can also achieve a more predictable and optimized return on investment (ROI) by deploying additional network services without unnecessary equipment costs. This is especially beneficial for service providers with limited subscriber populations faced with having to add hardware that may significantly exceed the foreseeable demand in services.
- **Full lifecycle management of the VNFs:** This includes the creation, instantiation, and monitoring of the VNF until it is decommissioned.

The goal of NFV is to help enable service providers to better meet their business objectives of agility, reduced costs, and faster service delivery, and in order to do so it will have to interwork closely with existing OSSs. A September 2013 report in **Heavy Reading** cited some of the challenges:

"…NFV requires the implementation of a completely new level of management - not only of cloud infrastructure and the virtual resources that make up that infrastructure, but also of the consumption of those resources by individual VNFs. At the very least, NFV will require existing operations support systems (OSS) to interact with cloud resource management systems such as OpenStack. In the future, a cloud management and orchestration function and associated data center management systems may supersede 'legacy' OSS functionality and systems."

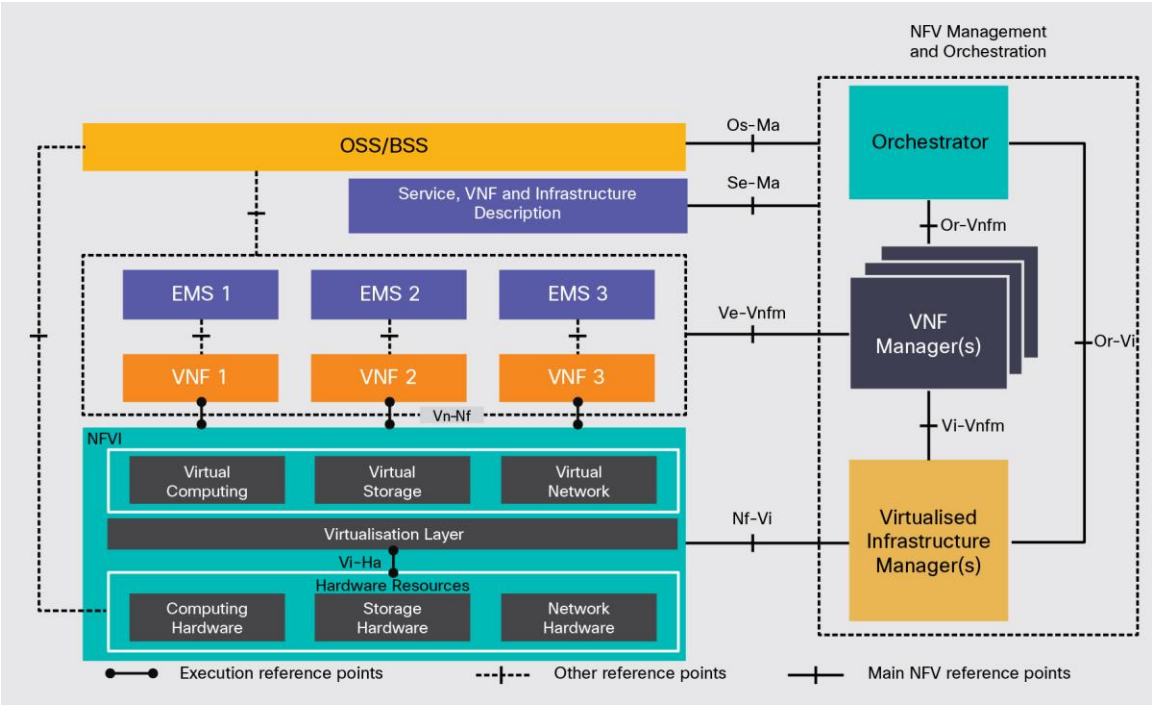
The Cisco® solutions for the current and future requirements the **Heavy Reading** article refers to are coming fast. As an undisputed leader in network and cloud infrastructure solutions, Cisco is delivering NFV orchestration solutions based on powerful, proven technologies for managing virtualized services and clouds.

