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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Next Generation Networks – Enhancements to NGN

Requirements and capabilities of orchestration in next generation network evolution

Recommendation ITU-T Y.2323

International Telecommunication Union

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Recommendation ITU-T Y.2323

Requirements and capabilities of orchestration in next generation network evolution

Summary

The orchestration in next generation network evolution (NGNe) is of great significance, because it takes into consideration the coexistence and corporation of traditional networks, such as the next generation network (NGN) and the network enabled by software-defined networking/network function virtualization (SDN/NFV). This Recommendation provides orchestration scenarios in NGNe, specifies the general requirements of the orchestration in NGNe, and also introduces its capabilities from the perspective of NGN evolution and the coordination of NGNs and the networks implemented by SDN and NFV technologies.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2323	2018-12-14	13	11.1002/1000/13805

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Next generation network, NFV, orchestration, SDN.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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1 Scope

This Recommendation provides orchestration scenarios in next generation network evolution (NGNe), specifies the general requirements of NGNe orchestration and defines the capabilities of NGNe orchestration. The orchestration in NGNe supports NGN and also incorporates new technologies including software-defined networking (SDN) and network function virtualization (NFV), especially from the network evolution perspective.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.2001] Recommendation ITU-T Y.2001 (2004), *General overview of NGN*.

[ITU-T Y.3321] Recommendation ITU-T Y.3321 (2015), *Requirements and capability framework for NICE implementation making use of software-defined networking technologies*.

[ITU-T Y.3322] Recommendation ITU-T Y.3322 (2016), *Functional architecture for NICE implementation making use of software-defined networking technologies*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 next generation network (NGN) [ITU-T Y.2001]: A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BSS Business Support System

DC Data Centre

E2E	End-to-End
IP	Internet Protocol
IPRAN	Internet Protocol Radio Access Network
IPSec	Internet Protocol Security
MPLS	Multi-Protocol Label Switch
NFV	Network Function Virtualization
NFVI	Network Function Virtualization Infrastructure
NFV-O	Network Function Virtualization Orchestrator
NGN	Next Generation Network
NGNe	Next Generation Network evolution
NGNe-O	Next Generation Network evolution Orchestrator
NMS	Network Management System
NS	Network Service
NSD	Network Service Descriptor
OSS	Operation Support System
OTT	Over-The-Top
PNF	Physical Network Function
PNFD	Physical Network Function Descriptor
QoS	Quality of Service
SDN	Software-Defined Networking
SDN-O	Software-Defined Networking Orchestrator
S-NICE	Software-defined Network Intelligence Capability Enhancement
vCPE	virtual Customer Premises Equipment
VIP	Very Important Person
VL	Virtual Link
VLD	Virtual Link Descriptor
VNF	Virtual Network Function
VNFD	Virtual Network Function Descriptor
VNFFGD	Virtual Network Function Forwarding Graph Descriptor
VxLAN	Virtual extensible Local Area Network

5 Conventions

In this Recommendation:

The phrase "is required to" indicates a requirement that must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

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6 Background and motivations

Traditional operator networks, such as NGNs, lack agility, self-maintenance, on demand deployment and so on. As innovative technologies such as SDN and NFV develop, NGNs need to adopt their advantages to achieve end-to-end (E2E) automatic provisioning and connection, unified management of multi-vendor devices, centralized network service (NS) and network resource control, establishment of connection in combined networks that may include NGNs and SDN/NFV implemented networks.

To provide the features in the previous paragraph, orchestration in NGNe is introduced. Orchestration in NGNe covers not only new networks that are implemented by innovative technologies such as SDN and NFV, but also existing networks (NGNs) that include devices supporting traditional protocols and interfaces. Orchestration in NGNe shall establish connections among NGNs and SDN/NFV-enabled networks based on the high-level view of entire networks, thus E2E connection of the network can be obtained.

Furthermore, orchestration in NGNe is of great significance for network evolution, because it takes into consideration the coexistence and corporation of traditional networks, such as NGNs and SDN/NFV-implemented networks.

