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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

The functional architecture of virtualized control network entities management and orchestrator in next generation network evolution

Recommendation ITU-T Y.2322

International Telecommunication Union

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Recommendation ITU-T Y.2322

The functional architecture of virtualized control network entities management and orchestrator in next generation network evolution

Summary

The evolved next generation network (NGN) adopts the technology of network function virtualization. Recommendation ITU-T Y.2322 focuses on the functions, functional entities and reference points of virtualized control network entities management and orchestrator (VCNMO) and its subcomponents in the architecture of virtualization of control network entities (VCN). The Recommendation defines the functional architecture of VCNMO and specifies the related reference points, including the orchestrator, the VCN manager (VCNM) and the virtualized infrastructure manager (VIM) for VCN. The architecture design of this Recommendation fulfills the requirements proposed by Recommendation ITU-T Y.2320. In this Recommendation the high level description of functions and reference points related to orchestrator, VCNM manager and VIM are consistent with the functions and reference points standardized in Recommendation ITU-T Y.2321.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2322	2018-01-13	13	11.1002/1000/13463

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NGN, orchestrator, virtualization.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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The functional architecture of virtualized control network entities management and orchestrator in next generation network evolution

1 Scope

This Recommendation defines the functional architecture of virtualized control network entities management and orchestrator (VCNMO) and specifies the related reference points of VCNMO and its subcomponents, which include the orchestrator, the VCN manager (VCNM) and the virtualized infrastructure manager (VIM) for the virtualization of control network entities (VCN).

This Recommendation is based on [ITU-T Y.2320] and [ITU-T Y.2321].

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.2320] Recommendation ITU-T Y.2320 (2015), *Requirements for virtualization of control network entities in next generation network evolution*.

[ITU-T Y.2321] Recommendation ITU-T Y.2321 (2016), *Functional architecture for supporting virtualization of control network entities in next generation network evolution*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 virtualized control network entity (VCNE) [ITU-T Y.2320]: A control network entity deployed on virtualized infrastructure (i.e., across one or multiple virtual machines (VMs)).

3.1.2 virtual machine (VM) [ITU-T Y.2320]: The virtualized computation environment that behaves like a physical server.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 network service descriptor: A configuration template that describes a network service.

3.2.2 virtualized control network entities management and orchestrator (VCNMO): A collection of functions in VCN to manage and orchestrate control network entities deployed on virtualized infrastructure.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Access Control

CPU	Central Processing Unit
FE	Functional Entity
IP	Internet Protocol
MF	Management Function
NGN	Next Generation Network
NGNe1	Next Generation Network evolution phase 1
NIC	Network Interface Card
OS	Operating System
PCNE	Physical Control Network Entity
QoS	Quality of Service
RBAC	Role-Based Access Control
VCN	Virtualization of Control Network entities
VCNE	Virtualized Control Network Entity
VCNED	Virtualized Control Network Entity Descriptor
VCNM	VCN Manager
VCNMO	Virtualized Control Network entities Management and Orchestrator
VI	Virtualized Infrastructure
VIM	Virtualized Infrastructure Manager
VLAN	Virtual Local Area Network
VLD	Virtual Link Descriptor
VM	Virtual Machine
vPCRF	virtualized Policy and Charging Rule Function
vS-CSCF	virtualized Serving-Call Session Control Function

5 Conventions

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.

In the body of this Recommendation and its annexes, the words shall, shall not, should, and may sometimes appear, in which case they are to be interpreted, respectively, as is required to, is prohibited from, is recommended, and can optionally. The appearance of such phrases or keywords in an appendix or in material explicitly marked as informative are to be interpreted as having no normative intent.

