Platform Technology to Support Network Functions Virtualization Solution

● Shoji Temma ● Hiroaki Tanaka ● Masataka Sakata

The concept of network functions virtualization (NFV), introduced at SDN & OpenFlow World Congress 2012, is bringing about a significant change in the network environment. NFV enables various networking functions to be virtualized on general-purpose servers and thereby makes it easier to create highly reliable networks at low cost. Fujitsu has applied NFV to its FUJITSU Intelligent Networking and Computing Architecture (FINCA), introduced in 2013. This paper explains this concept and describes Fujitsu's initiatives in developing platform technologies to support NFV. It also takes a look at how NFV will affect future networks.

1. Introduction

The server environment has undergone significant changes due to server virtualization technology, and virtualization is now leading to changes in network environments in the form of network functions virtualization (NFV). Network functions have conventionally been implemented using purpose-built hardware appliances, but NFV will enable these functions to be provided by software running on virtual machines (VMs) on general-purpose servers.

In this paper, we first overview NFV and then describe Fujitsu's architecture and products for achieving NFV from the viewpoint of platform technology. We then present an example of an NFV solution, and finally, we discuss how networks of the future will be shaped by NFV.

2. NFV overview

NFV was first presented at the SDN & OpenFlow World Congress held in Germany in October 2012 as an NFV White Paper[1)] issued by the European Telecommunications Standards Institute (ETSI). The vision for NFV presented in this paper is shown in **Figure 1**. The ETSI subsequently established the NFV Industry Specification Group (ISG), which held its first plenary meeting in January 2013. It was decided at this meeting to develop an architecture and prescribe basic specifications for virtualizing various types of functions in a telecommunications network.

The need for NFV has grown because of various factors, such as escalating expenses due to expanded application of purpose-built hardware appliances, increasing difficulty in designing and operating a conventional network, securing skilled personnel to run it, taking longer to provide new services, and the rising cost of constructing a network infrastructure. NFV is aimed at solving these problems by using general-purpose servers to achieve five objectives:

1) Shorten the time-to-market for new services,
2) Optimize resource usage efficiency and reduce equipment costs, installation space, and power consumption,
3) Improve operating efficiency by providing an automatic operation and intelligent platform,
4) Provide flexibility and scalability for dealing with dynamic requests in a multi-tenant environment,
5) Promote open systems to support multivendor (hardware and software) interoperability.

The NFV ISG released its first set of specifications describing the direction of NFV technology for meeting the above objectives in October 2013. More than 150 companies (among them Fujitsu), including 28 service providers, attended the first NFV ISG plenary meeting.

