Sustainable Implementation-Level Workflow For Automating NFV Operation

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***Abstract*— Network function virtualization is expected to enhance automated operation such as service deployment and fault recovery. As an effort to achieve automated operation for NFV, the ZOOM project has been launched by TM Forum. However, standardization of the business process framework (eTOM) is still limited to the abstracted process level, and an implementation-level process needs to be created by each organization considering vendor-specific implementations of control and management. As a result, implementation-level operation tasks are diverging and the cost of process maintenance is increasing accordingly. On the other hand, NFV MANO standardized by ETSI is expected to reduce implementation variations of control and management. From the above background, the harmonization of both standard models eTOM and ETSI to achieve a telecom operation map that can drive an automated onboarding NFV infrastructure should be considered. The contribution of this paper is to show how NFV MANO standards can derive a versatile implementation-level eTOM workflow by abstracting resources and functions of NFV. The paper describes the challenges of defining eTOM through mapping of MANO operations and eTOM processes.**

Keywords—NFV; automation; eTOM; ETSI; workflow.

I. INTRODUCTION

One of the concerns facing network operators is to accelerate the time to market of new network service and to reduce capital expenditures (CAPEX) and operational expenditures (OPEX) toward a future network. By the appearance of new technology providing a software-based network function, which is called network function virtualization (NFV) discussed in ETSI NFV [1], technology incorporating virtualization technology into telecommunications helps telecom operators enhance automated operation (e.g., deployment and fault recovery). In particular, the fault recovery operation has become a top priority because the recovery process in NFV is becoming increasingly complex in case of adaptation of the existing human-based operation due to the increase in managed resource components (e.g., server, operation system, hypervisor, and network functions). Thus, automated fault recovery (a.k.a. auto-healing) is strongly expected in terms of improvement of service quality and reduction of OPEX by eliminating manual-based operation. For the sake of auto-healing, a policy-based approach and workflow-based approach have been proposed [2][3][4]. The policy-based approach basically defines the design of actions and operation procedures to control resources by sophisticated scripting. But high skill is required to create and modify such policy by the operator. In fact, the operator requires an easily maintainable framework keeping automation in order to reduce human error and the need for human effort. On the other hand, the workflow-based approach is attractive for the operator because it enables the design of an operation procedure by using powerful language, i.e., Business Process Modelling Notation (BPMN), and allows operators to graphically create the workflow and provide high reuse potential. However, there is no standard implementation-level workflow defining operational procedure. Thus, the modelling and implementation of the workflow are highly dependent on developers' and vendors' specifications. On top of that, the number of workflows, which are maintained and updated, increase because of further expansion of service, eventually leading to an increase in maintenance cost. To address the above problem, we propose deriving a versatile implementation-level eTOM workflow by abstracting resources and functions of NFV.

In this paper, firstly we identify the requirement to solve the problems with describing related works. Secondly we present the proposed approach to define sustainable implementation-level workflow with harmonizing top-down definition approach of eTOM and implementation-level standard of ETSI MANO function. Also the workflow is presented in this section. Thirdly the validation of proposed workflow is conducted in order to demonstrate an efficiency. Finally we summarize the findings of this paper.

II. RELATED WORKS

Figure. 1 shows a comparison of the recovery process between a traditional non-virtualization network and NFV. In a traditional network, the management interface (e.g., TMForum MTOSI [5]) and information framework (TMForum SID) [6] related to the Operation Support System (OSS) have already been standardized to provide a way of achieving technology-neutral access [7]. However, the implementation-level workflow has not been standardized because the recovery procedure is highly dependent on the vendor's implementation, types of network elements, and human-based operation such as hardware repair remaining in the traditional network. On the other hand, the NFV network is controlled and managed by the Management and Orchestration (MANO) [8] consisting of an NFV orchestrator (NFVO), VNF manager (VNFM), and virtualized infrastructure manager (VIM). The MANO is

responsible for integrally managing the entire lifecycle related to network service and virtual network function (VNF) such as instantiation, termination, and healing operation. By using the lifecycle-controllable API defined by ETSI NFV, the OSS can integrally control the NFV network. In addition, the MANO hides the details of the hardware and virtualized infrastructure a.k.a. NFV infrastructure (NFVI), from the OSS and workflow. As a consequence of these abstractions, it leads to a reduction in not only implementation variation of control and management based on the vendor, but also human-based operation based on the infrastructure. The implementation-level workflow can be standardized thanks to MANO in the NFV environment accordingly.

