Technology Reports
Fulfillment Automation NFV
Special Articles on Smart OPS for Further Efficiency and Advancement of Network Operations

Automated Facility Construction Work Achieved through the Implementation of Fulfillment OSS

DOCOMO Technology, Inc. Solution Service Division Kentaro Ishii Kazuo Takayanagi
Core Network Engineering Department Kentaro Wakitaka†
DOCOMO CS, Inc. Core Network Department Yuta Tanaka

Network facility construction works need to be fast and flexible for the commencement of 5G services and the ongoing expansion and diversification of IoT services. To address these issues, NTT DOCOMO has been implementing virtualization technologies in its core network facilities, and has introduced the Fulfillment OSS to achieve automation and efficiency with the design and settings input, which are crucial elements of the lifecycle of core network facilities, to significantly reduce the complexity of design and settings operations and operate the network with even higher quality.

The Fulfillment OSS incorporates equipment design rules and parameters as input data required for constructing and changing the network facilities needed for services, and improves quality and efficiency of facility construction works by enabling automatic management and design of parameters and schematics required for various equipment.

1. Introduction

Network facility construction works need to be fast and flexible for the commencement of 5G services and the ongoing expansion and diversification of IoT services.

NTT DOCOMO developed its core network*1 virtualization platform system based on Network

† Currently Chugoku Regional Office

*1 Core network: A network consisting of switching equipment and subscription information management equipment, etc. Mobile terminals communicate with the core network via radio access networks.

Functions Virtualisation (NFV)*2, which uses common requirements and reference architectures defined by the European Telecommunications Standards Institute (ETSI)*3 [1] [2]. Since commencement of its commercial services in March 2016, this system has achieved improved reliability, rapid service provision, easy connection during times of congestion and improved economies with network facilities and operations.

NTT DOCOMO introduced NFV to enable on-demand responses with planned hardware construction to match demand for facilities and software building as required. To broadly visualize virtualized facility construction processes, gain a thorough understanding of them, bring even more reliability, speed and efficiency to virtualized facility construction, and reduce OPerating EXpenses (OPEX)*4, NTT DOCOMO implemented the Fulfillment Operation Support System (OSS)*5 for automation and efficiency of the design and settings works in the lifecycle of NFV related equipment.

This article describes an overview of the Fulfillment OSS.

2. Targets of Fulfillment OSS Automation and Requirements

The Fulfillment OSS is a system that automates facility construction work after the application of network virtualization technologies as shown in **Figure 1**, by incorporating input information such as design rules and parameters for equipment requiring construction and update.