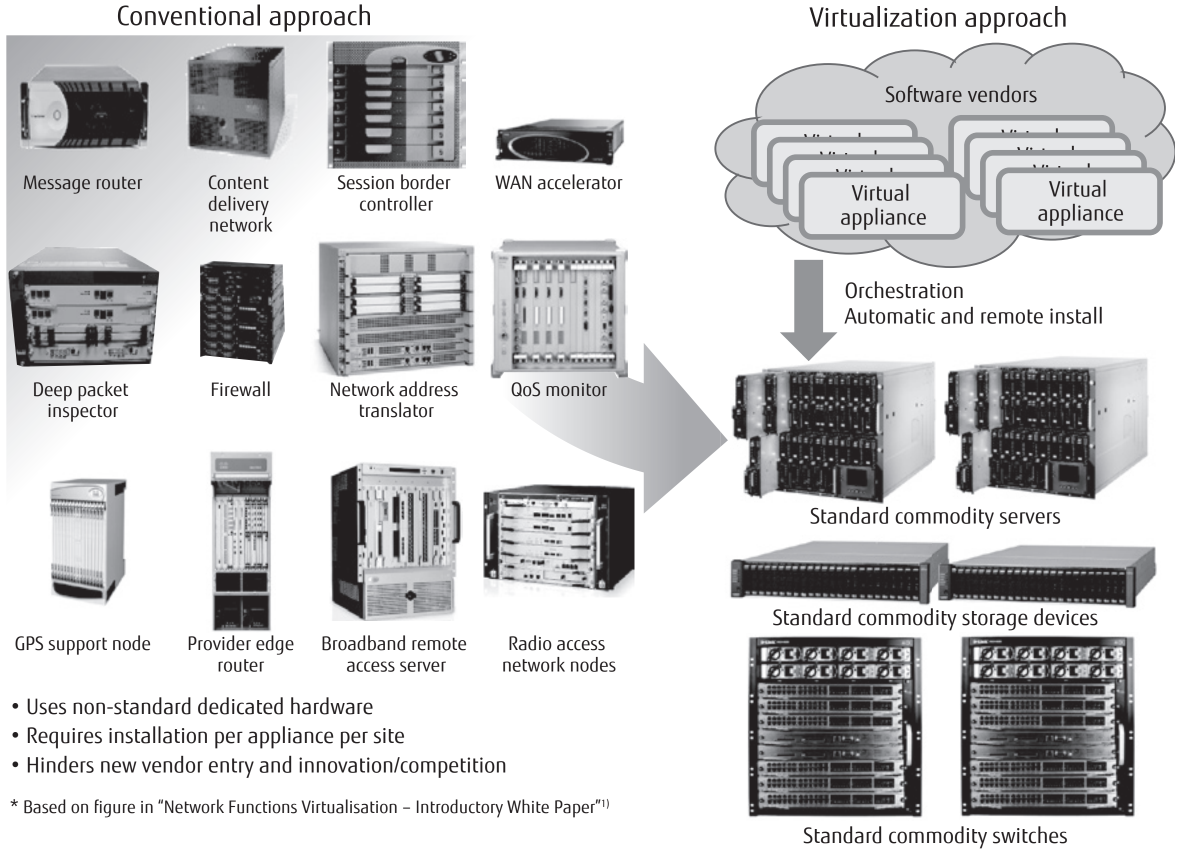


Figure 1
Vision for network functions virtualization.

3. Three constituent elements

As shown in **Figure 2**, the NFV framework can be divided into three elements.[2)]

1) NFV infrastructure (NFVI)

Infrastructure for executing virtualized network functions (VNFs), including physical resources such as servers, storage devices, and switches and the virtualization mechanism for these resources

2) Virtualized network functions

Network functions such as firewalls and routers achieved by software running on NFVI

3) NFV management and orchestration (MANO)

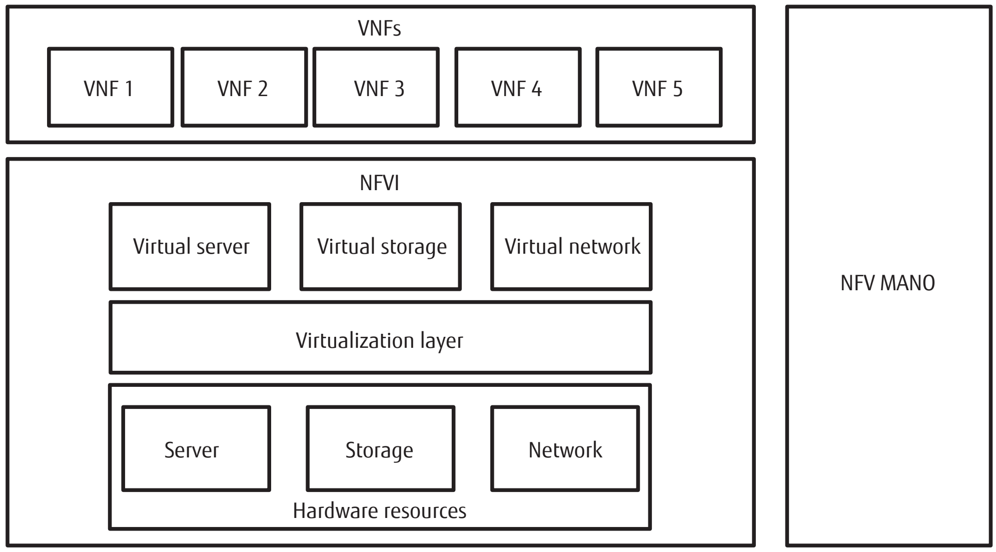
Orchestration and lifecycle management of physical resources and software resources (virtualization mechanism) in VNFs and NFVI

A typical configuration of a network service provided by VNFs is shown in **Figure 3**. In this example, a network service is achieved by combining multiple VNFs deployed along an end-to-end packet flow path.

In the following section, we discuss the trend toward open systems in relation to NFV.

