Enhanced Quality of Service Measurement Mechanism of Container-based Cloud Network Architecture

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Abstract—As the growth of development on both network architecture and cloud computing, the existing quality of service (QoS) measurement mechanism in VNF design is not sufficient for the cloud network architecture, especially the development of container technology. It is important for service provider to provide to customers a service level agreement (SLA) on cloud network service by provision of Container-as-a-Service (CaaS) and container network function (CNF). In this paper, we propose an enhanced vQOS (EvQOS) measurement mechanism for container-based network architecture that retains the vQOS in VNF architecture [1] including the TWAMP light (TWL) protocol and the northbound interface design, and provides a containerization architecture and the friendliness of system management and monitoring.

Keywords- QoS; container-based; cantainer network function(CNF); Virtualized Network Function(VNF); network function virtualization (NFV).

I. INTRODUCTION

As the growing development of cloud network technology such as cloud computing, SDN/NFV, and container, it makes Communications Service Providers(CSP) encounter changes and promotions in existing service architecture, and also allows CSPs to provide cloud business in home and enterprise service through differentiated and customized network or resources.

The cloud services, including the Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS), have been adopted by various industries. The Container-as-a-Service (CaaS) [4] is the most important cloud service for development of container technologies in recent years, which provides more efficient and scalable resource allocation due to less overhead compared to virtual machine technologies [4] [5].

In addition to benefits of providing cloud services, the CSP devotes efforts to upgrade the system and equipment of the network architecture due to technologies of cloud computing SDN and NFV [6], such as the virtual OLT (vOLT) in access network, the virtual BNG (vBNG) in transfer network, and the virtual CPE (vCPE) in customer network [7]. They are primarily integrated to business/operation support system (BSS/OSS) to make service provision for cloud network service of enterprise or home network. The CSP can subscribe packages they want by a service chain of each VNF, CNF and the connected networks. The network topology becomes more complex than before.

After the CSP provisions the network connections and allocated require resources for network service chains, in order to maintain the connectivity and service available, the CSP has to ensure the service quality through monitoring resource and measuring the network performance. Generally, most CSPs would perform central-network-side performance measurement in demand from IP router to CPE through the protocol such as ICMP and TWAMP light (TWL) [8][11], or CPE-side in demand from CPE to central network through the protocol such as FTP/HTTP for file transfer or UDP for EchoPlus, to get results of bandwidth, delay, jitter and loss [2][3][9]. In our previous paper, we have further proposed an architecture of vQOS measurement mechanism using TWL protocol shown in Figure 1 which is considered to provide deployment of vQOS VNF in cloud platform to measure performance from cloud site to IP router and to CPE [1].

Furthermore, Docker is an important technology to realize the containerization of virtual functions and in recent years. Container orchestration technologies such as Docker swam and Kubernates have also been developed based on Docker, which are also important technologies for subsequent implementation of cloud-native applications and CaaS services [10]. The Kubernates is widely built to execute container-based service in the enterprise cloud and the three major public cloud providers, i.e. Google GCP, Microsoft Azure, and Amazon AWS.

In this paper, we consider the requirements of container-based networking and propose an enhanced quality of service measurement mechanism of container-based network architecture. It is also implemented and deployed in the Docker container and Kubernetes architecture, which can provide QoS measurement of clusters or nodes.