Currently, separate hardware and software

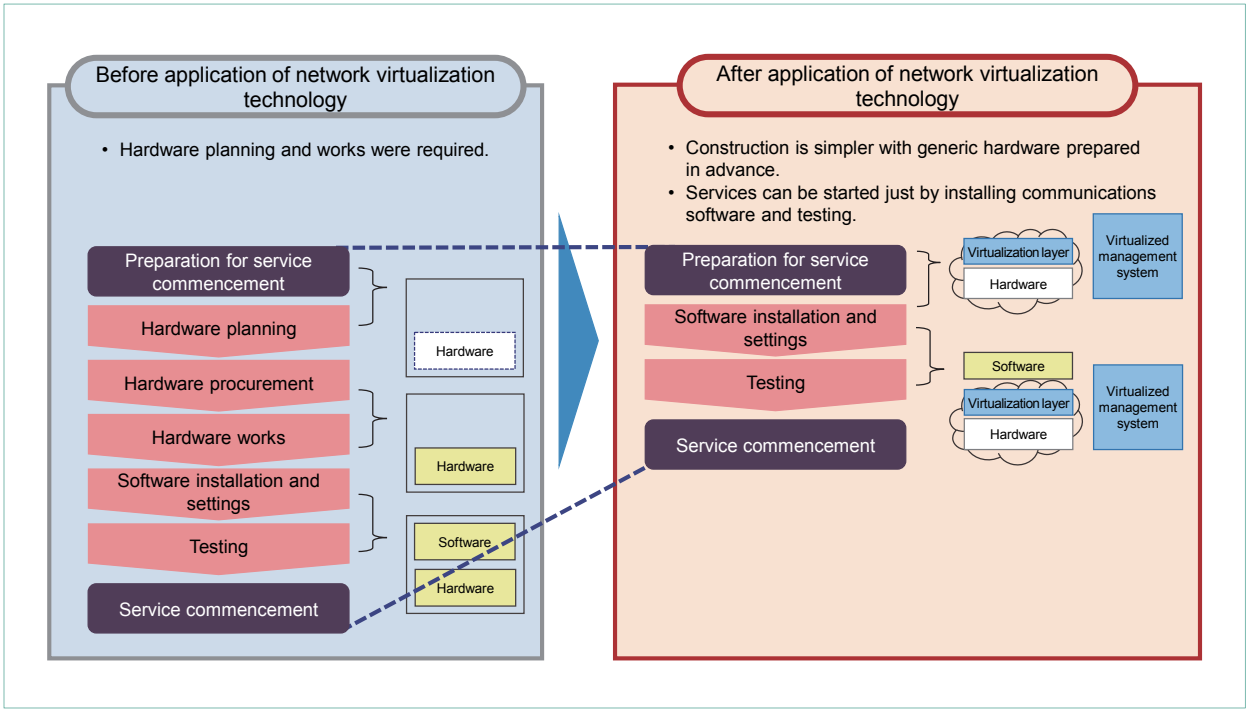

Figure 1 Changes to facility construction processes up to service commencement through the application of network virtualization technologies

*2 NFV: Achieving a telecommunications carrier network on generic hardware using virtualization technologies.

*3 ETSI: A European non-profit organization that formulates standard specifications for the telecommunications field.

*4 OPEX: The amount of money expended for designing, setting, maintaining and managing facilities.

*5 OSS: A system for discovering, controlling, and dealing with faults and congestion on a mobile communications network, or an operations support system for network operators. For a network operator, this means a system for full or partial network or system fault management, configuration management, charging management, performance management, and security management.

design and construction work and on-demand responses are enabled with virtualized facility construction work. While this has made work more efficient, we faced the challenges of optimizing the sophisticated and complex work processes that handle massive amounts of design rules and parameters associated with facility construction, and thoroughly visualizing the progress of facility construction works to enable a broad view and complete understanding so that such works can proceed steadily and efficiently in situations where a number of constructions are performed in parallel. To solve these issues and maximize the effectiveness of network virtualization by the implementation of the Fulfillment OSS, the following requirements must be satisfied.

- Review and improvement of the work processes so that they suit virtualized facility construction
- Efficient management and automated design of schematics and parameters required for facility construction
- Comprehensive progress management of entire processes from design through to completion

3. Optimizing Facility Construction Works Based on Standard Specifications

In reviewing work processes for virtualized facility construction, as a reference model, we used the enhanced Telecom Operation Map (eTOM)*6 framework*7 advocated in the Tele Management Forum (TM Forum)*8 for standardization of operations work [3]. **Figure 2** shows the eTOM framework.

