Research on Implementation Scheme of Power IMS Network Based on NFV Architecture

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Abstract. At present, the State Grid Corporation switching network is evolving from a program-controlled switching network based on circuit-switched technology to a next-generation switching network based on IP technology. The virtualization of power communication core network has become the development trend of grid communication. Among them, network function virtualization (NFV) decouples the software functions and hardware functions of traditional network equipment, reduces the investment and operation costs of the network and improves the deployment efficiency of new services. This paper analyzes the benefits of NFV technology architecture and NFV to power IMS core network, proposes the implementation scheme and network evolution of power IP multimedia subsystem (IMS) network based on NFV architecture, and constructs the virtual network architecture as the architecture scheme of network function virtualization. The scheme of bearer network in the virtualized environment of power IMS core network is proposed, and the advantages and challenges of current NFV technology are summarized.

Keywords: Power IMS · National grid · Power communication · Virtualization

1 Introduction

As the core network of business control, IMS is built on the Internet standard at the beginning of design, adopts open and universal session initiation protocol (SIP) control protocol, and has good portability and easy development. The new business will not only shorten the development cycle, but also get online faster. The system is easy to upgrade and network operation and maintenance is more flexible. By introducing IMS technology, the communication network of the national grid can be upgraded to the multimedia converged communication network, and the mobile and fixed networks can be further integrated to realize support for multi-service terminals. However, despite the mature technology and strong capabilities, this architecture is different from the requirements of the State Grid Corporation's administrative and dispatch switching networks. The State Grid Corporation serves the industry. Its application population is fixed in size and demand is relatively simple. This makes the hardware equipment designed for telecom operators long-term idle and the hardware usage rate is low, which causes waste of hardware resources and energy consumption.

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On the other hand, there is a contradiction between the centralized management of IMS and the original localized management of the State Grid Corporation. To this end, according to the characteristics of national grid demand and requirements, the implementation scheme of power IMS network based on NFV architecture is proposed, and the advantages and achievability are also analyzed.

NFV has changed the way existing network operators build networks: instead of using dedicated network equipment, information technology (IT) virtualization technology is used to implement various types of networks on standard high-performance servers, switches, and storage devices. The functionality of nodes and user front-end devices. In [1], the NFV and software defined network (SDN) technologies are introduced into the core network, and the core network is virtualized. At the same time, based on the complex stream processing platform, the long-term evolution architecture of the core network based on SDN/NFV is established. In order to study the arrangement and placement of NFV services, the NFV service orchestration mechanism and placement algorithm are proposed, and a visual NFV service orchestration and placement system is designed and implemented in [2]. In [3], NFV is used to adaptively monitor the IT infrastructure and provide data to the analytics engine to detect attacks in real time while using infrastructure to block attacks. In [4], a method based on fault injection NFV infrastructure (NFVI) reliability assessment and benchmarking is proposed. The application of this method in virtualized IMS environment is also discussed.

The above documents are all virtualized deployment of public network IMS, which is rarely involved in power. Therefore, the power IMS network is deployed for virtualization based on the characteristics of the national power grid and the virtualized deployment architecture. When deploying a power IMS network, the application of NFV can virtualize network functions, further simplify the operation and maintenance management of the underlying network facilities, and improve the management and control capabilities of the network. In order to meet the functional requirements brought by the bearer network in the deployment process of the power IMS network, the communication system resources occupied by different services are rationally allocated and dynamically adjusted through the centralized control protocol standard, and the power IMS network virtualization capability is further enhanced.