The following section covers industry standards for NFV management and orchestration (MANO) that are the guiding design principle for the Cisco NFV Solution, followed by a section outlining Cisco's differentiated approach to providing this industry-standards-based solution.

Evolving Industry NFV Orchestration Standards

Figure 1 is an example of a framework provided by the European Telecommunications Standards Institute (ETSI) NFV Industry Specifications Group, a consortium of service providers and vendors that addresses NFV architectures and orchestration for NFV.

Figure 1. ETSI NFV Reference Architecture



The ETSI MANO framework breaks down the management and orchestration needs for the NFV architecture into three functional layers:

- **Virtualized Infrastructure Managers (VIMs):** This layer handles the virtualization of physical hardware in the data center by integrating with VM managers like OpenStack or VMware vSphere. Using a hypervisor like ESXi or KVM, the VM manager provides the ability to create multiple virtual compute, network, and storage elements. The VIMs provide lifecycle management functions (create, edit, delete, start, and stop) for the virtual data center elements related to compute, network, and storage functions.
- **VNF Managers (VNFMs):** The VNF managers handle the configuration, lifecycle management, and element management of the virtualized network functions.
- **NFV Orchestrator (NFVO):** The orchestrator provides lifecycle management of the network services that includes instantiation, scale-out/in (elastic scaling), performance measurements, and event correlation, as well as resource management, validation, and authorization for resource requests, and policy management.

The VIM and VNFM layers together provide the VNF and resource lifecycle management capabilities. The NFVO provides the lifecycle management around the virtualized network service.

Attributes of Best-in-Class NFV Orchestration

While traditional OSS vendors are trying to adapt their existing product lines to cater to the needs of the NFV world, the reality is that most of them have yet to effectively address the needs of service providers described earlier in the paper. First, emerging best-in-class orchestration should be based on a layered and abstracted approach as illustrated in the ETSI framework. The goal of the layered approach is to allow easier management of various domains or functions leading to a more flexible infrastructure and enabling the addition of functions and platform features as needs arise, including those from third-party vendors. Abstractions allow operators (without deep technical knowledge) and their customers to provide and consume services, respectively, without having to understand the complex underlying physical infrastructure.

Additionally, the best-in-class orchestration solution should provide the following important characteristics:

- **Open technology and standards-based API**, so it can integrate multiple vendor technologies across network domains, supporting not only northbound integration (to customer facing applications) and southbound integration (to infrastructure elements) but also east-west integration to Cisco or third-party systems components.
- **Flexible and agile architecture**, to simplify the management of interdependent operational processes while meeting evolving and changing business needs. The NFV orchestration solution should seamlessly integrate with the legacy OSS and tools that service providers use to manage their current infrastructure and support service instantiation across mixed physical and virtual network elements. The blending of current capabilities and services with new service components will help service providers utilize the benefits of "up-sale" and "cross-sale" tactics to retain customers, expand average revenue per user (ARPU), and address large, medium, and small business services.
- **Scalable and multitenant**, supporting a wide spectrum of services that meet a wide range of customer needs.
- **Elasticity**, to meet unpredictable service demands and optimize the usage of network capacity and resources. The goal is to place network functions where they will be least costly yet most effective in meeting the requirements of the service and to provision specific resources only when needed. The solution should enable the intelligent use of network capacity, resources, and policy-based service standardization to minimize both operating expenses (OpEx) and capital expenditures (CapEx).
- **Rapid service delivery**, allowing for services to be turned on in minutes or hours instead of weeks or months.
- **Support for high availability** for service reliability.
- **Policy compliance**, spanning regulations and security requirements to help meet end-to-end service-level agreements (SLAs).