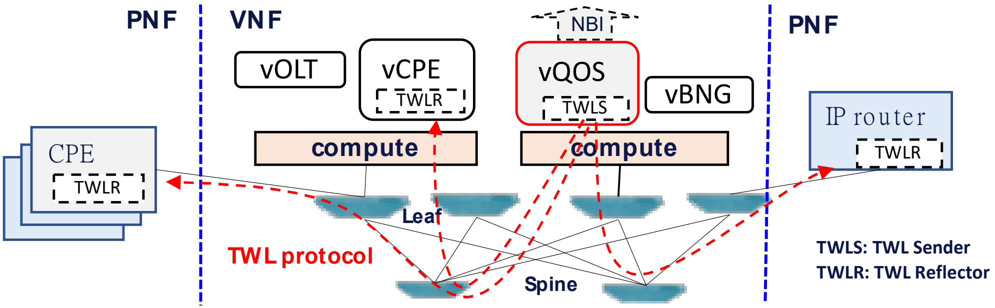

Figure 1. The architecture of vQoS measurement machanism using TWL protocol

The rest of this paper is organized as follows. In Section II, we show the vQoS measurement in VNF as proposed previously. In Session III, we represent QoS measurement in CNF design requirements and propose an enhanced vQOS (EvQOS) architecture. In Section IV, we demonstrate the EvQOS CNF in Kubernates and show the analysis of measurement results. In Section V we discuss the future work about QoS and analysis, and applications of QoS measurement. Finally we have a conclusion in Section VI.

II. Existing Mechanism of QoS Using TWL Protocol

In today's broadband network environment, Service Providers use standardized mechanisms for broadband access network service monitoring and performance measurement. Broadband Forum (BBF) TR-390 [8] suggests Two-Way Active Measurement Protocol Light (TWL) as the alternative solution and has been implemented at existing IP router/switch equipment. We have built these framework and architecture in [1]. Next, we describe the architecture and integration of mechanism as following:

A. *TWL (TWAMP Light) Protocol*

TWL is the subset of TWAMP defined in RFC 5357 document and is used to measure QoS between two test nodes [11]. One side implements the TWL Session-Sender (TWLS) functions while the other side performs the TWL Session-Reflector (TWLR) functions. Comparing to other well-known active approaches, TWL is more accurate to provide up to microsecond level. Besides, TWL can measure not only round-trip time but one-way latency and jitter with time synchronizing on the test nodes. Broadband Forum also recommends that the IP Edge router and the Customer equipment must support TWL measurement protocol to provide performance measurement from the central office to the client sites [8]. Then, Service Providers could use this standardized protocol to measure QoS of the end-to-end test nodes without interoperating.

B. *VNF Functionality*

A Virtualized Network Function (VNF) defined in ETSI standard is a Network Function capable of running on an NFV Infrastructure (NFVI) and being orchestrated by an NFV Orchestrator (NFVO) and a VNF Manager. With the evolution of SDN and NFV on data center, broadband network equipment could be separated into Physical Network Function (PNF) and VNF, such as vOLT, vBNG, vQOS and so on [7]. Because network function is separated, it is important to ensure there is no problem between PNF and VNF.

C. *vQOS (virtualized QoS) in VNF*

vQOS functionality [1] is also one of the VNF functions and can be deployed at virtual machine and common hardware x86 server. As shown in Figure 2 the vQOS implements the TWL Session-Sender function through Linux C and the northbound API (NBI) function through Node.js. Also, MongoDB is used to access the configuration parameters and the result values of QoS measurement on demand. The interfacing system can perform QoS measurement of VNF to PNF and VNF to edge or customer networks by accessing NBI of vQOS.

III. Architecture of Enhanced vQOS Measurement

To upgrade the vQOS from a VNF to a CNF, the vQOS has to provide a user-friendly control and management interface, and is able to monitor specific circuits and network periodically. Therefore, the way of designing user interface and deploying in cluster environment is our major consideration.

- User-friendly: we have provided the OpenAPI 3.0 for other systems to interact and access vQOS, but it is not user-friendly for CNF engineers and managers who would like to integrate the vQOS. To make it operate easily, we implement a web interface designed in Vue.js framework in vQOS for control and management. To monitor the circuit and network periodically, we implement a cronjob module in vQOS and provide the periodic measurement configuration through the web interface.

- Flexible: with the assistance of IT technology, we build vQOS functions in Docker container and manage it in Kubernetes, a container orchestration for automating deployment, scaling, and management of containerized applications. Therefore, we can determine when to deploy and terminate vQOS functions as needed.