2 Introduction of NFV

NFV is a new type of network technology initiated by operators. It aims to carry related network functions through common hardware and virtualization technologies. Network costs are reduced and business development and deployment capabilities are improved. In the NFV architecture, all network functions are in pure software mode on the unified distribution of computing, storage and network infrastructure [5, 6]. The software functions are no longer bundled with the original dedicated hardware platform. Its architecture is shown in Fig. 1:

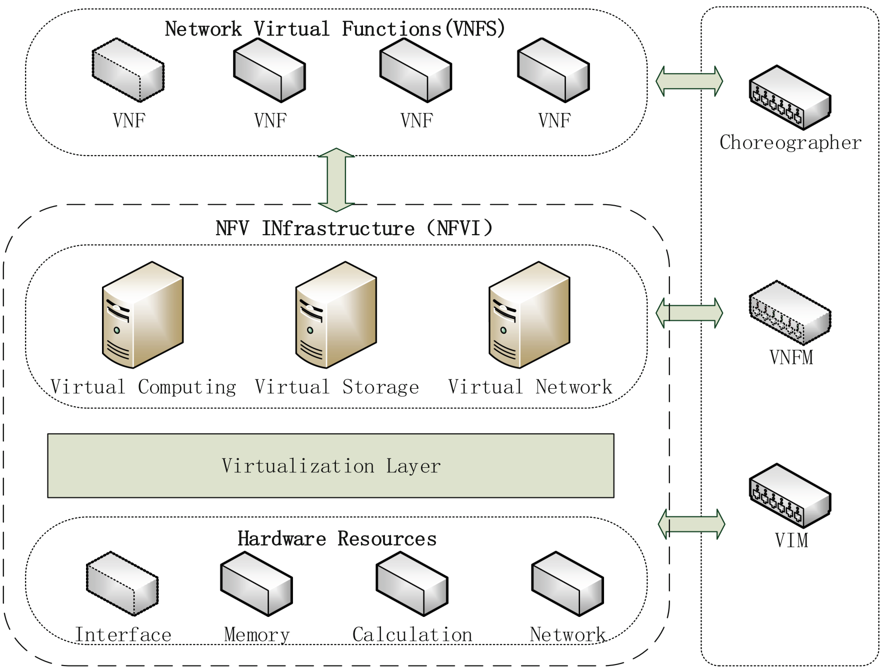

Fig. 1. NFV network architecture

According to this architecture, the three-part entity function of NFV is shown in Fig. 1:

(1) Virtual Network Function (VNF): Includes software that runs on the NFVI to perform specified network functions, such as Proxy/Interrogating/Serving Call Session Control Function (P/I/S-CSCF) and Home Subscriber Server (HSS) in the IMS network. The function and state of a network element node is independent of whether it is virtualized or not. A VNF can be made up of multiple internal components. In this scenario, the same VNF can be deployed on multiple virtual machines or on the same virtual machine. The former virtual machine only runs one component of the VNF.

(2) NFVI: An environment that provides deployment, management, and execution of VNFs, including hardware and software. Hardware resources include computing, storage, and networking resources that provide processing, storage, and connectivity capabilities for VNFs through the virtualization layer. The hardware resources are abstracted by the virtualization layer, and the software functions of the VNF are decoupled from the underlying hardware, so that the independence of the hardware resources from the VNFs is guaranteed.

(3) NFV management and business orchestration: including business orchestration system, VNF management system and NFVI management system. Among them, the business orchestration system is responsible for the layout and management of NFV infrastructure and software resources, and provides network services on the

NFV; the VNF management system is responsible for the management of the VNF life cycle (such as establishing, updating, expanding, and terminating); The ability of the VNF to manage and control the computing, storage, and network resources it requires is managed by the NFVI.

The introduction of NFV in the power IMS core network is to migrate power equipment from the current dedicated platform to a common device. That is to say, various network elements become independent applications, and can be flexibly deployed on a unified platform based on standards-based servers, storage, and switches, so that each application can rapidly reduce the virtual resources to achieve rapid expansion and expansion. As a result, the flexibility of the network has been greatly improved [7–9]. The key to NFV is how to decouple the traditional network functions from the proprietary network hardware, run on a common standard server while ensuring network performance, and implement NFV management and functional design.

