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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

Functional architecture of orchestration in next generation network evolution (NGNe)

Recommendation ITU-T Y.2324

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Recommendation ITU-T Y.2324

Functional architecture of orchestration in next generation network evolution (NGNe)

Summary

Orchestration in next generation network evolution (NGNe) is of great significance, because it takes the coexistence and incorporation of traditional networks such as next generation networks (NGN) and networks enabled by software-defined networking/network function virtualization (SDN/NFV) into consideration. Recommendation ITU-T Y.2324 provides the general functional architecture of the orchestration in NGNe, specifies its functional entities and establishes the functionalities of these functional entities, as well as providing descriptions of all reference points of orchestration in NGNe.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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NFV, NGNe, orchestration, SDN.

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1 Scope

This Recommendation provides the general functional architecture of orchestration in next generation network evolution (NGNe), specifies its functional entities and establishes the functionalities of these functional entities of orchestration in NGNe, as well as providing descriptions of all reference points. Orchestration in NGNe supports not only NGNes, but also provides coordination with networks implemented by new technologies including software-defined networking or network function virtualization (SDN/NFV), especially from the network evolution perspective. This Recommendation builds on [ITU-T Y.2323], with which its content is aligned.

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.2323] Recommendation ITU-T Y.2323 (2018), *Requirements and capabilities of orchestration in next generation network evolution.*

[ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

[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) [b-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:

AFE	Adaptor Functional Entity
API	Application Programming Interface
BSS	Business Support System
CMS	Cloud Management System
COFE	Capability Openness Functional Entity
CPE	Customer Premises Equipment
DAFE	Data Awareness Functional Entity
IPsec	Internet Protocol security
NFV	Network Function Virtualization
NFVI	Network Function Virtualization Infrastructure
NFVO	Network Function Virtualization Orchestrator
NGN	Next Generation Network
NGNe	Next Generation Network evolution
NMS	Network Management System
NS	Network Service
OFE	Orchestration Functional Entity
PNF	Physical Network Function
QoS	Quality of Service
SDN	Software-Defined Networking
SDNO	Software Defined Network Orchestrator
TCFE	Template Catalogue Functional Entity
vCPE	virtualized Customer Premises Equipment
VNF	Virtualized Network Function
VNFM	Virtualized Network Function Manager
VxLAN	Virtual Extensible Local Area Network

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

6 Background and motivations

Many operators are now adopting technologies such as SDN and NFV to build enabled networks. As a result, operator network architecture has become more complex than ever before. This situation brings difficulties for traditional networks, such as NGNs, with corporate SDN- and NFV-enabled networks to meet the requirements of increasingly diversified network services (NSs). Orchestration in NGNe adopts an open network architecture approach to evolve NGN to provide services and resources on combined networks, which include NGNs, as well as those enabled by SDN and NFV. Orchestration provides an effective solution to manage complex network architecture and deploy a diversified NS.

From the network evolution perspective, there are three types of network: NGNs; SDN technology-implemented networks; and NFV technology-implemented networks. The orchestration in NGNe supports NGN and incorporates networks that are implemented by SDN and NFV technologies to achieve end-to-end orchestration. Furthermore, an orchestrator in NGNe can also be connected to the cloud management system (CMS) to support network and cloud-computing coordination for customers.

Orchestration in NGNe has been introduced to meet the requirements of on-demand resource deployment, self-maintenance, rapid service adjustment, customized end-to-end quality-assured network connectivity establishment, automatic provisioning and connection, unified management of multi-vendor devices, centralized NS and network resource control.

7 Functional architecture of orchestration in NGNe

7.1 Overview

Orchestration in NGNe not only supports NGNes, but also provides coordination with networks implemented by new technologies, including SDN, NFV and cloud computing, especially from the network evolution perspective. To achieve end-to-end effectiveness, appropriate orchestration in NGNe is required for corporate NGN and networks that are implemented by SDN and NFV technologies.