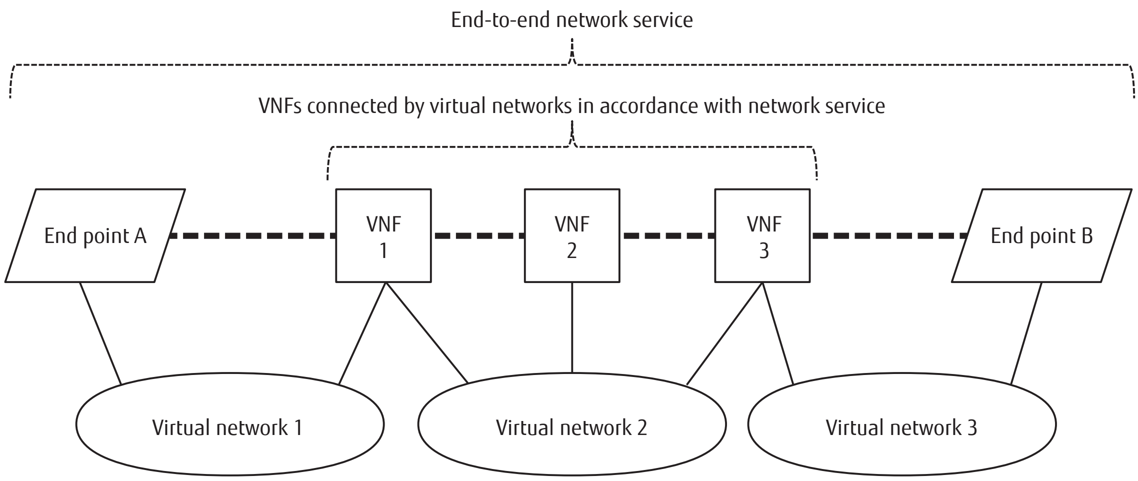
4. Trend toward open systems

As described above, the ETSI declared that the promotion of open systems is one of several NFV objectives. At ETSI, discussions are now focused on architecture, and similar discussions are being held by other standardization bodies. For example, the Internet Engineering Task Force (IETF) is discussing a service chaining method that links VNFs to provide an on-demand service or a single service achieved by connecting multiple services. At the same time, user communities such as Open Platform for NFV (OPNFV), OpenStack, and OpenDaylight are developing open software on the basis of discussions in ETSI, IETF, and other standardization bodies.



* Based on figure in "ETSI Network Functions Virtualisation (NFV), Architectural Framework"[2)]

Figure 2
Network functions virtualization framework.



* Based on figure in "ETSI Network Functions Virtualisation (NFV), Architectural Framework"[2)]

Figure 3
Typical configuration of end-to-end network service provided by VNFs.

5. Fujitsu's approach

Fujitsu presented its FUJITSU Intelligent Networking and Computer Architecture (FINCA) in 2013 (**Figure 4**). FINCA provides customers with optimal functionality and performance. It utilizes a three-domain configuration consisting of "data center," "wide area network (WAN)," and "smart devices," each with its own characteristics, and a two-layer format consisting of a virtual infrastructure layer and a distributed service platform layer. The aim is to merge server technology and network technology to enable network-wide ICT optimization to be achieved through software-defined networking (SDN). Fujitsu, as an advocate of architectures like FINCA, is perfectly situated to support NFV.

An example of how the NFV framework can be configured using Fujitsu products and applications is shown in **Figure 5**.