7 Requirements of orchestration in next generation network evolution

7.1 Overview

There exist three main types of network, including NGNs, SDN technology-implemented networks and NFV technology-implemented networks. The orchestration in NGNe supports NGN and incorporates new technologies including SDN and NFV, especially from the network evolution perspective. To achieve E2E orchestration, orchestration in NGNe is required to corporate NGNs and networks that are implemented by appropriate SDN and NFV technologies.

Figure 1 illustrates the framework of orchestration in NGNe.

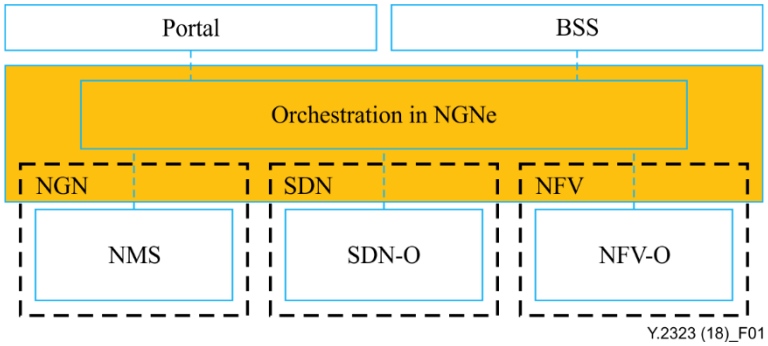

Figure 1 – Framework of orchestration in next generation network evolution

7.2 Requirements to support next generation networks

In the initial stage of network evolution, most services still run on traditional networks, such as NGNs, and the network management system (NMS) is responsible for managing and operating traditional network elements in NGNs.

Orchestration in NGNe is required to include the following aspects to support NGNs:

- interfaces with NMS for NGN service provisioning and activation;

- awareness of corresponding service component to be fulfilled in NGNs;
- receipt of network topology information from NMS;
- high-level understanding of service, network topology and resources of NGNs;
- assignment of resources necessary to establish connectivity services;
- validation or testing of NS functionality in NGNs;
- establishment of collaborations of NGNs with SDN-enabled networks and NFV-enabled networks;
- detection of all flow information and obtaining devices status from NMS;
- management of an abstract view of service, network topology and resources of NGNs.

7.3 Requirements to support an SDN-enabled network

An SDN-enabled network can be a newly designed or established network, or a re-architectured network that does not support SDN before enablement with SDN technology, including a separate control and data plan, and programmatic control of resources and service.

Orchestration in NGNe is required to include the following aspects to support SDN technology-enabled networks:

- interfaces with the software-defined networking orchestrator (SDN-O) to request connectivity through the SDN domain;
- awareness of corresponding service components to be fulfilled in the SDN domain;
- determination of the service components and service access point in the SDN domain;
- receipt of network topology information from SDN-O;
- acquisition of device and control nodes status from the SDN-O;
- detection of all flow information from the SDN-O;
- management of an abstract view of service, network topology and resources of the SDN domain;
- assignment of resources necessary to establish connectivity services based on the view in the previous entry;
- validation or testing of NS functionality in the SDN domain;
- identification of manual service activities and progress tracking in the SDN domain;
- management of multiple SDN-Os and selection of appropriate SDN-Os to interact with, if multiple SDO-Os are deployed.

7.4 Requirements to support a network function virtualization-enabled network

The network function virtualization orchestrator (NFV-O) is responsible for lifecycle management of the NFV NS. An NS consists of one or multiple virtual network functions (VNFs), and the connections between the VNFs or physical network functions (PNFs).