The Cisco NFV Solution for the Evolved Services Platform

The Cisco NFV Solution has been developed to address orchestration requirements for NFV and the spectrum of service provider services. It is part of the Cisco Evolved Services Platform (ESP) aligned with Cisco's Open Network Software Strategy, Figure 2. Cisco ESP provides the overall framework for unified, end-to-end services delivery over legacy and next-generation physical and virtual infrastructures, spanning multiple network domains including customer premises equipment (CPE), WAN, NFV, data center, and more. The Cisco NFV Solution offers the required attributes for best-in-class orchestration, as outlined in the previous section, for the NFV domain of the Cisco ESP.

Figure 2. Cisco Open Network Software Strategy

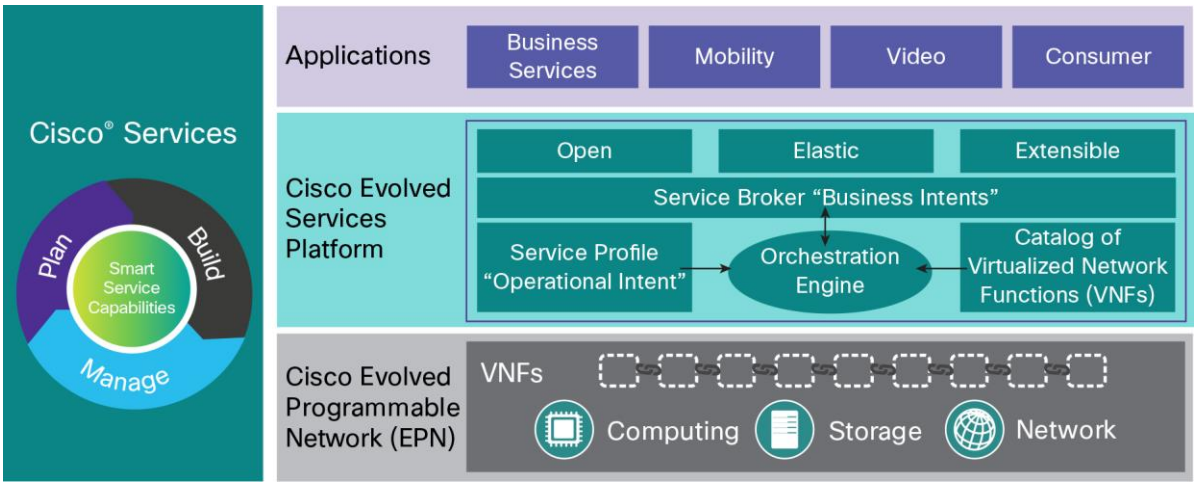
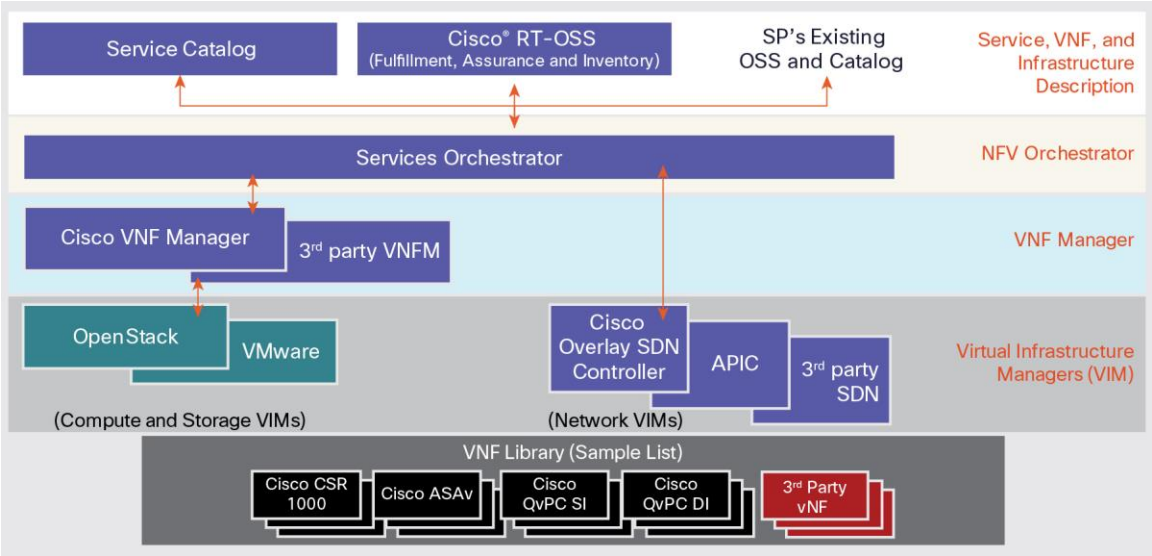