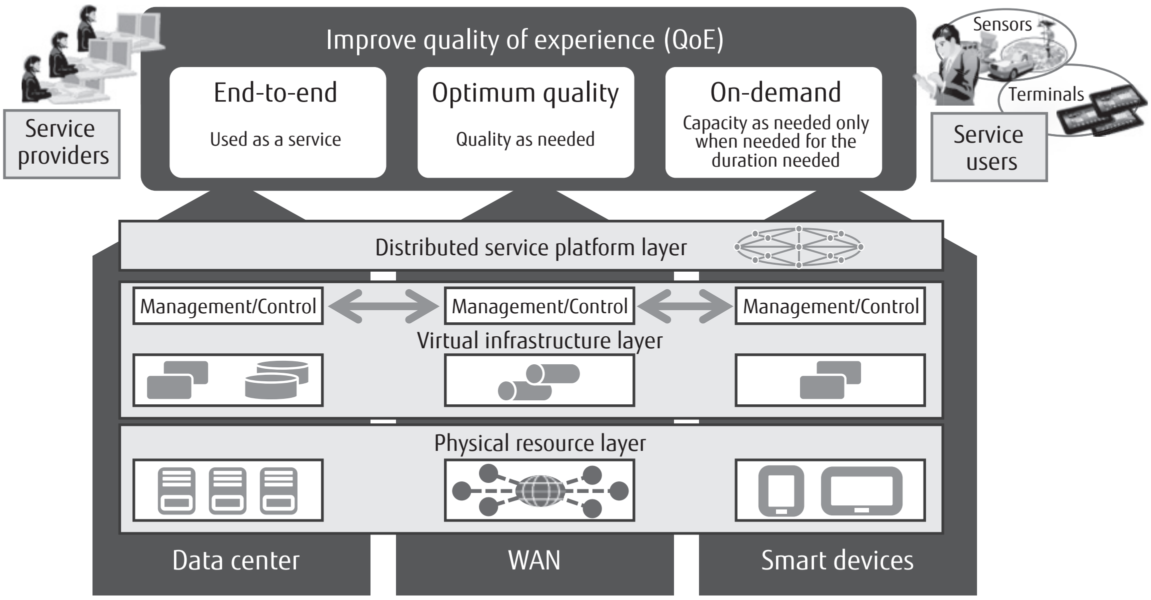


Figure 4
FINCA overview.

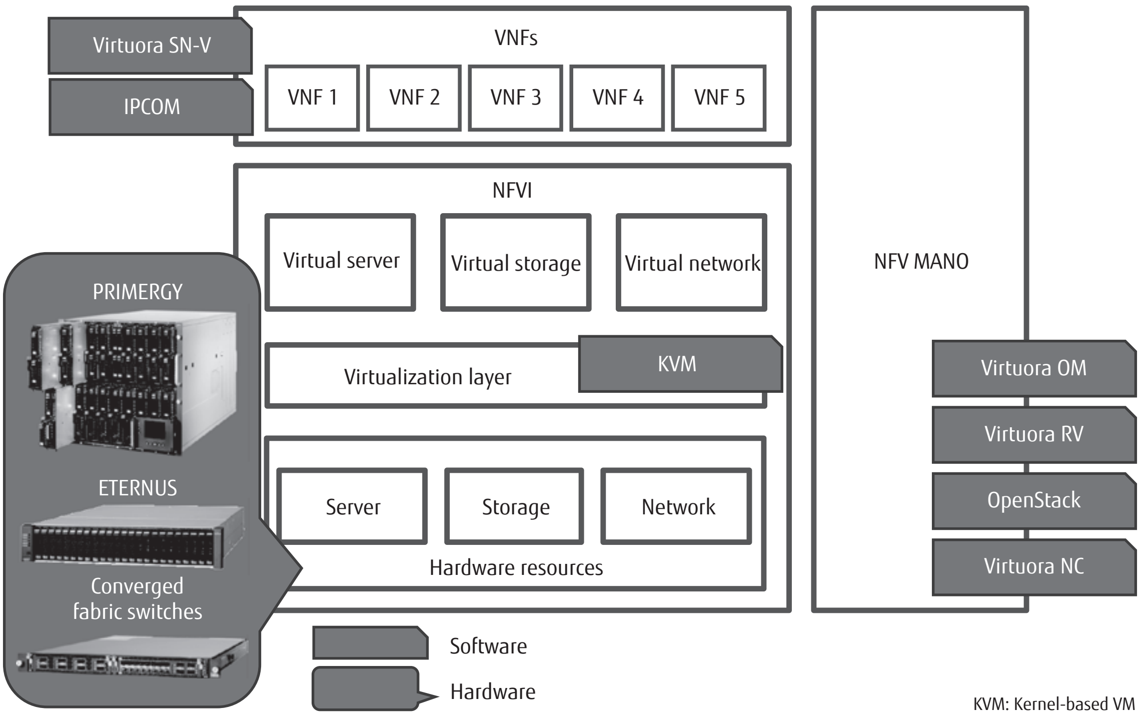


Figure 5
Example of NFV framework using Fujitsu products.