Orchestration in NGNe is required to include the following aspects to support NFV technology-enabled networks:

- interfaces with the NFV-O to allocate/upgrade/release network function virtualization infrastructure (NFVI) resources;
- interfaces with the NFV-O to request instantiation of VNFs;
- interfaces with the NFV-O for service provisioning and activation;
- lifecycle management of VNFs and NSs;
- management of VNF forwarding graphs;

- discovery and awareness of the NFVI hardware/software resources and capabilities/features;
- awareness of corresponding service components to be fulfilled in the NFV domain;
- determination of the service components and service access point in the NFV domain;
- receipt of virtual and physical network topology information from the NFV-O;
- acquisition of VNF and PNF status from the NFV-O;
- management of an abstract view of service, network topology and resources of the NFV domain;
- assignment of resources necessary to establish connectivity services based on the view in the previous entry;
- validation or testing NS functionality in NFV domain;
- management of multiple NFV-Os and selection of appropriate NFV-Os to interact with, if multiple NFV-Os are deployed;
- receipt of performance and fault information of VNFs and virtual resource from NFV-Os.

7.5 Requirements to support end-to-end orchestration

Traditional network, such as NGN, services are managed through an operation support system/business support system (OSS/BSS) and configuration of network elements may go through NMS. SDN and NFV technologies significantly change the way operators design, create and deliver products and services to end users. With standardization of protocols and models, NMS will be replaced by an SDN/NFV orchestrator. However, the existing network and system will not be replaced immediately, and the service will be introduced to run on the SDN/NFV-enabled network step by step.

Orchestration in NGNe manages E2E NSs, including connectivity among NGNs, the SDN-enabled network and NFV-enabled network. The orchestration in NGNe allocates resources, instantiates VNFs and configures network connectivities to activate E2E services.

Orchestration in NGNe is required to include the following aspects to support E2E orchestration:

- receipt and execution of customer or services requests from northbound systems (BSS or Portal);
- request modification before or during request execution;
- request cancellation before or during request execution;
- identification and decomposition of a service request into one or multiple service components, and distribution of these service components into the corresponding domains to fulfil the service;
- interfaces with traditional NMSs, SDN-Os and NFV-Os for E2E orchestration;
- interfaces to modify the workflow and shift a service component from one domain to another;
- interfaces with service assurance-related applications;
- management of an abstract view of static or dynamic resources and network topology of multi-domains;
- lifecycle management of E2E NSs;
- resource allocation and orchestration;
- global topology management;
- network configuration and service activation;
- identification of manual service activities and tracking the progress;
- establishment of collaborations among different network domains;

- establishment of collaborations among networks that are in different evolving phases (e.g., one network is a traditional NGN and another network is a NGN that adopts SDN and NFV technologies).

8 Capabilities of orchestration in next generation network evolution

8.1 Capabilities of service orchestration

Orchestration in NGNe is required to support the E2E services provided by the NGNe provider among combined networks, which include NGNs and networks implemented by SDN and NFV technologies. From the service perspective, orchestration in NGNe shall have the following capabilities, including service decomposition capability, service status checking or querying capability, service catalogue management capability and service lifecycle management capability.

- Service decomposition capability: orchestration in NGNe can receive service requests from BSS or Portal, and calculate the correct sub-services sequence according to every incoming service request, then the orchestration in NGNe shall dispatch sub-services to the SDN-O, NFV-O and NGN NMS, respectively.
- Service status checking or querying capability: orchestration in NGNe can query the status of a service instance, update the status of a service instance and process the status of a service instance. If the status of a service instance become abnormal, orchestration in NGNe shall alarm the status of the service instance to the BSS or Portal.
- Service catalogue management capability: orchestration in NGNe can provide a service catalogue to BSS or Portal and provide a service description for each service in the service catalogue. Orchestration in NGNe allows users and administrators to select services from the catalogue, and also supports updating services in the catalogue including adding new services to the catalogue, removing existing services from the catalogue and updating some parameters of services in the catalogue.
- Service lifecycle management capability: orchestration in NGNe can design a cross-domain service to adapt and meet service requirements from users and administrators. Orchestration in NGNe shall manage the service instance including creating a new service instance, activating a created service instance, deactivating an activated service instance and deleting a deactivated service instance.