3 Network Implementation Scheme of Power IMS Based on NFV

3.1 Power IMS Network

The public IMS network consists of a service layer, a control layer, and an access layer. Open interfaces are used between different layers. The control capability and service providing capability of the SIP-based multimedia session service are provided on the Evolved Packet Core (EPC) and other IP bearer networks. At the same time, the IMS service plane and control plane network element have the characteristics of intensive computing processing, which is consistent with the commercial off-the-shelf (COTS) server's strong computing capability and is suitable for processing the state transition and signaling interaction processes, so it is especially suitable for virtualized deployment.

Compared with the public IMS network, the power IMS network is designed according to its concept and is carried on the integrated data network. The virtual private network (VPN) is divided into other service networks. The IMS network architecture and policy control architecture features are fused in the power IMS network. In addition to the Layer 3 architecture service layer, control layer and network bearer layer of the traditional IMS network, it adds a bearer control sublayer within the control layer. And the ability of the intelligent network is called by the CSCF in the form of a third-party capability control server, which realizes the organic combination of the session control and the bearer control sub-layer, and improves the intelligence degree of the network.

3.2 IMS Virtualization Solution Based on NFV Architecture

According to the needs of enterprise information development, IMS technology has been identified by the State Grid Corporation as the next-generation administrative switching network technology system, and the IMS switching network is promoted in all network provinces. The network element equipment in the IMS network has a complete standard specification. After the core network element is virtualized, the NFV does not change the logical architecture of the network, and each network element function is automatically loaded or unloaded on the general hardware platform in the form of software. The interfaces of the IMS network still exist and the signaling process remains unchanged. This requires that the bearer network of the data center where the virtualized network function is located automatically supports the establishment of a virtual private network for the IMS virtualized network function. Allocate network resources and IP addresses, provide dedicated network channels with QoS guarantees, and ensure that the virtual private network can span data centers across domains.

The NFV technology was introduced by the State Grid IMS in [9, 10], enabling users to obtain the necessary protection while accessing the service on a unified hardware platform. The resource utilization rate is improved, and the equipment space occupation and energy consumption are reduced. The NFV network model implements specific application functions for general purpose hardware. Each node can implement multiple functions, and the network device type is distinguished by software on a unified hardware platform. Under normal circumstances, the unified hardware platform is relatively independent, so that the problem of tight coupling between hardware and software existing in traditional network devices is solved, and an effective fault guarantee mechanism can also be obtained.

The main structure of NFV that incorporates the characteristics of the power IMS network is shown in Fig. 2 below. Its main functional entities include: Virtualization of call control functions: P/I/S-CSCF completes session work and service control; Virtualization of network interworking functions: Media Gateway Control Function (MGCF), Border Gateway Control Function (BGCF), Media Gateway (MGW) complete analog access and interconnection of power exchange networks; Media resource control virtualization: Multimedia Resource Function Controller (MRFC) and Multimedia Resource Function Processor (MRFP) provide media resources for terminal devices; User management virtualization: the storage of information such as routing and signing of power communication services by the HSS; Virtualization of the underlying hardware resources: including intelligent access terminals such as maintenance terminals and video voice services of municipal power companies.

During this virtualization deployment process, physical network resources are virtualized through the NFV architecture to form a virtual network. The virtual network is opened to the IMS virtualized network function in a service manner, and is responsible for carrying the service flow, thereby shielding the actual physical network. The controller in the data center domain is responsible for managing physical node devices such as switches and routers in the domain, and transmits information about the physical network to the virtual infrastructure management system through the northbound application programming interface. The virtual infrastructure management system then based on the collected physical network topology information. The network topology and state of the entire virtual network are sorted out, the network resources of the virtual network are managed, and relevant information is opened to the virtual network function management system and the service orchestration system. The use of NFV technology to transform the edge network elements of the grid and virtualize the network functions can shorten the deployment cycle of new services, and the corresponding workload will be greatly reduced.