Figure 3 illustrates the Cisco NFV Solution and how it maps to the ETSI MANO framework introduced earlier. It is composed of three key functional building blocks - the Services Orchestrator, the VNF Manager, and the Overlay SDN Controller. Other elements of the Cisco NFV Solution include the Service Catalog, responsible for providing the self-service portal for ordering and designing services, and a real-time OSS (RT-OSS) for visibility into time-to-service, order tracking, jeopardy management, and SLA measurement related to the fulfillment and delivery of services, among others. All components can be deployed independently or as a combined solution.

Figure 3. Cisco NFV Solution Architecture



The Services Orchestrator is responsible for providing the overall lifecycle management at the network service level. It utilizes model-based workflows that enable the design of services based on predefined service elements and the reuse of existing service templates. This allows service providers to rapidly fulfill a large variety of services. The Services Orchestrator provides a northbound interface to OSSs and BSSs, and helps support the business management of services delivered across both legacy and virtualized infrastructures.

The Services Orchestrator also provides intelligent workload automation by using real-time analytics and performance monitoring. Based on factors such as hardware and VM utilization data as well as inventory, fault, performance, and analytics data for the deployed VNFs, services can be strategically placed in the most optimal locations across the infrastructure - enhancing service performance and availability while optimizing the use of resources.

The Services Orchestrator also enables policy-driven capacity management, which involves the setting and enforcement of policies and the use of resources based on business considerations, compliance requirements, and SLAs. For example, service providers can set thresholds on the run rate (cost of operations) of implementing an NFV service in aligning with their business objectives. A compliance requirement may include ensuring a level of security provisioned with an NFV to comply with industry or government regulations, while SLAs may require specific bandwidth or quality of service (QoS).

The VNF Manager provides automated VNF lifecycle management including the creation, provisioning, and monitoring of VNFs. The VNF Manager is also responsible for the scale-up and scale-down of the VNFs based on dynamic and fluctuating service demands. The VNF Manager uses cloud computing resource managers such as OpenStack and VMware at the VIM layer to configure and provision compute and storage resources across multivendor data center networks.

The Overlay SDN Controller provides management of the virtual overlay of the data center infrastructure and connects the virtualized services (a VNF or a set of chained VNFs) to the service provider VPNs, the Internet, or both. This enables rapid deployment of complex virtualized services made out of composite VNFs in multitenanted service provider data centers.

Other functionalities of the Cisco NFV Solution include, but are not limited to:

- Assigning IP addresses to physical and virtual resources
- Loading of new device and service models (a software image on a VM would be required to deploy a virtual network function)
- Updating of service model attributes; default attributes are available; however, the operator may want to modify these attributes based on the specific service requirement
- Ensuring of certificate authority, system identity, authentication, authorization, and accounting (AAA) management, and crypto functions for authorization purposes as well as for the enforcement of licensing

Through the functionalities described above, the Cisco NFV Solution helps drive the required business and operations management that helps enable a seamless, unified service delivery experience for customers.

How Cisco NFV Solution Offers Best-in-Class Attributes

In earlier sections, we've described the basic building blocks and their associated functions of the Cisco NFV Solution and the best-in-class orchestration attributes. Table 1 summarizes how the solution supports these required attributes, along with a description of their benefits.