6 Functional architecture of VCNMO

6.1 Overview

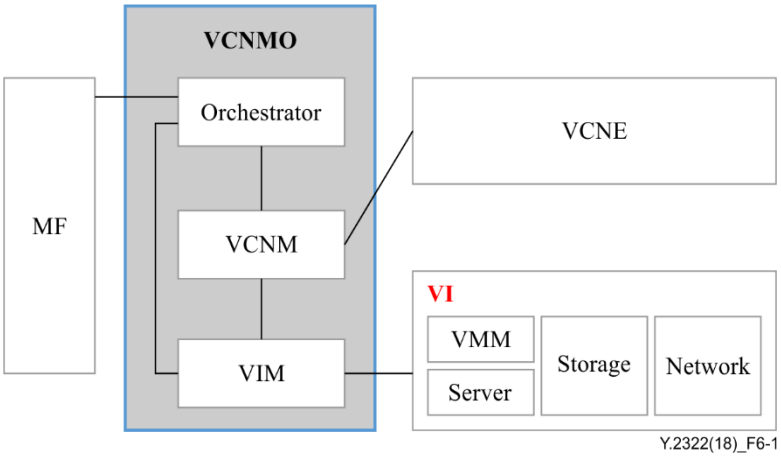

Figure 6-1 – Relationship between VCN and VCNMO

VCNMO is a collection of functions in VCN including orchestrator functions, VCNM functions and VIM functions to manage and orchestrate control network entities deployed on virtualized infrastructure. The relationship between VCN and VCNMO is shown in Figure 6-1.

6.2 Orchestrator functions

Orchestrator functions are responsible for global service and resource management and orchestration in VCN. Orchestrator functions get virtual resource information from VIM functions and maintain a global view of virtual resource. Orchestrator functions handle resource requirements from VCNM functions and co-operate with VIM functions to satisfy these requirements. Orchestrator functions validate and authorize resource requests from VCNM functions, those requests which may impact the network will be rejected by orchestrator functions. In contrast to VCNM functions which support life cycle management of virtualized control network entities (VCNEs), orchestrator functions manage the life cycle of network services which are basically composed by multiple VCNEs and connections among them.

Orchestrator functions support interworking with management functions in NGN and offer their own interfaces to be used by them. Orchestrator functions receive service requests from the management functions and instantiate or modify network service according to these requests.

In addition, orchestrator functions can be further split into service orchestrator functions and resource orchestrator functions.

Figure 6-2 shows the functional architecture of VCNMO.

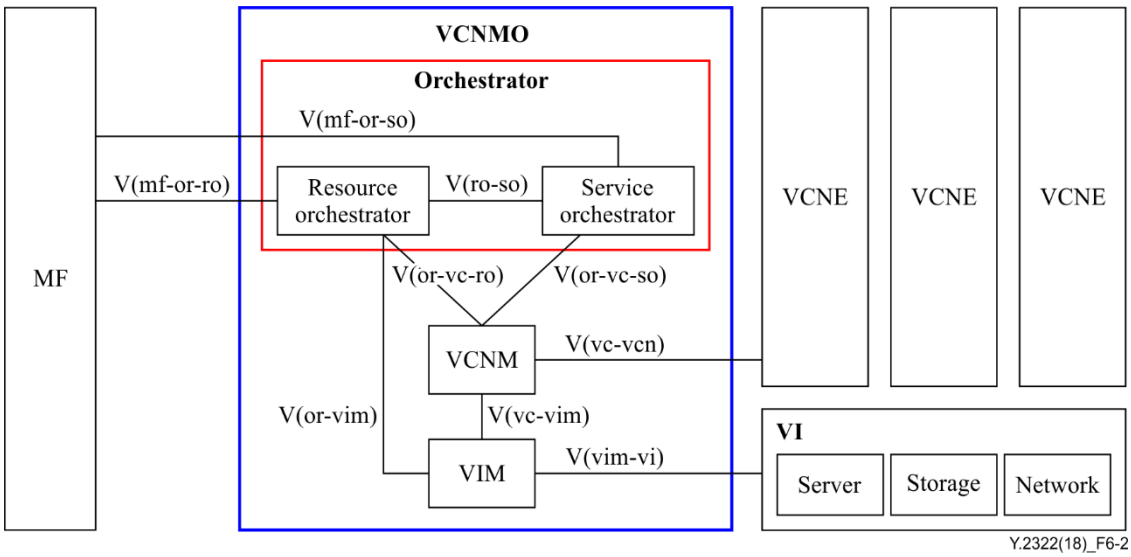

Figure 6-2 – The functional architecture of VCNMO

Service orchestrator functions are responsible for:

– network service lifecycle management, e.g., request creation, query, update and termination of a network service by coordinating with VCNM and resource orchestrator functions.

– granting VCNE lifecycle management operations to VCNM.

– network service descriptor and associated descriptor management.

Resource Orchestrator functions are responsible for:

– getting virtual resource information from VIMs and maintaining a global view of virtual resources at different granularities, including usage per VCNE or per network service.

– handling authorization requirements requests from VCNM and VIM that can satisfy these requirements and then sending resource allocation requests to VIM.

– requesting VIM to perform resource allocation.

– VCNE package management.