5.1 Hardware resources

1) FUJITSU Server PRIMERGY

Under the slogans "Integration: visualize the entire system," "Flexibility: respond to changes," and "Savings: reduce labor and expenses," PRIMERGY products are aimed at simplifying the configuration of a network from the server-centric viewpoint and at creating a system environment having a mixture of virtual and physical servers. The infrastructure manager (ISM) enables integrated operation and management, from hardware to facilities, so that they achieve unprecedented levels of efficiency and power savings. The FUJITSU Server PRIMERGY series comprises PC servers that can deal with future changes and meet customer needs through an extensive lineup ranging from rack-mount to blade servers.

2) FUJITSU Storage ETERNUS

ETERNUS is a storage system that can meet diverse customer needs, from mission-critical core systems to information and content systems. They support Fujitsu's mission of "endlessly protecting the important assets of our customers" under the concept of "ensuring business continuity."

3) Converged fabric switches (CFXs)

Converged fabric switches create inter-server connections that support PRIMERGY flexibility by

- providing a high-speed, high-bandwidth, and high-reliability communications environment using link aggregation (LAG) technology (multi-chassis LAG technology) spanning multiple CFXs and accommodating the dynamic and free migration of virtual servers without bottlenecks,
- configuring an independent network for each tenant through a "virtual fabric" function that logically partitions the network,
- operating as a single large switch controlling all CFXs from a root CFX.

5.2 NFV MANO

1) FUJITSU Network Virtuora OM/RV

Virtuora OM and Virtuora RV are software stacks that enable network operators to shorten the lead time for launching new services by automating various operations during the NFV service lifecycle. Virtuora OM provides orchestration features for building and managing network services with virtualized network applications on virtualized resources in accordance with on-demand requests. Virtuora RV provides resource virtualization features and virtualized resource management that improve reliability and manageability.

2) FUJITSU Network Virtuora NC

Virtuora NC is centralized management software for wide area networks. It supports optimal centralized control and management of virtual networks with on-demand service and service-chaining, incorporating the concept of SDN.

5.3 VNFs

1) FUJITSU Network Virtuora SN-V

Virtuora SN-V is network virtualization node software that works on generic PC servers and provides U/C-plane separation in response to SDN trends in wide area networks. This software provides virtual private network (VPN) features (L2 over L3 tunneling and forwarding) and resource virtualization (slicing) of wide area networks.

2) FUJITSU Network IPCOM

IPCOM is a virtual appliance that Fujitsu has been providing for many years as IPCOM EX and IPCOM VX products. It integrates a variety of functions such as a unified threat management (UTM) function (including firewalls, unauthorized access countermeasures, URL filters, and virus countermeasures), L7-QoS functions, and server load balancers.

5.4 Reference architecture

Fujitsu integrates the NFV functional elements described above on the basis of the reference architecture shown in **Figure 6**. This architecture uses hardware products such as PRIMERGY introduced above as hardware resources and configures NFVI using the Kernel-based VM (KVM) as a virtualization layer and Open vSwitch (OVS) as a virtual switch. It uses OpenStack to deploy and manage the VMs and ISM to manage the hardware. Virtuora OM/RV orchestrates all of the above to configure MANO. In addition, VNFs such as IPCOM and Virtuora SN-V run on VMs deployed by OpenStack, with detailed task definitions and operations handled by VNF Manager.

We introduced above an example of an NFV configuration using products based on FINCA. In the following section, we introduce an example NFV-based solution.

6. Solution example

The following presents an example of an NFV solution for an Internet connection service (**Figure 7**).

6.1 Solution scenario

- User A connects to the Internet via a firewall and adds a deep packet inspection (DPI) function later.