Table 1. Cisco NFV Solution Summary: Best-in-Class Orchestration Capabilities

Required Attribute	NFV Solution Capabilities	Benefits
Open technology and standards-based APIs	• Uses Representational State Transfer (REST) API for integration with BSS/OSS or higher-level orchestrators and applications • Uses common and open languages to enable data model and service model flexibility such as the YANG standard for network configuration management and Technology and Orchestration Specification for Cloud Applications (TOSCA) • Hypervisor and VM manager agnostic, using systems such as OpenStack to manage compute and storage resources • Supports service catalog with VNFs from Cisco and third-party vendors	• Lower operational costs through ease of integration and use of existing tools, systems, and applications • Industry-standard approach to service design • Flexibility to choose the required and/or desired vendor technologies, solutions, and applications
Architecture flexibility, agility, and scale	• Provides a multitenant service creation environment that allows users to design services based on single or multiple VNFs and single or multitenant configurations • Overlay SDN Controller provides operators to work with multiple overlay technologies to easily create rich service topologies without having to understand the complex underlying physical topology of the data center network • Supports orchestration across multiple distributed data centers • NFV Solution is a part of the Cisco ESP, an end-to-end service management platform for the EPN supporting both VNFs and physical network functions (PNFs)	• Maximum service availability, scale, and performance through distributed control and usage of network resources • Better return on investment by making full use of existing infrastructure to deliver end-to-end services • Service providers can transition to virtualized networks at their own pace through support for both legacy and virtualized elements • Subscriber-centered, service-driven, programmable networks
Service elasticity	• Supports policy-driven, elastic scale-in/scale-out operations based on application performance trends • Enables deep, real-time analytics, for optimized, network-aware service and content placement. Network-aware service admission and placement technology assesses which locations have available resources and where in the network is the most optimal to physically place a service	• Increased ROI through better resource utilization • Ability to offer a pay-as-you-go service model (subscribers are charged based on strictly monitored usage) • Lower costs through better utilization of resources with minimized risks to service performance degradation. Cisco has found that intelligent network-aware service placement can support 30-35 percent more traffic for the same provisioned bandwidth as compared to other workload placement algorithms
Rapid service delivery	• Simple interface for designing and modifying VNF templates including drag-and-drop controls. Services are presented in a technical catalog for direct access or for publishing to an OSS. • Automated orchestration, VNF lifecycle management, and workload automation • Offers an extensive and growing VNF library	• New services can be quickly introduced and monetized, through configuration and customization rather than development
High availability and policy compliance	• A virtual forwarder in a VM isolates network failure domain from compute • Comprehensive events and alarms to detect failures at multiple layers of the architecture stack. Alarms can be set to alert administrators to specific policy violations. Policy controls access restrictions, security measures, and auditing procedures at the solution governance level help ensure predictable outcomes for adherence to SLAs • Monitoring of service availability and redeployment provides visibility when failures occur. All data required is maintained in the policy database so services can be rebuilt in the event of a catastrophic failure	• Ability to meet stringent SLAs • Support for industry and government regulations including subscriber privacy policies

A Look at the Cisco NFV Solution in Action

Figure 4 illustrates the simplified service delivery and consumption process enabled by the Cisco NFV Solution. A new service can be easily created using drag-and-drop elements in templates. Once the service is instantiated, the clock now starts for the billing cycle with little to no human involvement. This puts the power in the user's hands and allows the service provider to generate revenue more quickly. The customer at a later date may decide he or she needs more capacity or additional services. This new model lends itself to an automated, highly agile service creation environment.