– providing fault and performance management information to the management function (MF).

6.3 VCNM functions

The VCNM functions are responsible for the VCNE lifecycle, fault, configuration and performance management and related virtual resources management. Each VCNE instance has only one associated VCNM function, however, a VCNM function may be assigned to manage a single VCNE instance such as one virtualized policy and charging rule function (vPCRF), one type of VCNE instance, such as a number of vPCRFs or multiple types of VCNE instance such as a number of vPCRFs and a number of virtualized serving-call session control functions (vS-CSCFs).

There are two architecture options of VCNM functions, one is the generic VCNM functions architecture and the other is the dedicated VCNM functions architecture. These architecture options are shown in Figure 6-3 and Figure 6-4 respectively:

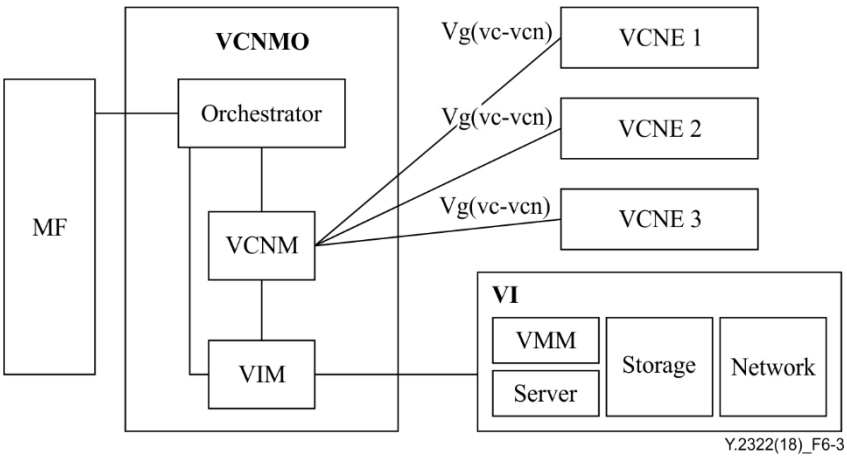

Figure 6-3 – Generic VCNM functions architecture

In the generic VCNM functions architecture, a generic VCNM function manages multiple VCNE instances which could perform different functions. For instance, a generic VCNM function could manage one vPCRF and one vS-CSCF at the same time.

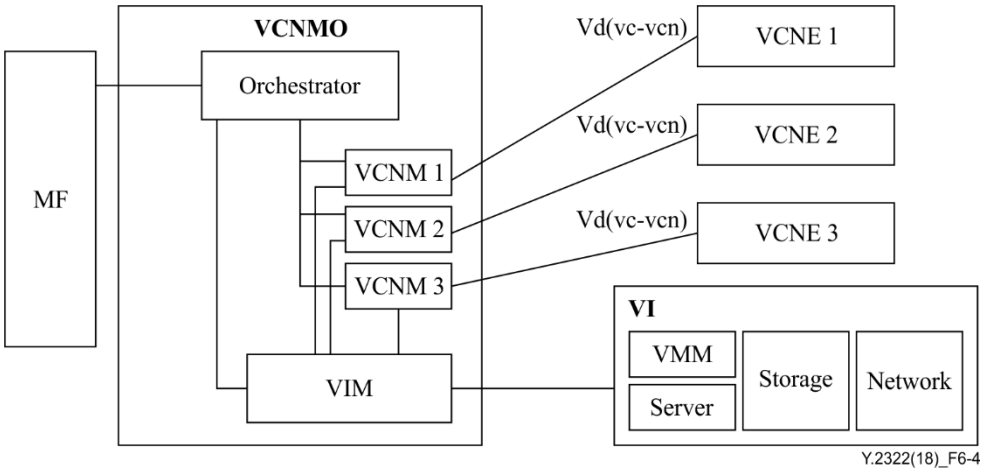

Figure 6-4 – Dedicated VCNM functions architecture

In the dedicated VCNM functions architecture, a dedicated VCNM function only manages one VCNE instance in order to optimize its performance. For instance, a dedicated VCNM and a vPCRF could be provided from the same vendor so that the performance of the vPCRF shall be optimized.

From the implementation perspective, the operator could choose one of the above two architecture options or both options in combination according to its own considerations. For both of the VCNM architectures, the following list expresses the functionalities performed by the VCNM functions.