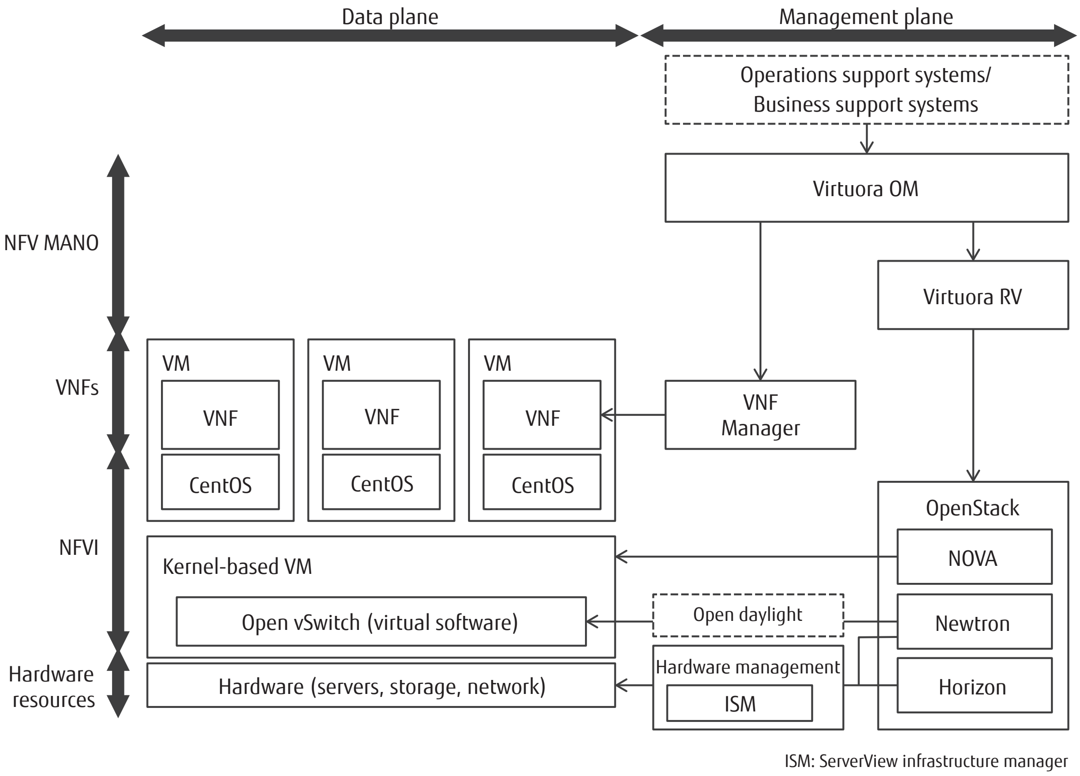


Figure 6
Reference architecture.

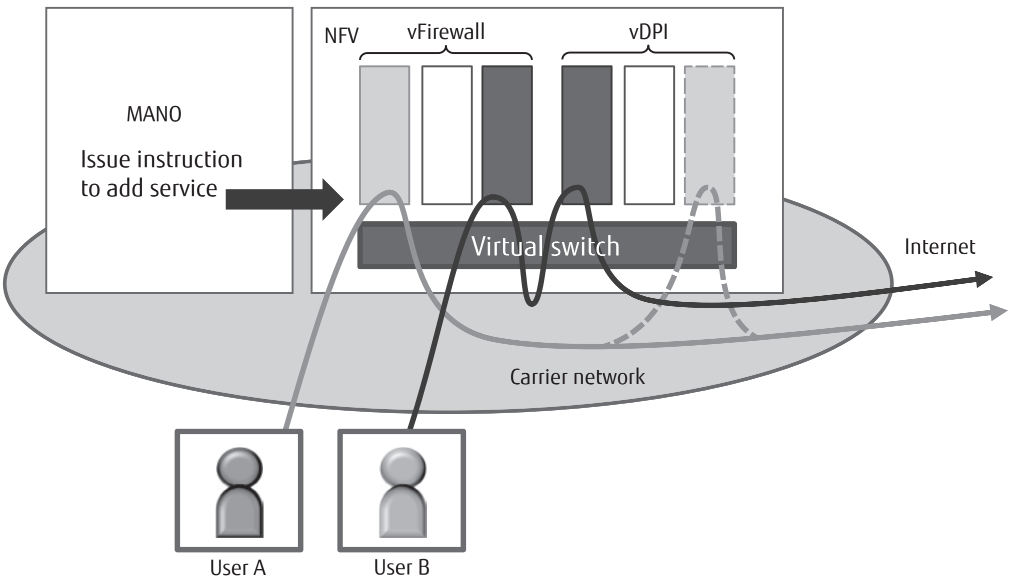


Figure 7
Application of NFV to Internet connection service.

- User B connects to the Internet via a firewall and DPI.