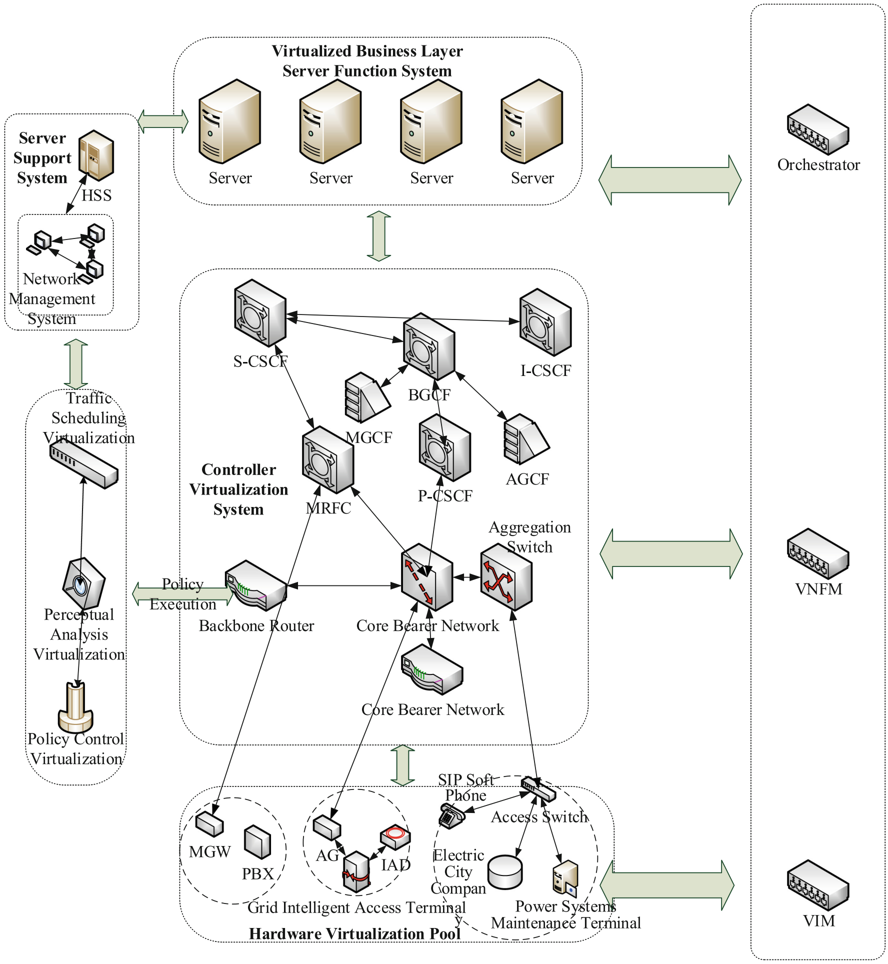

Fig. 2. NFV architecture model of power IMS core network

3.3 Application Scenario of State Gird IMS Network Virtualization Technology

After understanding the power IMS network virtualization process and its network architecture and networking solution, its application scenarios should be studied. Combined with the actual situation of the State Grid IMS network, the specific requirements of NFV technology are obtained, so that the key issues are studied in a targeted manner. The actual application environment and user scale of the State Grid IMS network and the main application environment of NFV technology are different from those of telecom operators. It is a prerequisite for the application of NFV technology to the State Grid IMS network:

(1) Application scenario 1: When the dispatching switching network fails, the basic communication capability of the dispatching switching network can be quickly restored

by using the IMS infrastructure of the administrative switching network in a very short time to maximize resource utilization.

The administrative switching IMS network is used to provide communication guarantee capability for the scheduling switching network. When the primary and backup systems of the switching network fail simultaneously, through NFV hardware and software decoupling and distributed computing, realize the resource sharing between the dispatching exchange network and the administrative switching network of the State Grid, and realize the on-demand scheduling and allocation of resources.

(2) Application scenario 2: Provide a logically independent IMS network infrastructure for different departments without increasing hardware investment.

NFV enables software from different vendors to run on a unified virtualized infrastructure. Through NFV technology, it can provide customizable communication service capabilities for different units. It will be quickly launched, flexible in configuration, and will not affect the communication security of other units and fast fault recovery.

(3) Application scenario 3: The maintenance workload is not greatly increased due to the increase of new services, and the decentralized management is developing toward cloud management.