1) Virtual resource management

- VCNE-related resource management: The VCNM functions request to the orchestrator or the VIM to manage the virtual resources which are needed for VCNE instantiation, scaling and termination.
- Virtual resource fault management: The VCNM functions collect fault information related to the virtual resources assigned to VCNE instance(s) and correlates this fault information with the impacted VCNE instance(s).
- Virtual resource information management: The VCNM functions query information and receive notification regarding consumable virtual resources provided by the VIM.

– Virtual resource performance management: The VCNM functions invoke the virtual resource performance management operations on the virtual resources for the VCN instance, receive corresponding performance information and map this performance information to the VCNE instances.

2) VCN lifecycle management

– VCNE instantiation: The VCNM functions support the instantiation of a VCNE instance, resource allocation, configure deployment specific parameters for the VCNE instance and store the information of allocated resource and configured parameters for the instantiated VCNE.

– VCNE instance updating: The VCNM functions support the updating or upgrading VCNE's operating system (OS) or application software.

– VCNE instance scaling: The VCNM functions support the scaling operations to expand or contract the capacity of a VCNE instance, including scale in, scale out, scale up and scale down. Considering not all VCNEs support all these operations, a VCNM function will perform a set of operations on a VCNE instance depending on the VCNE capabilities.

– VCNE instance termination: The VCNM functions support termination of a VCNE instance.

3) VCNE fault management

– Virtual resource-related VCNE fault management: The VCNM functions provide virtual resource-related fault information of the VCNEs it manages and notify about VCNE alarms due to state changes in the virtual resources used by the VCNE.

– VCNE healing: The VCNM functions perform assisted or automated healing on a VCNE instance.

4) VCNE configuration management

– The VCNM functions support VCNE parameters configuration management, including setting initial configuration parameters and other configurable parameters for a VCNE instance.

5) VCNE information management

– VCNE package management: The VCNM functions obtain details of available VCNE packages of the VCNE and receive notifications as a result of on-boarding or changes of VCNE packages.

– VCNE instance information management: The VCNM functions receive run-time data related to VCNE instances from VCNE that it has created and provide information on the mapping relationship between the VCNE instance(s) and associated virtual resources.

6) VCNE performance management

– The VCNM functions notify the availability of VCNE performance information, resulting from received virtual resources performance information.

6.4 VIM functions

VIM functions are responsible for operating and configuring virtual infrastructure including virtual resource management and virtual infrastructure status monitoring. VIM functions could manage not only VMs, but also containers in the VI. Container technology has gained prominence in the cloud market and it gives a new hike to container based virtualization. As the container technology has been used more and more by different parties, it could also be used for the virtualization of control network entities and thus it has become important for VCNMO to adopt its recent developments

and features in the technology. Figure 6-5 shows that the VIM functions could operate the containers as well as the traditional VMs in VCN.

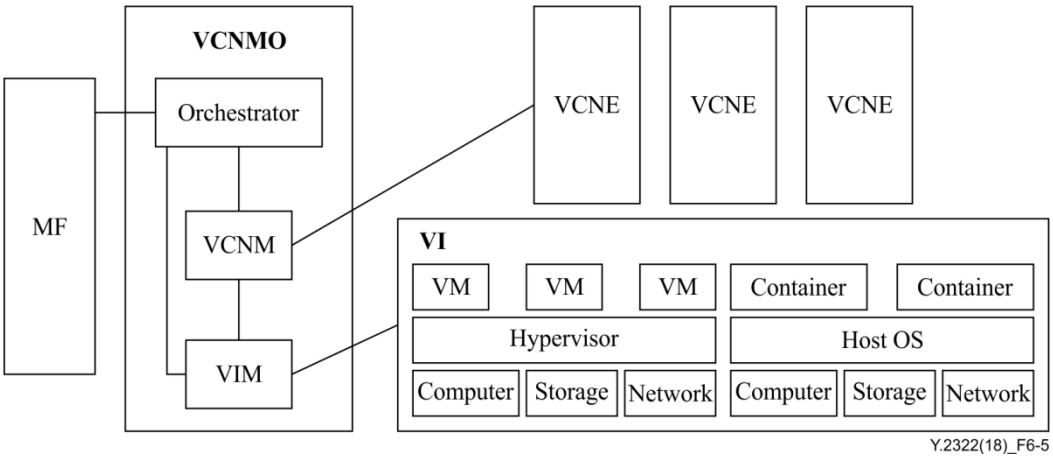

Figure 6-5 – VIM functions support containers

Furthermore, VIM functions support the following functionalities:

– Booting or shutting down servers, OS installation to servers.