Figure 1 illustrates the functional architecture of the orchestration in NGNe.

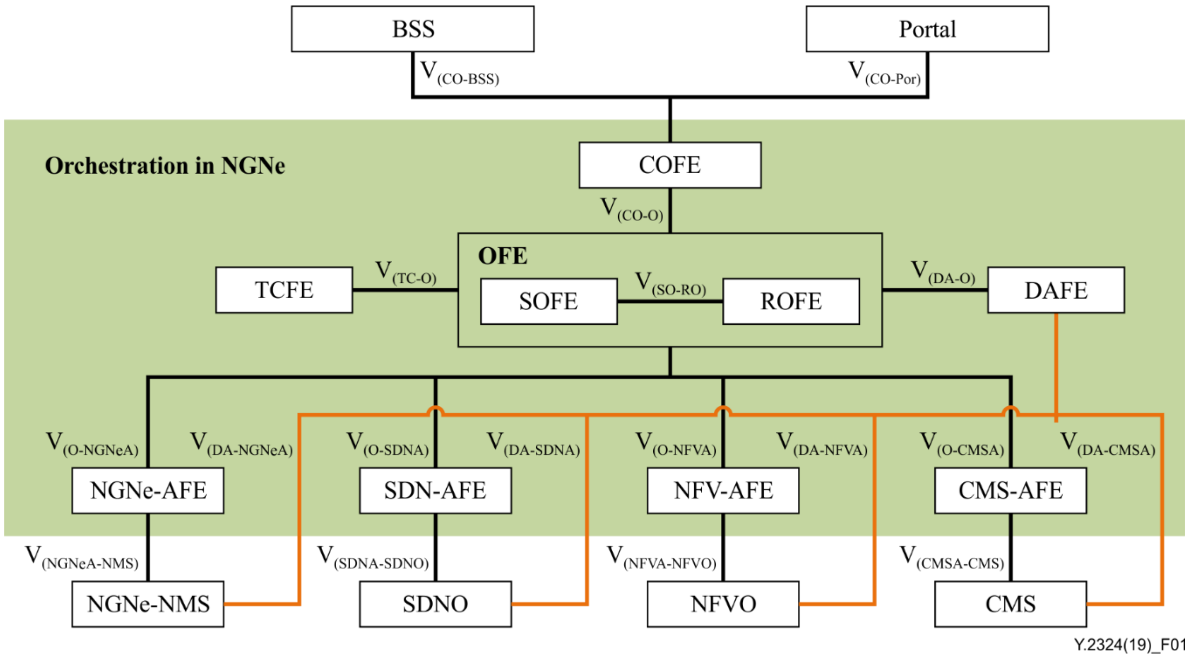

Figure 1 – Functional architecture of orchestration in NGNe

8 Functional entities of orchestration in NGNe

8.1 Functionality of capability openness functional entity

The capability openness functional entity (COFE) opens the capabilities of orchestration in NGNe to business support systems (BSSs) and portals and provides the functionalities in clauses 8.1.1 to 8.1.4.

8.1.1 Global service and resource openness

The COFE opens the global service and resources of combined networks composed of NGNe as well as SDN- and NFV-implemented networks to authorized users and administrators. The global service and resources refer to not only interfaces, network devices, links and bandwidth, but also cloud resources including cloud computing and cloud storage.

8.1.2 Providing unified application programming interfaces

The COFE receives service requests initiated by different applications or third parties by providing unified application programming interfaces (APIs). The COFE analyses these service requests and forwards them to an orchestration functional entity for further operations, including service decomposition and resource allocation.

8.1.3 Exchanging accounting messages

The COFE generates and updates accounting messages and sends them to other systems, such as BSSs. The COFE also supports the synchronization of accounting information when charging events are triggered.

8.1.4 Authentication and authorization

The COFE interacts with other systems such as BSSs to achieve end-user, application and service-related identity and accounting information for authentication and authorization. Each request is authenticated to confirm that the request has the right to consume the resources controlled by the orchestration in NGNe and further authorized according to the quality of service (QoS) configuration of different types of service or user.