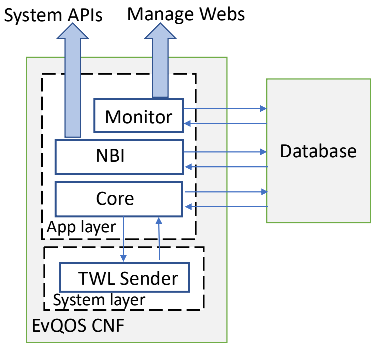

Figure 2. Enhance vQOS in CNF

The enhance vQOS(EvQOS) in CNF architecture we proposed is illustrated in Figure 2 based on the above considerations. In addition to retaining the NBI and separated the database functions, the monitor function is also designed in the EvQOS to provide monitor functionality for requirement of regular monitoring. It can provide service manager to login through web, configure and analyze the regular monitoring. The following described in detail.

A. Authentication and Authorization

The EvQOS CNF includes a user authentication inspection to provide a basic web security protection. The CNF managers have to login a user account to get authenticated before using the system. Also, the user account can be applied to a role, which is configurable to define the permission of each functionality of the system. Through the role feature, we can provide various user authorities.

B. Moniter Configuration

After logging in, the EvQOS web GUI provides configuration of the connection parameters about the deployed TWLR node sites shown in Table I, such as the IP address, TWLR port, packet size and interval, and test duration, which provide the ability to configure multiple node connections for measurement. The measurement function then can be configured to execute manually or periodically, so that the CNF managers could perform a specific measurement or a regular network quality monitoring.

C. Analysis

After a period of measurement, the EvQOS can graphically display the statistics of delay, jitter, and loss over the time

Setting Parameter	Description
ID	Test Node ID
DestIP	Destination IP address of the TWLR test session
DestPort	Destination UDP port of the TWLR test session
PacketSize	Size of the TWL test packets
TTL	TTL field of the IP header of the test packets
DSCP	DSCP field of the IP header of the test packets
Interval	Amount of time between TWL test packet transmission
TestDuration	Amount of time the TWL test periodically
StaticsMaxTH	Index of high value(Nth) measured for delay and jitter

Table I. Parameter definition of moniter configurations

Result Parameter	Description
RTTDelayMin	Minimum value of roundtrip delay in μ second
RTTDelayMean	Average value of roundtrip delay in μ second
RTTDelayMaxTH	Nth largest value of roundtrip delay in μ second
StoRJitterMaxTH	Nth largest value of sender to reflector jitter in μ second
RtoSJitterMaxTH	Nth largest value of reflector to sender jitter in μ second
StoRPacketLoss	Packet loss of Sender to Reflector path
RtoSPacketLoss	Packet loss of Reflector to Sender path
RTTPacketLoss	Packet loss of roundtrip path

Table II. Parameter definitions of measurement results

separately. Figure 4 shows the statistic charts, and the detail measure parameters are shown in Table II.

IV. DEPLOYMENT AND RESULTS

We build EvQOS and TWLR Docker image files and deploy them in different Kubernetes' nodes. As show in Figure 3 the EvQOS CNF is deployed on Kubernates node, and several TWLRs are deployed in the other nodes separately. After these nodes start servicing, we login to the EvQOS node, set the IP and port of measure target to the TWLR node, set the period parameters, including interval 1 second and test duration 900 seconds, and then monitor the connection quality analysis between nodes for a long time, with the results of sampling every 15 minutes. Figure 4 shows the measurement results for 6 hours and represents the variation of packet delay, jitter and loss during the period of time.