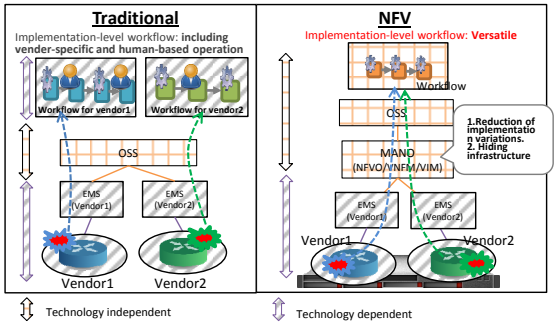

Fig. 1. Comparison of fault recovery process between Traditional and NFV.

In general, there are two major approaches to considering a workflow guideline: one is a top-down approach such as enhanced Telecom Operation Map (eTOM) defined by TMForum [9], which aids the end-to-end business and operations processes specialized in the telecommunications industry, and the other is a bottom-up approach such as the Information Technology Infrastructure Library (ITIL)[10] that represents the most famous collection of best practices for managing IT services. ITIL basically needs quite a lot of operational knowledge regarding NFV operation in order to model an appropriate workflow, but there is no knowledge through actual operation. In this paper, we focus on the eTOM framework to evaluate the appropriate workflow. In the future, we assume that ITIL is utilized to improve the workflow when we have sufficient knowledge.

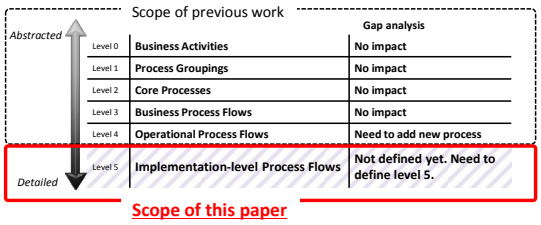

Fig. 2. Current status of evaluating eTOM.

Figure 2 shows a current status of evaluating eTOM. eTOM is composed of a six-level process (Level 0 to Level 5), and each level drills down into further detail and provides specific processes. In our previous work, we conducted a gap analysis between the auto-healing process using NFV MANO and existing eTOM from Level 0 to Level 4 in TM Forum catalyst project "Recover First, Resolve Next" [11]. Through this project, we confirmed that eTOM is capable of adapting to NFV operation by adding only one process (e.g., healing resource trouble process) in Level 4. However, no implementation-level workflow (Level 5) is yet standardized. In this paper, we tried to derive a versatile implementation-level workflow based on eTOM.

III. Proposed Approach

For the scope of definition, we focused on the auto-healing process because automation of fault management has become a top priority as mentioned in chapter 1. Thus, this paper shows the procedure of "Heal Resource Trouble" definition which is responsible for executing tasks of auto-healing. Initially we describe a traditional procedure for fault recovery in typical environment of NFV infrastructure. After that, we propose the approach to definition of eTOM Level 5 workflow.

The approach is divided into three parts. The first step is to make a list of tasks which are portions of "Heal Resource Trouble" workflow. The second step is to explain a result of mapping applicable ETSI NFV MANO functions to the listed tasks. This step is required to ensure the general versatility and coherency of the definition for each task of eTOM Level 5 regardless of the type of managed resource/system. The step 3 is to define the versatile eTOM Level 5 "Heal Resource Trouble" workflow while connecting the result of mapping by referring to the interface. Finally, some use cases are also described to figure out the validation of the proposed workflow as the standard definition.

A. Making a list of required tasks

Figure 3 shows a first step of proposed approach to define a detail operation procedure of "Heal Resource Trouble". The right-hand part, which is a separate box, indicates the category of auto-healing tasks in "Heal Resource Trouble". In these category boxes, the required tasks are listed for each healing pattern. Firstly, auto-healing can be categorized by the difference in type of resource into three patterns, physical network function (PNF), VNF, and Network Service (NS) respectively. It is mentioned that the PNF Healing depends on vendor/equipment-specific implementation. As a result, it is out of scope of MANO and consideration of a versatile operation procedure is required individually. The second option is VNF Healing which is selected if a VNF resource fails. This operation consists of "Check Available Resource" and "Instantiate VNF". "Check Available Resource" reserves resources such as CPU/memory, storage and network resources. After that, "Instantiate VNF" is executed to deploy VNF itself on NFVI and configure network connectivity. We note that if the PNF/VNF healing cannot clear the status of failure, the component resources of service should be recovered. Thus, the third option is NS Healing which is triggered for restoration of the service level of connectivity. The NS Healing is categorized into 2 patterns from perspectives of "Restore" and "Rollback". For example, as for the "Restore", it consists of "Check Available Resource" and "Instantiate NS", the same as VNF Healing process. If the result of "Restore" does not work for recovering service connectivity, the "Rollback" pattern is triggered to fix to the

previous condition. These patterns are selected according to the policy implemented by the operator. After execution of each healing, the "Check alarm notification" task is finally conducted to identify whether the status of the fault is cleared or not. As above, "Heal Resource Trouble" can be detailed by considering the roll and each portion with top-down definition approach.