8.2 Functionality of service orchestration functional entity

The service orchestration functional entity (SOFE) provides the functionalities in clauses 8.2.1 to 8.2.3.

8.2.1 Service composition or decomposition functionality

The SOFE analyses service requests received and composes or decomposes them based on their type, such as connectivity establishment and end-to-end bandwidth adjustment services. When a service request is issued through the COFE, the SOFE first decomposes the overall service request into subrequests that can be executed by underlayer systems (NGNe-adaptor functional entity (NGNe-AFE), SDN-AFE, NFV-AFE or CMS-AFE). Then the SOFE interacts with the TCFE and determines how each subrequest is handled by matching the prefabricated templates stored in the TCFE. After determining each subrequest processing method, the SOFE composes the subrequests and transmits them to corresponding components for further operations. For example, the SOFE integrates the requests that need to be performed by traditional network devices and sends them to the NGNe-AFE, consolidates requests referring to SDN devices or topology and sends them to SDN-AFE, merges requests related to a virtualized network function (VNF) and sends them to NFV-AFE, and combines requests about cloud hosting or cloud storage and sends them to CMS-AFE.

8.2.2 Service status checking or querying functionality

The SOFE sends request messages to corresponding underlayer systems (NGNe-AFE, SDN-AFE, NFV-AFE or CMS-AFE) to query services status. When the underlayer systems receive the request messages or find there are performance data or alarm information that need to be reported, they send corresponding reply messages to the data awareness functional entity (DAFE). After the DAFE processes the reply messages, it interacts with the SOFE and reports warning information or other device performance data information based on the specific situation. The SOFE checks the service status by analysing this information and performs appropriate operations, e.g., reporting warning information or adjusting service requests.

8.2.3 Distributing or adjusting service requests based on network resources functionality

After the SOFE decomposes the overall service request into subrequests that can be executed by underlayer systems (NGNe-AFE, SDN-AFE, NFV-AFE or CMS-AFE), the SOFE interacts with the ROFE, to which it sends the subrequests for resource allocation. The SOFE also makes service adjustments based on ROFE requirements when the ROFE is informed that there are some resource-related issues that need to be resolved, e.g., resource insufficiency.

8.3 Functionality of resource orchestration functional entity

The resource orchestration functional entity (ROFE) provides the functionalities in clauses 8.3.1 to 8.3.3.

8.3.1 Network resource allocation functionality

The ROFE is the main system to deal with resource-related issues, while the SOFE mainly handles service requests. After the SOFE decomposes the overall service request into subrequests that can be executed by underlayer systems (NGNe-AFE, SDN-AFE, NFV-AFE or CMS-AFE), the SOFE sends the services requirements to the ROFE.

The ROFE interacts with the TCFE and determines how many network resources are needed to deal with each subrequest by matching the prefabricated resource allocation templates stored in the TCFE. In this way, the ROFE allocates existing available network resources based on service requirements and returns the assignment result to the SOFE. This functionality allows the ROFE to support end-to-end management of network resources.

8.3.2 Resource usage monitoring functionality

The ROFE sends request messages to corresponding underlayer systems (NGNe-AFE, SDN-AFE, NFV-AFE or CMS-AFE) to query basic network resource data. When the underlayer systems receive request messages or find there is resource usage-related information that needs to be reported, they send corresponding reply messages to the DAFE. After the DAFE processes the reply messages, it interacts with the ROFE and reports the resource usage situation. The ROFE updates the unified resource information and instructs the SOFE to readjust the service requirements when the existing resource cannot meet demands.

8.3.3 Resource list checking functionality

In some situations, in order to facilitate ordering or adjust on-demand network system services, client or system operation staff may want to obtain a list of available resources. Similarly to the resource usage monitoring function, the ROFE interacts with underlayer systems and the DAFE to obtain information about available resources. After that, the ROFE sorts out the list of resources based on the information obtained, interacts with the COFE and reports available or occupied resource lists based on client requirements.