This framework divides operational targets into

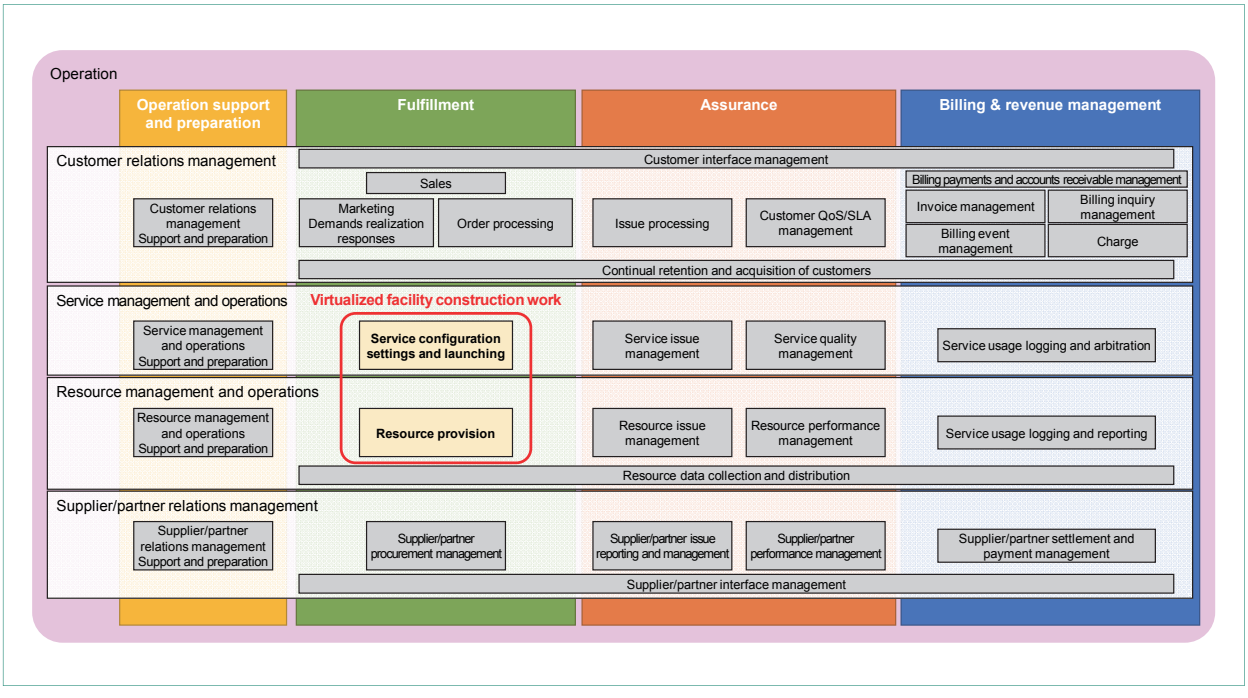

Figure 2 The eTOM framework

*6 eTOM: A collection of frameworks formulated by TM Forum summarizing work processes and information distribution in operations in the telecommunications field.

*7 Framework: Software that encompasses functionality and control structures generally required for software in a given domain. In contract to a library in which the developer calls individual functions, code in the framework handles overall control and calls individual functions added by the developer.

*8 TM Forum: A European non-profit organization that formulates standard specifications for the telecommunications field.

four layers - customers who use services, services provided, resources that comprise services, and suppliers and partners that provide resources. Work to manage customer information and information related to service structures and prepare support, work in the fulfillment area required to build and achieve services, work in the assurance area for maintenance and management of service operations, and work required for billing for service usage are systematically sorted for each of these separate operational layers.

Virtualized facility construction work entails "service configuration settings and launching" and "resource provision," which fall into the fulfillment area of the framework. In this work, workflows for understanding current usage conditions of the facility required for services, facility planning, physical and logical parameter design for building, and setting and testing equipment have been standardized.

In our review of work processes, we studied the aspects below to apply this framework.

(1) Clarification of current work processes and tasks
(2) Task optimization and sorting of work processes
(3) Separating the facility construction work of virtualized facility construction and settings into (1) design work using common design parameters as "common design" and "physical works," and (2) design work using different design parameters for each construction as "network settings," "virtualization platform settings" and "communication software settings," and then assigning tasks to their related work modules after defining these five work modules
(4) In addition to the five work modules, we defined "progress management" for managing the progress of overall works

Table 1 shows the defined work modules and the details of work of each module. Also, **Figure 3** shows work modules for design and construction

Table 1 Works entailed in each work module

Work module	Details of work
Process progress management	Overall work process progress management
Common design	Processes of unified management of network design rules and parameters, and facility design work
Physical works	Processes of on-site settings work required for physical equipment installation and wiring, and initial equipment startup
Network settings	Processes of physical network equipment settings to implement SDN and testing work
Virtualization platform settings	Processes of NFVI and VIM settings and testing work
Communications software settings	Processes of VNF settings and testing work

NFV Infrastructure (NFVI): Virtualization functions including physical resources consist of generic hardware and storage to run communications software, and hypervisors.
Software Defined Network (SDN): A generic term for technology that enables centralized control of communications equipment with software.
Virtualized Infrastructure Manager (VIM): Functions for controlling NFVI.