8.2 Capabilities of resource orchestration

Orchestration in NGNe is required to support global network resources management and optimization in the combined networks, which include traditional NGNs and networks implemented by SDN and NFV. From the resource perspective, orchestration in NGNe shall provide the following aspects:

- acquisition of a global view of network resources among different networks;
- performance of global resources optimization according to user and administrator requests;
- translation of a service instance into resources requirements;
- allocation and release of network resources;
- adjustment of network resources priority according to quality of service (QoS) requirements from service requests;
- instantiation/scaling/healing/upgrading and deletion of VNFs;
- initiation of a rollback for unsuccessful resources allocation;
- performance of resource pre-occupying request;
- link/route/Internet protocol (IP) address assignment or allocation;
- creation/deletion/updating network connectivity resources;

- enquiry and tracking of resources status;
- monitoring of real-time network resource consumption;
- reporting of alarm messages if resource usage exceeds threshold.

9 Interface requirement of orchestration in next generation network evolution

9.1 Interface requirement with the network management system

Orchestration in NGNe is required to exchange information with the NMS for network management, including a combination of various networks and devices information, such as:

- device status information for device monitoring;
- device interface and flow information for service provisioning and link activation;
- routing information for routing table adjustment;
- service policy information for QoS configuration;
- NGN topology information for global network management;
- NGN device and link usage information for resource management.

9.2 Interface requirement with software-defined networking orchestrators

Orchestration in NGNe is required to exchange information with SDN-Os for connectivity management, including a combination of various networks and devices information, such as:

- SDN device identity information for device registration and recording;
- SDN device interface information for device interface configuration;
- connection information for tunnel establishment [e.g., virtual extensible local area network (VxLAN) or Internet protocol security (IPSec)];
- routing information of SDN domains for routing path management;
- service policy information for QoS configuration;
- SDN network topology information for global network management;
- SDN device and link usage information for resource management.

9.3 Interface requirement with network function virtualization orchestrators

Orchestration in NGNe needs to exchange information with NFV-Os for NS lifecycle management, including a combination of various pieces of virtual network information, such as:

- virtual network function descriptor (VNFD) for initiating or deleting a VNF;
- virtual link descriptor (VLD) for deploying a virtual link (VL);
- physical network function descriptor (PNFD), which is used to determine the connection between PNF and VL;
- virtual network function forwarding graph descriptor (VNFFGD), which is used to determine the forwarding path between different VNFs;
- virtual resource usage information for monitoring and optimization purposes.

This information will be used to form a network service descriptor (NSD), which is used to describe the behaviour requirements of VNF deployment and operation, and also includes connection, interface and virtual resource requirements.

10 Security considerations

The main aspects of security considerations of orchestration in NGNe shall be aligned with software-defined network intelligence capability enhancement (S-NICE) [ITU-T Y.3321] and [ITU-T Y.3322].

Furthermore, to consider the centralized structure of orchestration in NGNe, system is required to ensure a more secure environment. In consequence, orchestration in NGNe is required to support the following features:

- enhanced single point failure protection, because orchestration in NGNe can interact with the SDN-O, the NVF-O and the NMS, therefore any problems of orchestration in NGNe might become a widespread network failure that could affect millions of users;
- secure mechanisms to ensure any configurations sent to orchestration in NGNe can only be generated by authorized parties to prevent malicious attacks;
- detailed log analysis system to provide the history of all configurations and operations conducted by orchestration in NGNe in order to record and detect any unusual actions;
- usage monitoring of the whole network, including SDN-enabled networks, NFV-enabled networks and NGNs, so that the network resource can be assigned and adjusted on demand to avoid overload.

Appendix I

Scenarios for orchestration in next generation network evolution

(This appendix does not form an integral part of this Recommendation.)