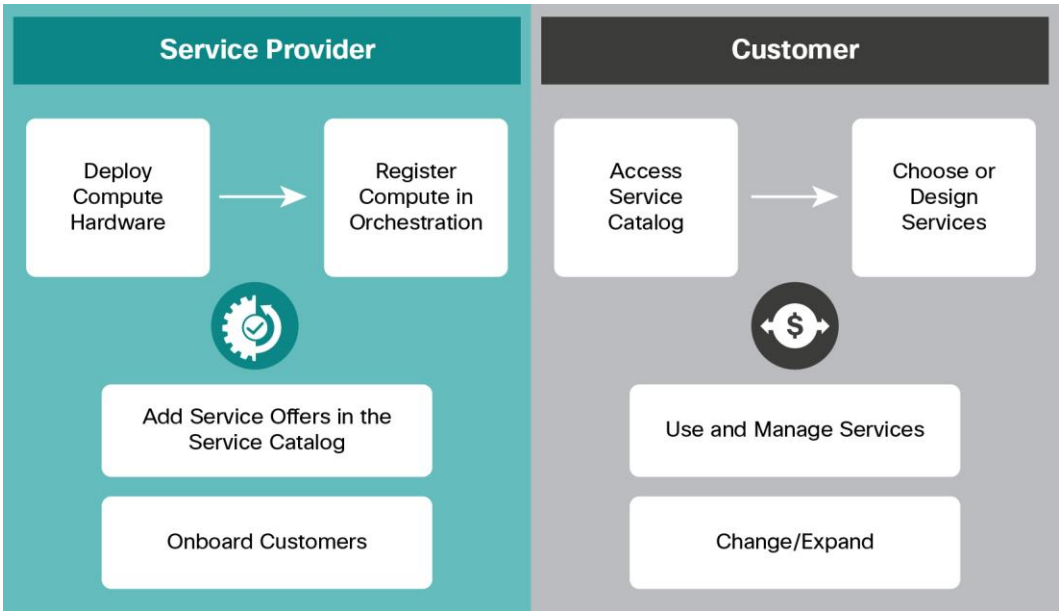
On the service provider side, the process involves:

- Operator allocates resources for the physical underlay by deploying the computer hardware and associated connectivities.
- The available resources are registered to the orchestration system.
- Operator provides service offerings by creating blueprints and placing them in the services catalog for end users to consume.
- Customers are added to the list of consumers with specific authorization levels and permissions.

On the customer side, the process involves:

- Customer accesses the services catalog to order a service.
- Customer selects from list of services in the catalog or designs a service blueprint that meets the customer's specific requirements.
- Services can be changed, expanded, or upgraded based on customer's evolving requirements.

Figure 4. Service Lifecycle - Service Provider to Customer



Summary

Evolving new solutions and industry approaches aim to transform service provider operations into faster, more agile, less complex, and highly cost-effective service delivery environments. SDN, NFV, automation, and orchestration all play important roles. The challenge is how to bring these elements together, supporting the coexistence of both traditional (legacy) and virtualized networks and facilitating the transformation process.

The Cisco NFV Solution makes full use of exciting work by the ETSI NFV Industry Specifications Group that defines a layered and abstracted approach to service management and orchestration. It supports open technology, standards-based APIs, and a scalable and agile architecture that enables rapid delivery of rich service offerings over multitenanted environments. The Cisco NFV Solution is an integral component of Cisco ESP, a unified service management platform for deploying physical and virtual network services in today's carrier networks.

The Cisco NFV Solution and its various components can be deployed independently or together as an integrated suite, as well as in conjunction with other domain solutions within the Cisco ESP. The Cisco NFV Solution provides application-aware control, management, and orchestration across the multivendor ecosystem. It uses Cisco's proven technologies and capabilities for managing virtualized services and cloud, already serving thousands of customer deployments worldwide.

Americas Headquarters
Cisco Systems, Inc.
San Jose, CA

Asia Pacific Headquarters
Cisco Systems (USA) Pte. Ltd.
Singapore

Europe Headquarters
Cisco Systems International BV Amsterdam,
The Netherlands

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