8.4 Functionality of data awareness functional entity

The DAFE provides the functionalities in clauses 8.4.1 to 8.4.4.

8.4.1 Data collecting functionality

After services have been successfully delivered through the COFE, users need to monitor various performance data of multiple services. Meanwhile, due to the influence of the basic network, basic equipment and external resources, the underlying network element device may experience unexpected circumstances, e.g., overload or device outage. In response, the DAFE needs to interact with underlayer systems (e.g., NGNe-AFE, SDN-AFE, NFV-AFE or CMS-AFE) to collect required data, including network topology, SDN devices, traditional network equipment, cloud hosting and cloud storage.

8.4.2 Warning principle setting and alarm functionality

For a first acknowledgement that indicator data is abnormal and to process the failure swiftly, the DAFE supports the setting of warning principles aimed at multiple systems (e.g., NGNe-AFE, SDN-AFE, NFV-AFE or CMS-AFE), various devices and diverse applications. In addition, the DAFE sends a notification when monitoring data meet the alarm condition.

8.4.3 Warning information classification and organization functionality

The DAFE classifies and organizes warning information reported by other functional entities (e.g., NGNe-AFE, SDN-AFE, NFV-AFE or CMS-AFE). The DAFE then analyses the information to obtain the root warning information and report it to help operations staff quickly locate network faults and perform related processing. This function can help to improve network operation efficiency, promote system reliability and reduce risks.

8.4.4 Warning information report functionality

The DAFE supports interaction with the SOFE to report service-related warning information and interacts with the ROFE to report resource-related information. The SOFE and ROFE adjust service requirements based on reported warning information.

In addition, if the system fault is so serious that it cannot be handled natively by the on-demand network system, the DAFE passes the warning information to clients and system operation staff through multiple channels including e-mail, texting (short message) or by sending an instant message through the portal.

8.5 Functionality of template catalogue functional entity

The template catalogue functional entity (TCFE) provides the functionalities in clauses 8.5.1 to 8.5.2.

8.5.1 Service template and resource template prefabricating and storing functionality

In order to provide unified and simplified services to end users, the TCFE provides functionalities for storage of the NGNe service template, VNF assignment template and resource allocation template, etc.

System development and maintenance staff can prefabricate the practical steps to execute a specific service requirement, e.g., creating a cloud host, initialling a VNF or configuring a network connection path. These steps will be encapsulated into a template that can be invoked by SOFE.

Concerning some public data resources that are required during service activation and resource allocation, TCFE also supports system development and maintenance staff to prefabricate the resource needed to implement each subservice requirement. When ROFE receives information about subservice requirements decomposed by SOFE, it will match them with the pre-defined resource templates to allocate global resources.

8.5.2 Service template and resource template query and matching functionality

TCFE interacts with SOFE, ROFE, and the support template query and matching function. As service templates have been pre-defined, SOFE sends the subservice requests to TCFE and matches them with the encapsulated templates to get the practical steps to process them after SOFE has decomposed the overall service request into subrequests that can be executed by underlayer systems (NGNe-AFE, SDN-AFE, NFV-AFE or CMS-AFE). Similarly, when ROFE receives information about subservice requirements decomposed by SOFE, it will interact with TCFE on which these subservice requirements will be matched with predefined resource templates. TCFE then returns the matched resource templates to ROFE to allocate network resource.

8.6 Functionality of NGNe adaptor functional entity

The NGNe adaptor functional entity (NGNe-AFE) provides the functionalities in clauses 8.6.1 to 8.6.2.

8.6.1 Traditional network- or device-related service requirements processing functionality

In the current stage of network evolution, SDN devices cannot meet all service requirements, which means that a large number of services still run on traditional networks. These services need to be implemented by traditional network devices, which may have various types of API. The geographic location of traditional network equipment and the capacity of the NGNe network management system (NGNe-NMS), are scheduled and managed by the corresponding NGNe-NMS.