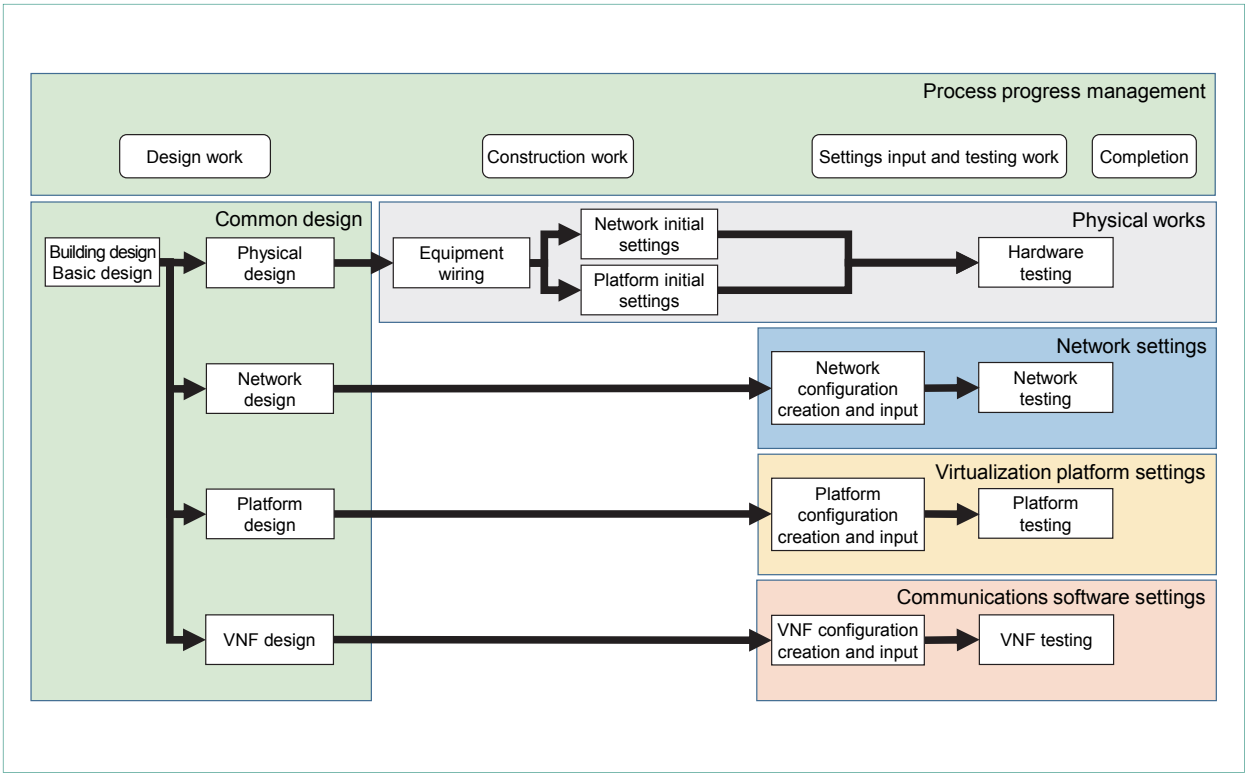

Figure 3 Work modularization for design and construction of virtualized facilities

of virtualized facilities.

4. System Structure of the Fulfillment OSS

When we systemized the work modules defined in the previous section with the Fulfillment OSS, we studied the Fulfillment OSS system structure in terms of the eTOM framework.

When considering system configuration, the following requirements must be satisfied to make application scope expansion easy and enable flexible response to network specifications changes in future.

- A loosely coupled system configuration based on functional segments
- Localized scope of influence when responding to network specifications changes

In terms of system configuration, when defining work modules, we adopted a policy of constructing a system based on work modules with optimized and loosely coupled design and construction work segments sorted for each target construction. Systematization entails defining the work modules as Function Blocks (FB)*9 and then systemizing in FB units. Also, with FB, to respond to network specification changes, we adopted a policy of localizing the scope of influence as a mechanism to avoid affecting FBs other than those for managing facilities with changing specifications, by managing only network information and design parameters for

*9 FB: Functional sections in which services offered by the system are divided into functions or target devices, etc. and implemented. Single FB or linked multiple FBs achieve the services.

facilities targeted for management.