– Creating, deleting, booting, hibernating and migrating VMs.

– Resource reservation.

– Assigning the network address of servers or storage configuration.

– Virtual local area network (VLAN) or routing of network device configuration.

– Virtual machine configuration, including its central processing unit (CPU), memory, network interface card (NIC), storage, etc.

– Container configuration, including its CPU, memory, storage, etc.

– Resource utilization status monitoring (e.g., the CPU or memory utilization rate, the throughput of network, etc.).

– Failure or fault events monitoring (e.g., the failure of shared storage, the failure of fan or power module, etc.).

– Resource availability data maintenance (e.g., the information on which physical servers are available, etc.).

6.5 Other related functions

6.5.1 Management functions of NGNe1

Management functions of next generation network evolution phase 1 (NGNe1) can interact with VCNMO to realize the following goals:

– Send a request to VCNMO to initiate the on-boarding of VCNE.

– Send a request to VCNMO to initiate the creation or deletion of VCNE.

– Receive the performance and fault information of VCNE related virtualized resource from VCNMO.

– Subscribe the VCNE lifecycle change notifications to VCNMO.

7 Reference point of VCNMO

7.1 External reference point of VCNMO

7.1.1 Vg(vc-vcn)

The reference point between the generic VCNM functions and associated multiple VCNE instances is mainly used for VCNE lifecycle management. The main functionalities of this reference point are aligned with the V(vc-vcn) reference point in [ITU-T Y.2321].

In addition, to enable independence between the generic VCNM and the VCNEs, the information language which is used to communicate between the generic VCNM and the VCNEs is expected to be VCNE-independent and provider-independent. Therefore, this reference point should support information transferring with this universal language.

7.1.2 Vd(vc-vcn)

The reference point between the dedicated VCNM functions and correlated VCNE instance is mainly used for VCNE lifecycle management. The main functionalities of this reference point are aligned with the V(vc-vcn) reference point in [ITU-T Y.2321].

In addition, from the implementation perspective, VCNM function provider could transfer some particular information from/to its correlated VCNE via this reference point in order to optimize the VCNE performance.

7.1.3 V(mf-or-so)

The reference point between the MF and service orchestrator functions is mainly used for descriptor and VCNE package management. The main functionalities of this reference are part of the functionalities of the V(mf-or) reference point in [ITU-T Y.2321].

– Service orchestrator functions → MF
  – Allows the management of network service descriptors and associated descriptors, such as VCNE and virtual link descriptor (VLD), including operations for on-boarding, querying, disabling, enabling, updating and deleting these descriptors.
  – Allows the management of VCNE packages including operations for on-boarding, querying, disabling, enabling and deleting VCNE packages.
– MF→ Service orchestrator functions
  – Allows the MF to subscribe to network service lifecycle change notifications and the orchestrator functions provide such notifications to the subscriber.
  – Allows the MF to manage the VCNEs by sending requests to create/modify/delete VCNEs.

7.1.4 V(mf-or-ro)

The reference point between the MF and resource orchestrator functions is mainly used for performance management and fault management. The main functionalities of this reference are part of the functionalities of the V(mf-or) reference point in [ITU-T Y.2321].

– Resource orchestrator → MF
  – Allows the provision of performance information (measurement results collection and notifications) related to virtual resources.
  – Allows the resource orchestrator functions to provide alarms related to virtual resources to the MF.

7.1.5 V(vim-vi)

The reference point between VIM and virtualized infrastructure (VI) is mainly used for managing usage and performance of virtual resources. The main functionalities of this reference point are aligned with the V(vim-vi) reference point in [ITU-T Y.2321].

7.2 Internal reference point of VCNMO

7.2.1 V(ro-so)

The reference point between the resource orchestrator functions and service orchestrator functions is mainly used for network service lifecycle management.

– Service orchestrator functions → Resource orchestrator functions
  – Allows the service orchestrator functions to ask resource orchestrator functions to allocate/release resources for network service instance or for VCNE.
– Resource orchestrator functions → Service orchestrator functions
  – Allows the resource orchestrator functions to provide resource operation results to the service orchestrator functions.

7.2.2 V(or-vc-so)

The reference point between the service orchestrator functions and VCNM is mainly used for granting of VCNE lifecycle operations.

– VCNM → Service orchestrator functions
  – Allows the VCNM to ask for granting of VCNE lifecycle operations.
– Service orchestrator functions → VCNM
  – Allows the service orchestrator functions to grant VCNE lifecycle operations.