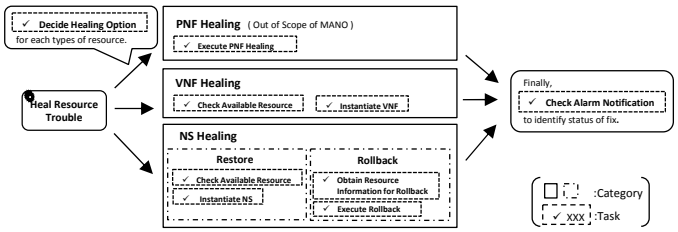

Fig. 3. Detail operation procedure of "Heal Resource Trouble".

B. *Mapping MANO Function to Tasks*

Step 2 of the proposed approach conducts mapping applicable MANO functions to the tasks listed in step 1 by referring to the specification of ETSI MANO defined by Interfaces and Architecture (IFA) working group in ETSI NFV. Table I shows the result of mapping for the listed tasks of "Heal Resource Trouble" by referring to IFA 005, 007 and 013 respectively [12] [13] [14]. From this result, we can see that the mapped MANO functions are represented more detail or even extent than listed tasks. It indicates a gap of representation level between the listed tasks of top-down-based definition and the standard implementation. To satisfy the requirement of the eTOM Level 5 standard, the listed tasks should be represented based on the ETSI MANO function in order to ensure versatility and coherency of definition. Taking into account the above perspective, we redefine proposed tasks as eTOM Level 5 as shown in this table. These are basically determined by employing the MANO function and modifying the name of the function for the reason of eTOM standard policy except for "Decide Healing Option" and "Execute PNF Healing". As for "Decide Healing Option", this task has responsibility for deciding the pattern of auto-healing based on a policy, for instance, total number of times of violating a certain threshold, emergency level of a detected alarm or service level agreement that depends on each service provider. But it is not affected by the difference of vendor specific implementation or type of resource. On the other hand, "Execute PNF Healing" is also out of scope of MANO, nevertheless, we define "Reset PNF" as the new definition of eTOM Level 5 because it is a common operation to recover PNF without repair of hardware so that all of types of PNF have the interface of executing reset operation. From the result of above definition, all of required tasks is represented versatilely. In the next step, we propose a workflow by using the above new definition.

TABLE I. RESULT OF MAPPING AND NEW DEFINITION OF ETOM.

Task	Mapped MANO Function	**New Definition as eTOM Level5**	Ref.
Decide Healing Option	No Function	**Decide Healing Option**	-
Execute PNF Healing	No Function	**Reset PNF**	-
Check available Resource (VNF)	Query resources information operation	**Query VNF Resources information**	IFA013
	Create Compute/Network/Storage Resource Reservation operation	**Reserve VNF Resources**	IFA005
Instantiate VNF	Allocate Virtualized Compute/Network/Storage Resource operation	**Allocate VNF Resources**	IFA005
	Instantiate VNF Operation	**Instantiate VNF**	IFA007
Check Available Resource (NS)	Query resources information operation	**Query NS Resources information**	IFA013
	Create Compute/Network/Storage Resource Reservation operation	**Reserve NS Resources**	IFA005
Instantiate NS	Allocate Virtualized Compute/Network/Storage Resource operation	**Allocate NS Resources**	IFA005
	Instantiate VNF Operation	**Instantiate NS**	IFA007
Obtain Resource Information for Rollback	Query resources information operation	**Query Resource information for Rollback**	IFA013
Execute Rollback	Terminate VNF Operation	**Terminate NS Resources**	IFA005
	Query resources information operation	**Query NS Resources information**	IFA013
	Create Compute/Network/Storage Resource Reservation operation	**Reserve NS Resources**	IFA005
	Allocate Virtualized Compute/Network/Storage Resource operation	**Allocate NS Resources**	IFA005
	Instantiate VNF Operation	**Instantiate NS**	IFA007
Check Alarm Notification	Notify Operation	**Check Alarm Notification**	IFA013

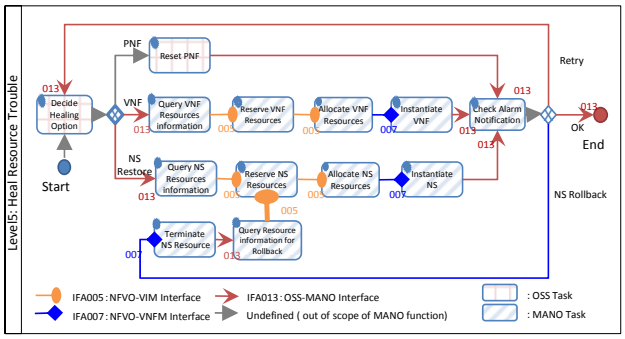

Fig. 4. Proposed eTOM Level 5 "Heal Resource Trouble" workflow.