I.1 Scenario of Internet protocol and optical orchestration

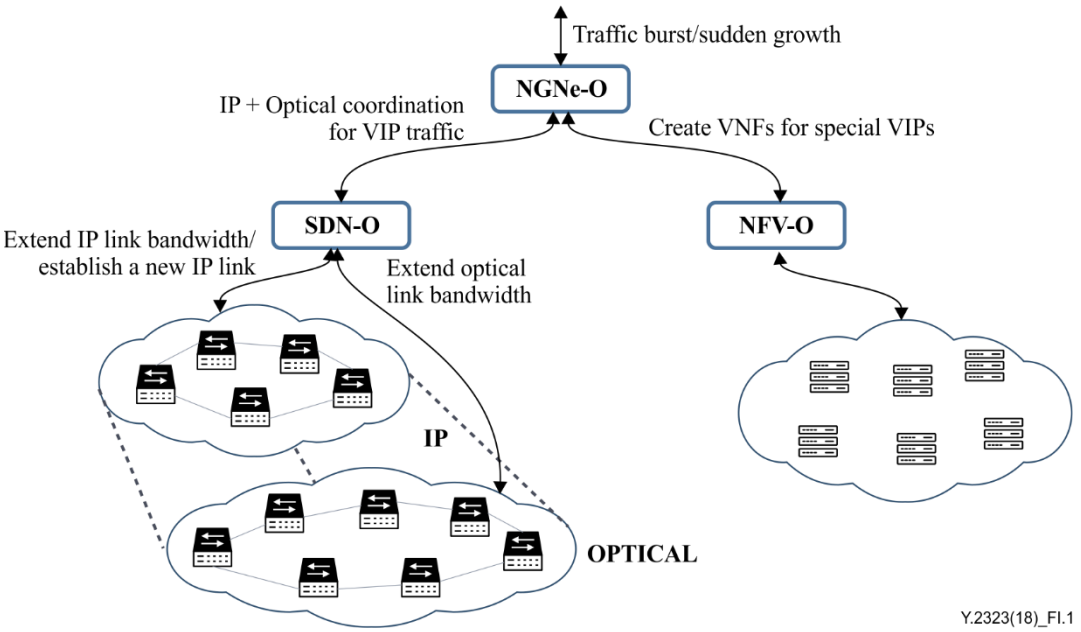

Figure I.1 – Scenario of Internet protocol and optical orchestration

Orchestration in NGNe is able to manage the IP network and the optical network simultaneously. In some special period, a traffic burst or sudden growth may occur in the network. In this scenario, orchestration in NGNe will extend the optical link bandwidth in the optical layer and the IP bandwidth in the IP layer at the same time; as a result, a specific tunnel for very important person (VIP) traffic can be built on demand. In addition, orchestration in NGNe needs to interact with SDN-O and NFV-O to achieve the following features:

1) SDN-O: support for IP and optical coordination for VIP traffic;

2) NFV-O: creation of VNFs for special VIPs (like a firewall).

Furthermore, after connection has been established, orchestration in NGNe monitors the flow status of the IP network; when the flow exceeds the preset threshold value, orchestration in NGNe can establish a new IP link or adjust the bandwidth of the existing IP link in the transmission network.

I.2 Scenario of end-to-end orchestration for the network management system and software-defined networking orchestrator

