Cross-Layer Fault Management in Network Function Virtualization

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***Abstract*—Fault management (FM) play a vital role in the daily operation of teleco providers, however, Network Function Virtalization (NFV), despite its glorious technical advantages, aggravates FM in multiple ways: *first*, each abstraction layer has its own approaches to treat faults, coordination between them is still a missing piece; *secondly*, an effective FM system at each single layer does not necessarily lead to an overall efficient FM system. A cross-layer FM system is therefore needed. In this paper, we analyze in details the scenario, problems and challenges faced by constructing such a system.**

I. Introduction

Thank its flexibility which directly leads to significant savings on OPEX & CAPEX as well as increased agility on service innovations, the concept of NFV [1] has been prevailing recently among teleco service operators. The fundamental idea behinds NFV is to build virtualized software network devices based on the hypervisor and Commercial-Off-The-Shelf (COTS) hardware. The infrastructure which NFV is based on is thus not built specifically for high reliability and availability; on the other hand, teleco services normally requires five nines of availability which is about an annual outage time of 5 minutes. Providers are now facing with the dilemma: while enjoying high flexibility and saving costs, they have to accept the risks of reliability. In the context of NFV, *faults have to be taken as facts rather than exceptions*. Currently, this is also one of the major reasons which hold back the teleco operators to adopt NFV system in their operational environment.

To tackle this dilemma, a highly efficient fault management system is needed to deal with and compensate the un-reliable soft- and hardware systems. As prescribed by many literature on reliability and availability [2], FM including detection of system faults and toleration as well as isolation of system anomalies. Finally impacted system should be recovered and services restored in a timely manner. One may argue however that each layer involved in the holistic NFV system already possesses its own mechanism to deal with fault, however the question is: is it enough to have a collection of individual FM systems to make a holistically efficient NFV FM system? If not, what can be done about it? In this paper, we elaborate to analyze and clarify the problematics. The purpose of this paper is to identify gaps and research challenges of building of highly efficient NFV FM system. This paper is organized as follows: Section II presents a typical NFV scenario, on which our further discussions are based; in Section III we make a in-depth analysis of the issues and problems involved in FM of NVF and try to crystallize research challenges; in Section IV we discuss research issues and a roadmap to solve this complex problem of cross-layer FM.

II. Scenario

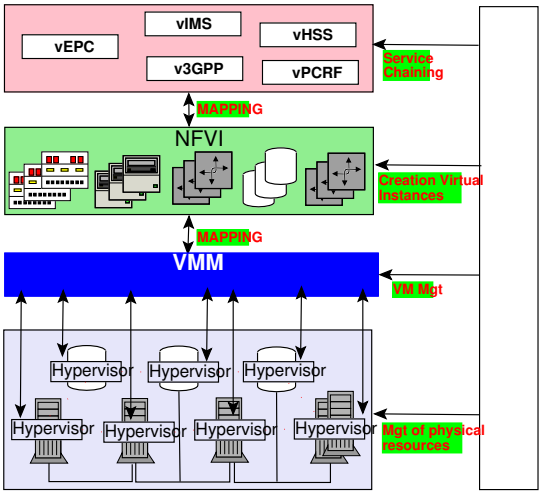

Fig. 1. NFV Reference Architecture

In this discussion we use ETSI's NFV architectural model [1] as our main reference model. Accordingly, the NFV architecture can be classified into three layers: the first layer is comprised of hardware resources including computing, storage and network devices, on which physical computing and communication take place. Typically, this layer is built on computing clusters with high-performance storage and networking devices. The second layer is virtualization layer where one or more hypervisors virtualize hardware's computing, communication and storage capabilities into sharable virtual resources, some example of hypervisors suitable for such tasks are, KVM, Xen or VMware, etc. Virtualization layer manages physical resources by means of scheduling the usage of CPU cycle, network interface virtualization (vNIC) or block storage devices through a pre-defined virtual infrastructure to hardware interface (VI-Ha). Having the virtualization resources provisioned, virtual infrastructures are now managed by platform such as OpenStack [3] or CloudStack [4] for sharing among multiple tenants for service implementation. A vertial component commonly known as Management and Netowork Operation (MANO) is supposed to deal with management activities on different layers and assist users to orchestrate NFV services on the top.

TABLE I. A TABLE ON SPECIFIC FM APPROACHES TO DIFFERENT NFV LAYERS

Layer	Typical HA Approaches	Example
Physical	Heartbeat, Fencing, Hot/Cold Standby, Reliable Messaging Bus	LinuxHA Project, Pacemaker, cman
Hypervisor	Virtual Resource Monitoring, Live Migration	VMWare HA, HA-Lizard
Virtual Network Functions	Application-specific FM methods	vendor specific application
Virtual Services	Traditional Network Service OSS/BSS	SNMP or other vendor specific methods to manage faults of virtual devices

III. PROBLEM STATEMENT

The central problem in the cross-layer fault management lays in the coordination of various FM appraoches from different layers involved in the NFV architecture and, frequently, also within individual layers. We classify those problem in *vertical* and *horizontal* dimensions. In this section, we analyze research challenges in details accrodingly to the above mentioned dimensions, then we provide a scenario that clarify an uncoordinated FM will aggreviate the holistic system when failures impact.

A. Problems of Vertical Integration of FM Approaches

Typically each layer of NFV architecture possesses its own specific FM approaches to ensure the services offered on this particular layer. There is hardly any information exchanged between layers regarding FM and let alone the coordination of separated layers. We argue that such a separate approach does not meet requirements of high efficient overall FM system.

1) FM between Virtualization and Physical Layers:

2) FM between NFVI and NFV Layers:

3) FM by Orchestration of NFV Services:

B. Problems of Horizontal Integration of FM Approaches

1) Coordinations between Distributed Clusters:

2) Multi-Orchestrator Collaboration:

IV. RESEARCH CHALLENGES

V. CONCLUSION

ACKNOWLEDGMENT

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[2] A. Avizienis, J.-C. Laprie, B. Randell, and C. Landwehr, "Basic concepts and taxonomy of dependable and secure computing," *Dependable and Secure Computing, IEEE Transactions on*, vol. 1, no. 1, pp. 11–33, 2004.

[3] "Openstack project," http://www.openstack.org.

[4] "Apache cloudstack project," http://cloudstack.apache.org.