C. *Defining Workflow while Connecting Result of Mapping*

Figure 4 shows the proposed eTOM Level 5 "Heal Resource Trouble" workflow while considering the connection between OSS and MANO interfaces. The key point of proposed workflow is that the system which executes the each task is interchangeable so that the each task and applied interface are defined separately. It means the proposed workflow is reusable even if the system architecture is changed.

IV. Validation

Figure 5 shows a use case of healing to validate the proposed eTOM Level 5 workflow. It is assumed that a link down failure is generated from a port of the physical router due to SFP module failure. When the OSS detects alarms that includes "link down" failure of the physical router, "Decide Healing Option" is executed and the OSS decides the healing pattern as PNF. At the task of "Reset PNF", the OSS requests EMS to conduct reset operation through the interface. After the response is received from EMS, the OSS identifies that the link down alarm is cleared. But the status of link down still remains in this case because of hardware failure. Thus, the sequence of the workflow is forwarded to "Retry" and "Decide Healing Option" is executed again. (Note that this workflow only confirms connectivity based on alarms so that it only has responsibility for "Recover First". Service connectivity testing and identifying of the root cause of failure are executed at the next Level 4 eTOM process.) The OSS decides the healing pattern as NS Restore. Then, "Query NS resources information" is called to identify the configuration setting, type of resource, hardware specification requirements, and location to deploy the CPE service component. From this information, NFVO calls for VIM to execute "Reserve NS Resources" to reserve the required resources. After the operation, NFVO also calls for VIM to execute "Allocate NS Resources" and the required resources are prepared. After allocation is completed, NFVO requests VNFM to deploy virtual network function images including all vCPE components such as vDHCP, vNAT, vRouter, and vFW at the "Instantiate NS" task. Finally, the OSS identifies the operation result and "clear" status, and the OSS finishes the workflow. Considering the above use case, it can be seen that the proposed workflow can be adopted for NFV operation automation without considering the difference in vendor-specific resource implementation or type of resource by harmonizing ETSI MANO standard.

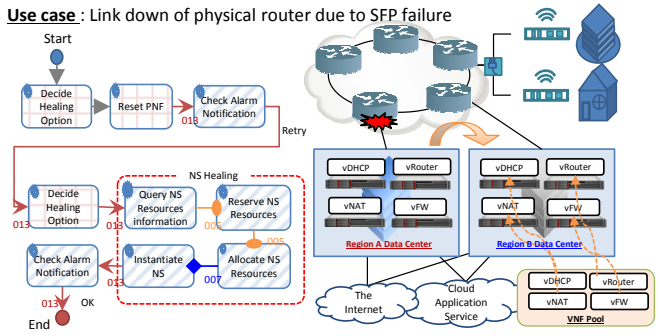

Fig. 5. Use case of executing proposed eTOM Level 5 workflow.

As a result of the validation, we can find that the proposed workflow has the reusability from two different perspectives. First point is that the proposed workflow can be applied to not only the fault recovery, but also the auto-scaling when the performance degradation of the resource is detected before the occurrence of fault. And as the different point of view, proposed workflow can be reuse even if the system architecture is changed by exchanging only the employed system (e.g., service orchestrator to manage a service function chaining [15]) and new network service (e.g., virtual Enhanced Packet Core), which consists of different network functions, is deployed. It is important indicator to consider whether the workflow is suitable as the eTOM Level 5 standard definition because of preventing expansion of workflow and reducing maintenance cost for adopting change of system architecture and deployment of new network service.

On the other hand, we find that the policy is the key element to control the workflow, for instance, such as criterion of the decision of healing option, acceptable value for resources allocation, optimal deployment location and so on. In order to achieve the sustainable implementation-level workflow for automating NFV operation, how to design of the policy is a controversial point of standardization as the future work.

V. Conclusions

This paper proposed an implementation-level workflow for automation operation for NFV. This paper showed how NFV MANO standards can derive a versatile implementation-level eTOM workflow by abstracting resources and functions of NFV. The approach to defining a versatile eTOM Level 5 flow has been proposed by conducting an analysis of required tasks and mapping to the NFV MANO standard. As a result of the analysis, we proposed a versatile eTOM Level 5 "Heal Resource Trouble" workflow and demonstrated that it can be adopted for NFV operation automation without considering the difference in vendor-specific resource implementation or type of resource by harmonizing ETSI MANO standard.

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