6.2 NFV operation

1) First, MANO initiates a virtual network to connect user A to the Internet and initiates a virtual firewall (vFirewall) as a network function. It then connects vFirewall to user A's virtual network.
2) Next, in a similar manner, MANO initiates a virtual network to connect user B to the Internet and initiates vFirewall and virtual DPI (vDPI) as independent network functions. It then connects vFirewall and vDPI to user B's virtual network.
3) Then, MANO initiates a new vDPI in response to a vDPI function-add request from user A and connects that vDPI to user A's virtual network.

In this way, MANO can construct a network service by dynamically initiating vFirewall and vDPI VNFs and issuing an instruction to connect those VNFs to the user's virtual network.

6.3 Benefits of NFV solution

The conventional approach to providing a solution for a connection service is to procure and install purpose-built hardware appliances to achieve firewalls, DPI, and other required functions. An NFV solution, in contrast, implements VNFs, such as firewalls, DPI, and other functions, as software and dynamically deploys those functions through software control by MANO. This approach eliminates the need for procuring and installing expensive purpose-built hardware and shortens the lead time for providing new services.

7. Effect of NFV on future networks

Finally, we discuss the outlook for NFV on the basis of Nippon Telegraph and Telephone Corporation's (NTT's) "NetroSphere concept,"[3] which is a new way to form future carrier network infrastructure.

NetroSphere aims to achieve a wide variety of services with shorter lead times, levels of reliability in accordance with user needs, and drastically reduced costs. To this end, the plan is to separate and modularize the functions making up a network into small modular components and to flexibly assemble those components on general-purpose servers as needed. This will enable the required network functions and capacity to be configured in a flexible and cost-efficient manner.

To apply this concept in the real world, NTT is collaborating with a wide range of partners, such as domestic and overseas vendors and research institutions, having different areas of expertise. Fujitsu is also participating in this endeavor.

NetroSphere is based on two key technologies.

1) New server architecture (MAGONIA)

MAGONIA is basic architecture for an open server system providing high reliability and scalability as a common platform that can be shared by a wide range of applications.

2) Multi-service fabric (MSF)

MSF manages and dynamically controls modularized servers and switches as virtual resources to achieve even higher levels of reliability and scalability while using low-cost equipment.

As an initial step in applying NFV on the basis of the NetroSphere concept, Fujitsu is studying the technical requirements for accommodating a triple-play service providing voice, video, and data over the same line. In the NetroSphere concept, MSF is used to distribute packets to MAGONIA-based NFV servers. A method for achieving this function in MSF has been proposed by Fujitsu. This method would assign appropriate roles to MSF and general-purpose servers when linking subscriber profiles and service resources located on NFV servers and when performing packet-distribution processing for each service. In this processing, resource and performance design is important for identifying services, rewriting packet headers, etc. Packet processing requires high throughput and low delay; the aim is to provide a solution for achieving an optimal balance among functionality, performance, and cost by offloading such processing as much as possible from expensive switch fabrics to low-cost general-purpose servers.

The NetroSphere concept suggests that the network itself will be transformed into a large information technology system (cloud) by implementing diverse network functions on general-purpose servers and merging those functions with the server system. Fujitsu believes that achieving practical implementation of NFV will make the NetroSphere concept a reality.

8. Conclusion

In this paper, we described network functions virtualization (NFV), a revolutionary network concept, introduced Fujitsu's approach to platform technology supporting NFV, and discussed the outlook for applying NFV to networks.

Server virtualization technology gave birth to the cloud, and now the cloud is poised to change the network. This transformation is still in its early stages as more technological development is needed. Fujitsu is committed to facing this challenge head-on with the aim of providing its customers with even better solutions.

References

1) M. Chiosi et al.: Network Functions Virtualisation—Introductory White Paper. SDN & OpenFlow World Congress, October 2012.
2) ETSI: Network Functions Virtualisation (NFV); Architectural Framework.ETSI GS NFV 002 V1.2.1, December 2014.
3) NTT: NetroSphere: Towards the Transformation of Carrier Networks—A novel R&D concept to innovate the network development by accelerating network functions modularization.
http://www.ntt.co.jp/news2015/1502e/150219a.html

Shoji Temma
Fujitsu Ltd.
Mr. Temma is currently engaged in the development of NFV systems.

Hiroaki Tanaka
Fujitsu Ltd.
Mr. Tanaka is currently engaged in the development of packet node solutions.

Masataka Sakata
Fujitsu Ltd.
Mr. Sakata is currently engaged in the development of optical node solutions.