When defining FB, we aimed for efficient implementation while accounting for the characteristics of the information managed with work modules. The information managed with work modules can be generally divided into the two categories of "information that spans processes and equipment under construction" and "information only related to the class of equipment under construction." **Table 2** shows information managed with work modules.

For process progress management and common settings, information is systemized and managed uniformly with the same FB to manage information spanning overall processes and target equipment. For other work modules, we implemented independent FB because only the information for each device under construction is retained.

Table 3 shows the defined work modules and their corresponding FBs. Also, **Figure 4** shows the defined FB and their corresponding function segments in the eTOM Fulfillment area.

As shown in Table 3 and Fig. 4, the Fulfillment OSS consists of design and inventory FBs, network provisioning*10 FBs, virtual platform provisioning FBs, and Virtual Network Function (VNF)*11 provisioning FBs. The roles of the four FBs that make up the Fulfillment OSS used to construct

Table 2 The information managed with the work modules

Work module	Managed information
Process progress management	Process progress information spanning processes and equipment targeted for construction
Common design	Design information spanning processes and equipment targeted for construction
Physical works	Management of details of physical work for construction and on-site settings information only
Network settings	Management of settings information for network devices for construction only
Virtualization platform settings	Management of settings information for virtualization platforms for construction only
Communications software settings	Management of settings information for VNF for construction only

Table 3 Defined work modules and their corresponding FBs

Work module	FB
Process progress management	Design, inventory FB
Common design	Design, inventory FB
Physical works	Actual physical works cannot be systemized, and are thus exempt from FB definitions
Network settings	Network provisioning FB
Virtualization platform settings	Virtual platform provisioning FB
Communications software settings	VNF provisioning FB

*10 Provisioning: Hardware and software settings and testing work required to operate resources such as the networks necessary for providing services.

*11 VNF: Communications functions implemented with software running on virtual machines.

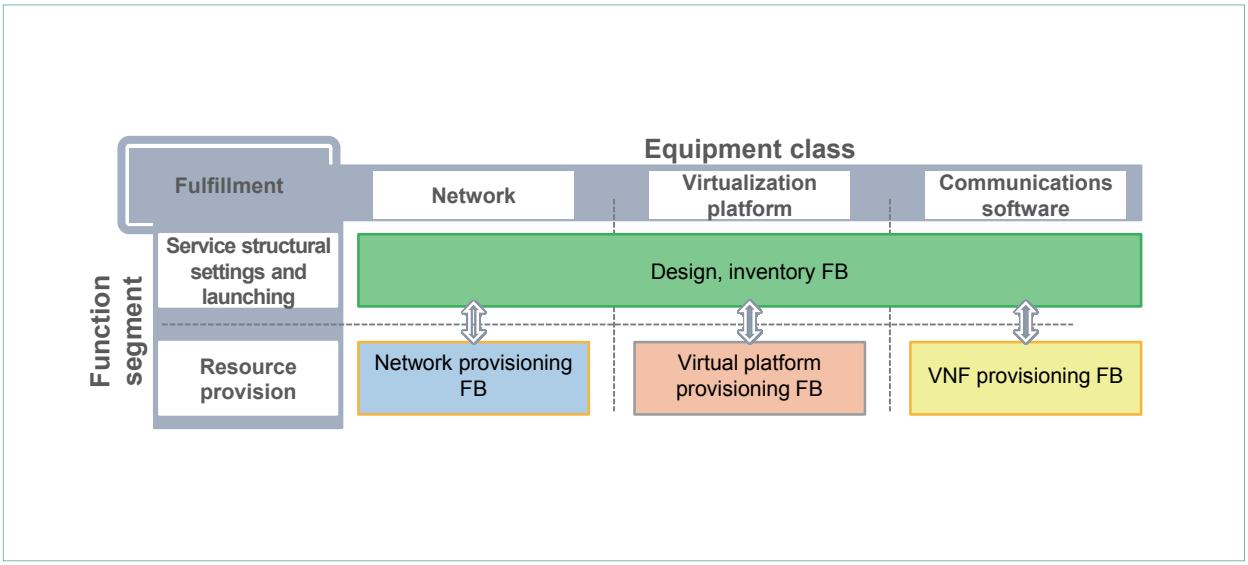

Figure 4 Defined FBs and their corresponding function segments in the fulfillment area

virtualized facilities and change their settings are shown below.