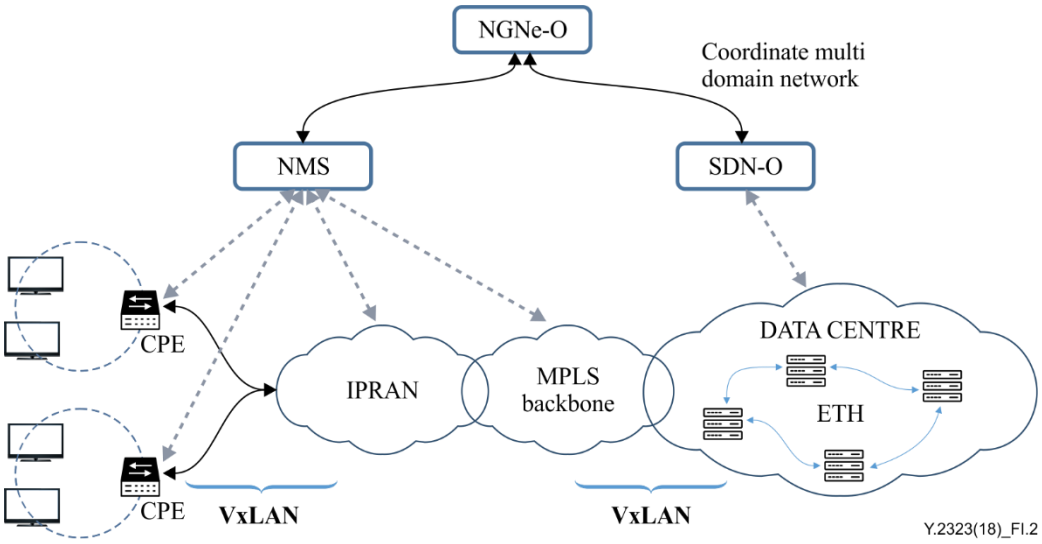

Figure I.2 – Scenario of end-to-end orchestration for the network management system and software-defined networking orchestrator

Orchestration in NGNe is capable of establishing the E2E connection from enterprise virtual customer premises equipment (vCPE) to data centre (DC). In this scenario, multi-segments of VxLAN are needed, not only to access the network and core network, but also the internal network of the DC. For example, when the access network is the Internet protocol radio access network (IPRAN), the core network is the multi-protocol label switch (MPLS) backbone and the internal network of DC is the Ethernet; the provisioning and coordination of vCPE/IPRAN/MPLS backbone/Ethernet are the responsibility of the orchestration in NGNe. Orchestration in NGNe can coordinate a multi-domain network resource (e.g., links, connections, bandwidth, VNFs) to perform operations such as creation, retrieval, updating or deletion in different networks in order to provide an E2E service to customers.

I.3 Scenario of end-to-end traffic-steering orchestration

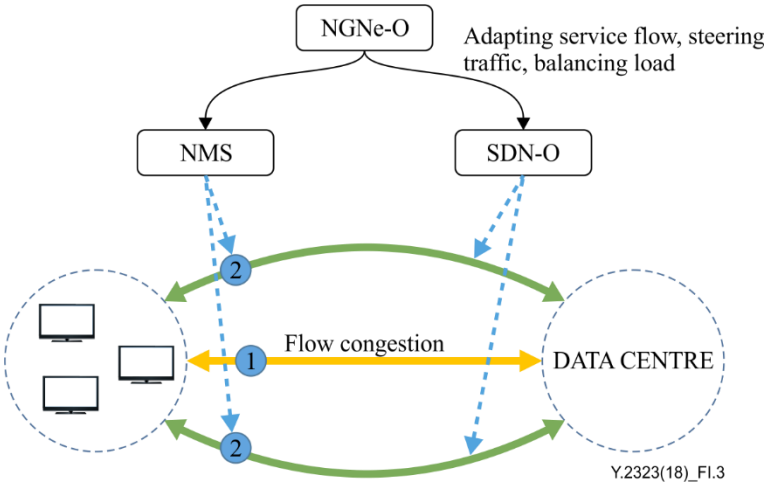

Figure I.3 – Scenario of end-to-end traffic-steering orchestration

With the development of the Internet and cloud technology, the net flow and changing trends in the backbone network present the characteristics of unpredictability and fluctuation. Without

orchestration in NGNe, the telecom operator network lacks coordinated planning, even if the SDN and NFV technologies have been widely implemented in the operator network.

It is very reasonable that the over-the-top (OTT) service flow has the character of fluctuation. For instance, various e-shopping website promotional campaigns will cause surges in traffic to the websites. The traditional planning expansion of the backbone network according to website peak usage, may cause backbone network resources to be idle at normal times. Furthermore, the characteristics of a distributed cloud DC introduce east-west flows between DCs, which raise bandwidth and QoS backbone network requirements, and also cause unpredictable changes in flow.

Therefore, E2E traffic steering orchestration is essential by the orchestration in NGNe, including sensing of the network topology, bandwidth and backbone network traffic, while adapting the service flow from a global perspective of resources, making traffic steering and load balancing automatic.

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