In the use of the State Grid IMS network, in order to reduce the hardware form, the core maintenance force is put into software and service maintenance. The operation and maintenance management is developed from the traditional local equipment management to the cloud virtual resource configuration, which improves the operation and maintenance efficiency. Reduce hardware costs by decoupling hardware and software.

(4) Application scenario 4: The old and new business alternates from device update to service update, and changes from device operation and maintenance to service operation and maintenance.

With the development of computer technology, in order to comply with the trend and maintain the advantages of the State Grid Corporation in the field of information and communication, the core position of software services should be reflected in the IMS network of the State Grid, and the superior resources should be invested in the software services.

(5) Application scenario 5: The NFV network and the traditional network are mutually disaster-tolerant backups, and the NFV network has a stronger self-healing capability.

NFV provides automatic recovery of network service functions. When a running network service component (or function node) crashes, the management and orchestration (MANO) can extract corresponding mirror information (snapshot information) according to the script policy in the predefined template. Quickly implement network service components (or function nodes) to be redeployed and implement automatic recovery of network functions.

(6) Application scenario 6: Flexible configuration of system capacity, flexible and rapid deployment of new service applications, and on-demand services.

The network's more flexible capacity adjustment capabilities have been given by NFV. The operator can implement automatic elastic expansion of cloud resources when the relevant network indicators reach the threshold according to the pre-configured capacity indicators and the extended scheduling policy. Elastic expansion includes four methods: scale out/in and scale up/down. Out/in refers to the increase or decrease of the number of virtual machines in the network element. Up/down refers to the change of the size of the virtual machine of the network element.

The core of NFV is hardware and software decoupling. Applications do not rely on hardware functions. State Grid can flexibly and rapidly develop and deploy various services and applications according to requirements to meet the needs of various departments.

4 Advantages of Power IMS Implementation Based on NFV Architecture

The use of core network virtualization technology in the State Grid, combined with the actual needs of the State Grid for targeted research, not only meets the economic and reliability issues of power IMS network deployment, but also through the virtualization technology part of the function can be achieved.

(1) One-click completion of power IMS virtual network function deployment in [11]: According to predefined service templates and scripts, virtual network functions including all IMS network elements of P/I/S-CSCF can be automatically loaded on the cloud platform. installation.
(2) Automatic expansion of power IMS virtual network function: The virtual network function key performance indicators operation indicator is automatically monitored by the virtual network function management system. Once the monitoring of the virtual network function load has exceeded the alert value, the virtual network function management system applies computing, storage, network and other resources, and automatically installs the relevant IMS virtual on the newly added virtual machine using predefined templates and scripts. Internet function.
(3) Automatic recovery of power IMS virtual network function: Once the load of the virtual network function is detected to be lower than the minimum value, the virtual network function management system notifies the virtual network function that it is ready to be shut down. After the virtual network function shutdown preparation is completed, the virtual network function management system will reclaim the allocated resources.
(4) Automatic disaster recovery protection of the power IMS virtual network function: When the virtual machine running the virtual network function instance fails, a new identical virtual opportunity is automatically created to take over the call assumed by the failed virtual machine.

5 Conclusion

With the development of virtualization and cloud computing technologies, the emergence of NFV provides a good idea for solving the shortcomings of the traditional core network architecture. NFV is based on virtualization technology, a new network product environment is provided, IT and power industry convergence is promoted, operators' network deployment capabilities are enhanced, and operational capabilities are enhanced. At the same time, NFV technology is applied to the State Grid IMS network, which can solve the current difficulties faced by the switching network. In addition, the State Grid Switching Network applies network function virtualization technology to the company's private network, which can promote the development of power communication technology and provide strong support for the scientific and rational evolution of corporate switching networks including dispatching switching networks and administrative switching networks. However, after using NFV technology, the original hardware maintenance work of the State Grid provinces will be greatly reduced, and new requirements will be put forward for personnel. How to deal with new technologies and the management methods brought about by them, is also the challenge of NFV technology in the State Grid IMS network.

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