1) Design, Inventory FB

This FB is responsible for uniform management of network design rules and parameters required for overall construction and settings changes of virtualized facilities, automation of facility design works, and overall work process progress management.

Design information is created as schematics with this FB and is passed to provisioning FBs for the class of equipment under construction to achieve efficient task execution.

Simply updating the internal data of this FB enables response to changes to design rules and parameters specifications that come with diversifying and ever-more complicated networks, and thus achieves the flexibility and agility required to keep up with network changes accompanying the implementation of new networks such as 5G and IoT.

In future, as the range of equipment classes applicable to the Fulfillment OSS expands, simply adding functions to this FB and introducing new FBs will enable application of the Fulfillment OSS to such equipment without influencing other provisioning FBs.

2) Network/Virtualization Platform/VNF Provisioning FBs

This FB is responsible for automated generation and input of configuration files*12 as well as commands for facilities under construction, and automatic testing to confirm normalcy based on the schematics received from the design and inventory FB.

This FB manages rules for generating commands and configuration files for settings and inputs to facilities under construction, and enables simple response to changes to configuration file and command specifications due to version updates, etc.

Also, by defining provisioning FBs separately and structuring them so that there are no links

*12 Configuration file: A file containing the information for the settings required to operate a network facility such as IP addresses and equipment numbers. Settings values in configuration files are loaded into network facilities, which behave according to the details of those settings.

between the provisioning FBs, FBs are configured so that they don't influence other provisioning FBs due to specification changes for facilities under construction, since network equipment, virtualization platforms and VNFs have different equipment characteristics.

5. Conclusion

This article has described a review of work processes of construction and settings changes of core network virtualization facilities, and automation of works through the implementation of the Fulfillment OSS to achieve efficient and automated design and settings input for facilities construction on complexing and diversifying mobile networks.

The implementation of the Fulfillment OSS has resulted in dramatically greater efficiency with a 77% reduction in work targeted for automation in construction of virtualized facilities (**Figure 5**).

Currently, we are proceeding with developments to achieve automated design and settings not only for network equipment in virtualized facilities, but also for the physical network equipment that comprises and provides closed networks by expanding the scope of application of network provisioning FB, by the first half of FY 2019.

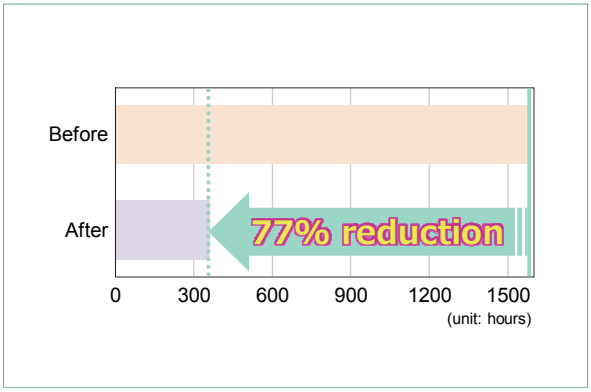

Figure 5 Effects of Fulfillment OSS implementation

As well as core networks, we aim to expand the scope of application to other networks, achieve automated design and settings in terms of units of service rather than units of equipment, and provide quick and efficient end-to-end services as soon as user demand arises.

REFERENCES

[1] ETSI: "Network Functions Virtualisation (NFV)." http://www.etsi.org/technologies-clusters/technologies/nfv
[2] H. Oto et al.: "Application of Virtualization Technology to Communications Networks," NTT DOCOMO Technical Journal, Vol.18, No.1, pp.4-10, Jul. 2016.
[3] TM Forum: "Business Process Framework (eTOM)." https://www.tmforum.org/business-process-framework/
[4] OpenStack Web site https://www.openstack.org/