The NGNe-NMSs may support different types of API, in addition to directly sending service requirements and service allocation messages to multiple NGNe-NMSs through the SOFE and ROFE, which increases system complexity and instability. In order to solve this problem, the NGNe-AFE operates as a unified API between the SOFE or ROFE and NGNe-NMSs, and processes traditional network or device configurations transmitted by the SOFE or ROFE to the corresponding NGNe-NMS. In this way, the NGNe-AFE encapsulates the capability of the NGNe-NMS to provide a simple and unified interface to the upper layer, so that different service requirements can propose service requests to the network function virtualization orchestrator (NFVO) in a unified manner.

To be precise, the NGNe-AFE interacts with NGNe-NMSs to:

- manage multiple NGNe-NMSs and select appropriate NGNe-NMSs to process service requirements;
- request traditional network connectivity;
- determine the service components and service access point of a traditional network;
- manage network topology and resources of an NMS domain;
- track and monitor progress of service-related requirements to traditional network and devices.

8.6.2 Traditional network- or device-related performance data, resource utilization and warning message collecting functionality

As mentioned in the functional description of the DAFE, in some specific situation, traditional network and devices need to report required performance data and warning information. These messages will be submitted by traditional devices to a corresponding NGNe-NMS that manages them. So, the NGNe-AFE supports:

- receipt of network topology from an NMS domain;
- acquisition of status of traditional network and devices from an NGNe-NMS;
- detection of all flow information of the NMS domain;
- receipt of warning information and other performance data from the NGNe-NMS.

8.7 Functionality of the SDN adaptor functional entity

The SDN adaptor functional entity (SDN-AFE) provides the functionalities in clauses 8.7.1 to 8.7.2.

8.7.1 SDN network- or device-related service requirements processing functionality

A software-defined network orchestrator (SDNO) is an important part of an SDN-based network on-demand system, SDN devices including customer premises equipment (CPE), virtualized customer premises equipment (vCPE) providing enterprises with private line access services, encapsulation and de-encapsulation tunnels (e.g., virtual extensible local area network (VxLAN), Internet protocol security (IPsec)) services, etc. SDN devices and networks are managed by the SDNO, with which NGNe orchestration needs to interact to implement a large number of SDN services, including network element device management, device interface configuration, tunnel establishment, static route configuration, policy routing configuration and QoS configuration.

For more convenient configuration of SDN services, their requirements will be allocated to specific SDN controllers through the SDNO. However, for large-scale networks, a single SDN orchestrator can only control one branch SDN controller or network topology due to location factors or processing power limitations. To solve this problem, multiple SDN orchestrators are designed into this network on-demand system. In order to decrease system complexity, the SDN-AFE operates as a unified API between the SOFE or ROFE and multiple SDNOs, and processes SDN network and device configurations transmitted by the SOFE and ROFE to the corresponding SDNO. The SDN-AFE is connected to all SDNOs, and encapsulates the SDN network control capability of the SDNO to provide a simple and unified interface to the upper layer, so that different service requirements can propose a network ability request to an SDNO in a unified manner.

To be precise, the SDN-AFE interacts with SDNOs to:

- manage multiple SDNOs and select an appropriate SDNO to process service requirements;
- request SDN inner-domain or SDN over-domain connectivity;
- determine the service components and service access point in the SDN domain;
- manage network topology and resources of the SDN domain;
- track and monitor progress of service-related requirements to the SDN network and devices.

8.7.2 SDN network- or device-related performance data, resource utilization and warning message collecting functionality

As mentioned in the functional description of the DAFE, in some specific situations, the SDN network and devices need to report required performance data and warning information. These messages will be submitted by SDN devices to the SDNO that manages them. So, the SDN-AFE supports:

- receipt of network topology from the SDN domain;
- acquisition of device and control nodes status from SDNOs;
- detection of all flow information from SDNOs;
- receipt of warning information and other performance data from SDNOs.