7.2.3 V(or-vc-ro)

The reference point between the resource orchestrator functions and VCNM is mainly used for operation of network service management. The main functionalities of this reference are aligned with the V(or-vc) reference point in [ITU-T Y.2321].

– Resource orchestrator functions → VCNM
  – Notifies the consequence of the resource request in the VCNE lifecycle management, such as reservation, authorization, allocation, adjustment and release of the resource.
  – Reports the VCNE related resource status.
– VCNM → Resource orchestrator functions
  – Initials resource request in the VCNE lifecycle management, such as reservation, authorization, allocation, adjustment and release of the virtual resource. The resource orchestrator functions handle the resource request to make sure that the VCNM/VCNE can obtain the requested resource. The request also contains the requirement description of resource deployment and/or specific requirement for resource pool.

7.2.4 V(or-vim)

The reference point between the VIM and resource orchestrator functions is mainly used for virtual resource management and VCNE package management. The main functionalities of this reference point are aligned with the V(or-vim) reference point in [ITU-T Y.2321].

7.2.5 V(vc-vim)

The reference point between the VCNM and VIM is mainly used for virtual resource management including VMs and virtual network topologies. The main functionalities of this reference point are aligned with the V(vc-vim) reference point in [ITU-T Y.2321].

8 Interworking between VCNE and PCNE

The interworking between VCNEs and physical control network entities (PCNEs) means the coexistence of virtualized control network entities and physical control network entities which could compose a single network to provide ubiquitous service to the users. The orchestrator functions in VCN could configure the virtualized control network entities and the management function of VCN could configure the physical control network entities of NGNe1, through the coordination of orchestrator functions and management functions of VCN, the NGNe1 providers could support interworking between VCNE and PCNE by adopting VCN. Figure 8-1 shows the architecture of VCN to support interworking between VCNE and PCNE of NGNe1.

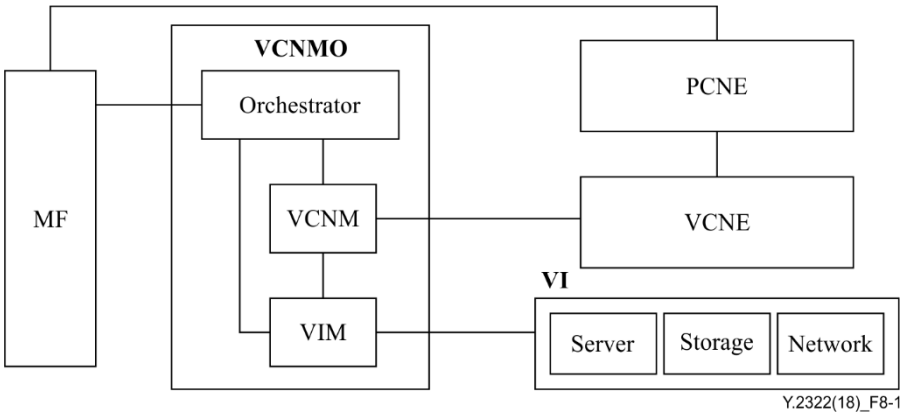

Figure 8-1 – VCN support interworking between VCNE and PCNE

According to Figure 8-1, the PCNE could directly connect to the appropriate VCNE by appropriate configurations without noticing that it connects to a virtualized control network entity. As a result, NGNe1 could provide ubiquitous service to the NGNe1 users while keeping a part of the network virtualized and the other part physical, as long as the VCN technology has been implemented.

9 Security considerations

To ensure the secure environment and secure communication, the VCNMO functional components (including orchestrator, VCNM and VIM) shall support the following features:

– Enforce mutual authentication.

– Protect/verify the integrity and confidentiality of the sent/received messages using the keys and algorithms negotiated with an authenticated and authorized receiver/sender.

– Protect the integrity and confidentiality of the stored data (including images) in their storages and the related keys shall be stored in tamper resistant trusted environment.

– Enforce access control (AC) or role-based access control (RBAC) policy to prevent unauthorized access.

– Usage of resources beyond the threshold limit by a given VCNE shall be notified to the orchestrator and permission shall be obtained for usage of additional resources.

– Prevent and mitigate the DoS/DDoS attacks.

– Protect against side channel attacks.

Other aspects of security consideration shall be aligned with [ITU-T Y.2320] and [ITU-T Y.2321].

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