8.8 Functionality of the NFV adaptor functional entity

The NFV adaptor functional entity (NFV-AFE) provides the functionalities in clauses 8.8.1 to 8.8.2.

8.8.1 Network service instances related service requirements processing functionality

The NFV is one of the key technologies that make up the on-demand system to satisfy user and application demands dynamically according to optimization criteria. An NFV NS consists of one or multiple VNFs, and the connections between the VNFs or physical network functions (PNFs). The VNF is created and managed by a virtualized network function manager (VNFM) and NFVO.

Similarly to an SDNO, for large-scale networks, a single NFV orchestrator can only control one branch VNFs due to location factors or processing power limitations. To solve this problem, multiple NFV orchestrators are designed into this network on-demand system. In order to decrease system complexity, the NFV-AFE operates as a unified API between the SOFE or ROFE and multiple NFVOs, and processes VNF configuration and life-cycle management messages transmitted by the SOFE and ROFE to the corresponding NFVO. The NFV-AFE is connected to all NFVOs, and encapsulates the VFN management capability of the NFVO to provide a simple and unified interface to the upper layer, so that different service requirements can propose a service request to the NFVO in a unified manner.

To be precise, the NFV-AFE interacts with NFVOs to:

- manage multiple NFVOs and select an appropriate NFVO to process service requirements;
- allocate, upgrade or release network function virtualization infrastructure (NFVI) resources;
- request instantiation of VNFs;
- manage the lifecycle of network functions and NSs;
- discover the NFVI hardware or software resources and capabilities or features;
- validate or test NS functionality in the NFV domain.

8.8.2 NF instance-related performance data, resource utilization and warning message collecting functionality

As mentioned in the functional description of the DAFE, in some specific situations, NS instances need to report required performance data and warning information. These messages will be submitted by NS instances to a corresponding NFVO that manages them. So, the NFV-AFE supports:

- receipt of the performance of network functions and resources from the NFVO;
- receipt of virtual and physical network topology information from the NFVO;
- acquisition of VNF and PNF status from the NFVO;
- receipt of monitoring or warning information relating to networks and resources from the NFVO.

8.9 Functionality of cloud management system adaptor functional entity

The cloud management system adaptor functional entity (CMS-AFE) provides the functionalities in clauses 8.9.1 to 8.9.2.

8.9.1 Cloud-related service requirements processing functionality

With the maturity and application promotion of cloud-computing architecture, a large number of services are deployed on the cloud, which means cloud-related technologies are indispensable parts of the on-demand system. Cloud services rely on inner-cloud network resources and cloud resources like cloud hosts and cloud storage to implement, and these resources are managed by a CMS.

Similarly to an SDNO, for large-scale networks, a single cloud management system can only control part of the inner-cloud network resources and cloud resources due to location factors or processing power limitations. To tackle this issue, multiple CMSs are designed into this network on-demand system. In order to decrease system complexity, the CMS-AFE operates as a unified API between the SOFE or ROFE and multiple CMSs, and processes inner-cloud network resources of cloud resource configuration and life-cycle management messages transmitted by the SOFE and ROFE to the corresponding CMS. The CMS-AFE is connected to all CMSs, and encapsulates the management capabilities of the CMS to provide a simple and unified interface to the upper layer, so that different service requirements can propose a service request to a CMS in a unified manner.

To be precise, the CMS-AFE interacts with the CMS to:

- manage multiple CMSs and select appropriate CMSs to process service requirements;
- allocate, upgrade or release inner-cloud network resources;
- create cloud hosts and cloud storage;
- manage the lifecycle of cloud hosts and cloud storage;
- provide basic cloud host operations, e.g., subscription, un-subscription, password modification and expansion;

- discover the inner-cloud network resources or cloud resources and capabilities or features.

8.9.2 Cloud domain-related performance data, resource utilize situation and warning message collecting functionality

As mentioned in the functional description of the DAFE, in some specific situations, the cloud domain needs to report required performance data and warning information. These messages are submitted by the cloud infrastructure to the corresponding CMS that manages them. So, the CMS-AFE supports:

- receipt of the performance of inner-cloud network resources and cloud resources from the CMS;
- acquisition of the status of cloud host and cloud storage from the CMS;
- receipt of monitoring or warning information from the CMS.

9 Reference points

This clause presents the detailed descriptions of reference points of orchestration in NGNe. Figure 1 shows the positions of those reference points.

NOTE – The orchestration functional entity (OFE) is the combination of the SOFE and ROFE.

9.1 Reference point $V_{CO\text{-}Por}$

$V_{CO\text{-}Por}$ is the reference point between the COFE and portal.

The portal processes signalling messages about basic service purchase and configuration information (e.g., network connection rental, cloud hosting rental and cloud lines rental) to the COFE through this reference point.

The COFE reports performance information and warning messages to the portal based on customer requirements through this reference point.

9.2 Reference point $V_{CO\text{-}BSS}$

$V_{CO\text{-}BSS}$ is the reference point between the COFE and BSS.

A BSS transmits a dispatching order to the COFE through this reference point.

The COFE and BSS exchange signalling messages concerning accounting-related services (e.g., billing generation and billing fallback) and synchronization of tenant account information through this reference point.

9.3 Reference points $V_{CO\text{-}O}$

$V_{CO\text{-}O}$ is the reference point between the COFE and OFE.

The COFE gathers and parses service messages generated by upper layer (e.g., portal, BSS) and transmits them to the OFE through this reference point.

The OFE reports performance information and warning messages to the COFE through this reference point.

9.4 Reference points $V_{SO\text{-}RO}$

$V_{SO\text{-}RO}$ is the reference point between SOFE and ROFE.

The SOFE sends decomposed subservice requirements to the ROFE for required resource allocation through this reference point.

The ROFE transmits resource utilization and distribution results to the SOFE through this reference point.

9.5 Reference points $V_{DA\text{-}O}$

$V_{DA\text{-}O}$ is the reference point between the DAFE and OFE.

The OFE sends requirements to the DAFE for setting warning principles for different networks and various devices through this reference point.

The DAFE gathers and reports utilization and performance information, as well as warning messages to the OFE through this reference point.

9.6 Reference points $V_{TC\text{-}O}$

$V_{TC\text{-}O}$ is the reference point between the TCFE and OFE.

The OFE sends subservice requirements decomposed by the SOFE to the TCFE to obtain predefined service and resource templates, and gets the practical steps to process service requirements though this reference point.

The TCFE matches subservice requirements to the encapsulated templates and returns the matched service and resource templates to the OFE though this reference point.

9.7 Reference points $V_{O\text{-}NGNeA}$

$V_{O\text{-}NGNeA}$ is the reference point between the OFE and NGNe-AFE.

The OFE connects to the NGNe-AFE and processes decomposed traditional network-related service requirements to the NGNe-AFE through this reference point.

The NGNe-AFE processes messages about traditional network resource allocation to the OFE through this reference point.

9.8 Reference points $V_{O\text{-}SDNA}$

$V_{O\text{-}SDNA}$is the reference point between the OFE and SDN-AFE.

The OFE connects to the SDN-AFE and processes decomposed SDN-related service requirements to the SDN-AFE through this reference point.

The SDN-AFE processes messages about SDN-enabled network resource allocation to the OFE through this reference point.

9.9 Reference points $V_{O\text{-}NFVA}$

$V_{O\text{-}NFVA}$ is the reference point between the OFE and NFV-AFE.

The OFE connects to the NFV-AFE and processes decomposed NFV-related service requirements to the NFV-AFE through this reference point.

The NFV-AFE processes messages about NFV-enabled network resource allocation to the OFE through this reference point.

9.10 Reference points $V_{O\text{-}CMSA}$

$V_{O\text{-}CMSA}$ is the reference point between the OFE and CMS-AFE.

The OFE connects to the CMS-AFE and processes decomposed CMS-related service requirements to the CMS-AFE through this reference point.

The CMS-AFE processes messages about cloud-computing resource and inner-cloud network resource allocation to the OFE through this reference point.

9.11 Reference points $V_{DA\text{-}NGNeA}$

$V_{DA\text{-}NGNeA}$ is the reference point between the DAFE and NGNe-AFE.

The NGNe-AFE reports traditional devices, network performance data and resource utilization to the DAFE through this reference point.

The NGNe-AFE reports monitoring and warning messages to the DAFE through this reference point.

9.12 Reference points $V_{DA\text{-}SDNA}$

$V_{DA\text{-}SDNA}$ is the reference point between the DAFE and SDN-AFE.

The SDN-AFE reports SDN devices, network performance data and resource utilization to the DAFE through this reference point.

The SDN-AFE reports monitoring and warning messages to the DAFE through this reference point.

9.13 Reference points $V_{DA\text{-}NFVA}$

$V_{DA\text{-}NFVA}$ is the reference point between the DAFE and NFV-AFE.

The NFV-AFE reports NFV devices, network performance data and resource utilization to the DAFE through this reference point.

The NFV-AFE reports monitoring and warning messages to the DAFE through this reference point.

9.14 Reference points $V_{DA\text{-}CMSA}$

$V_{DA\text{-}CMSA}$ is the reference point between the DAFE and CMS-AFE.

The CMS-AFE reports inner-cloud network resources (cloud host, cloud storage etc.) performance data and cloud resource utilization to the DAFE through this reference point.

The CMS-AFE reports monitoring and warning messages to the DAFE through this reference point.

9.15 Reference points $V_{NGNeA\text{-}NMS}$

$V_{NGNeA\text{-}NMS}$ is the reference point between the NGNe-AFE and NGNe-NMS.

The NGNe-AFE connects to the NGNe-NMS and exchanges traditional device configuration and topology management-related messages with the NGNe-NMS through this reference point.

The NGNe-AFE receives network topology, performance information and warning messages generated by the NGNe-NMS through this reference point.

9.16 Reference points $V_{SDNA\text{-}SDNO}$

$V_{SDNA\text{-}SDNO}$ is the reference point between the SDN-AFE and SDNO.

The SDN-AFE connects to the SDNO and exchanges SDN device configuration and topology management-related messages with the SDNO through this reference point.

The SDN-AFE gathers network topology and performance data of SDN devices generated by the SDNO through this reference point.

9.17 Reference points $V_{NFVA\text{-}NFVO}$

$V_{NFVA\text{-}NFVO}$ is the reference point between the NFV-AFE and NFVO.

The NFV-AFE connects to the NFVO and dispatches or processes service requirements to the NFVO through this reference point.

The NFV-AFE and NFVO exchange mapping messages between associated NSs and NFV resources through this reference point.

The NFV-AFE transmits messages dispatching and adjusting virtual network resources through this reference point.

The NFV-AFE gathers VNF lifecycle management messages and virtual network resources through this reference point.

9.18 Reference points $V_{CMSA-CMS}$

$V_{CMSA-CMS}$ is the reference point between the CMS-AFE and CMS.

The CMS-AFE connects to the CMS and processes decomposed services requirements through this reference point.

The CMS-AFE and CMS exchange messages about cloud resource (cloud host, cloud store etc.) lifecycle management through this reference point.

The CMS-AFE transmits information about inner-cloud network resources through this reference point.

10 Security considerations

The main aspects of security considerations of orchestration in NGNe are aligned with [ITU-T Y.3321], [ITU-T Y.3322], [ITU-T Y.2323] and [ITU-T Y.2701].

Bibliography

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

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