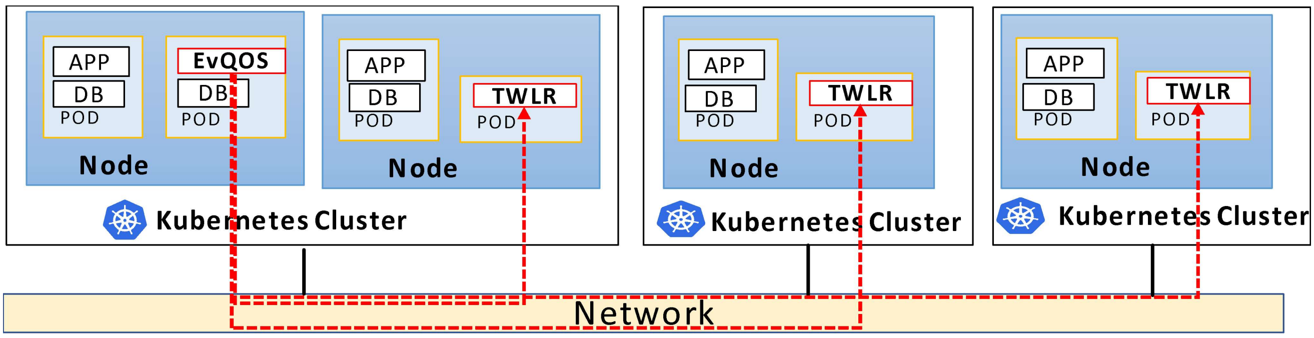

Figure 3. The deployments of EvQOS and TWLR in CNF

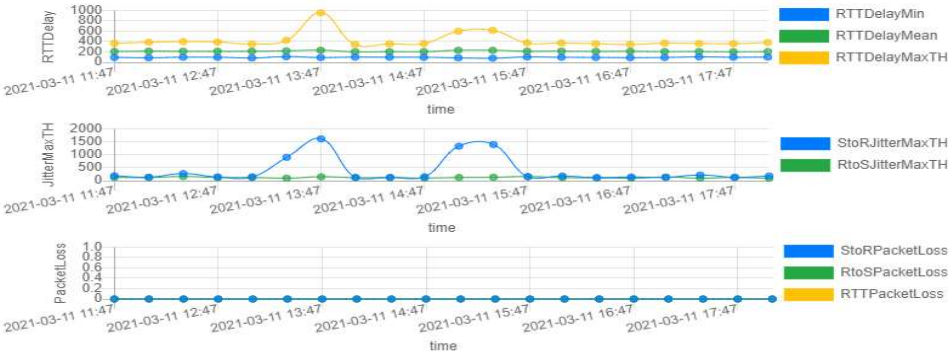

Figure 4. The architecture of QoS measurement machanism using TWL protocol

In addition to determine the stability of the network connection through RTTDelayMin and RTTDelayMean and deterioration through packet loss events, it can notify system or platform administrators. Some phenomenon can also be analyzed from these measurement charts. Take Figure 4 for example, with the long-term analysis of RTT delay and one-way jitter, the quality deterioration of RTTdelayMaxTH is observed, where the RTTdelayMaxTH is related to StoRJitterMaxTH and RtoSJitterMaxTH, so through the chart comparison we can find that the RTTdelayMaxTH is impacted by StoRJitterMaxTH. As most devices and systems currently do not have the function of supporting precise time synchronization, this analysis can help us find if the one-way routing quality changes.

V. Future Work

In addition to proposing the TWL protocol as the QoS measurement requirement between the IP router and CPE, the Broadband Forum also recently studied the quality attenuation architecture based on the network delay and loss results, and proposed decomposing the quality attenuation into geographic serialization and variable components as the applications of network health check, root cause analysis, and network characterization analysis [12]. It provides follow-up CSP as a design reference for the network QoS measurement framework.

VI. Conclusion

In this paper, we enhance the previously proposed vQOS in VNF quality measurement architecture [1] as the Enhanced vQOS (EvQOS) that is more suitable for container-based cloud architecture. It provides not only the NBI function required for system interfacing, but also for managers the real-time monitoring of the connection quality between nodes and network devices. And through the Docker and Kubernates containerized execution environment, the EvQOS and TWLR functions are built into Docker images and deployed on different Kubernates nodes to measure the network QoS between different nodes to confirm the feasibility and friendliness of the EvQOS design. It provides delay, jitter, and loss measurement and result analysis, and is able to monitor the stability of the network connection through periodic quality measurement.

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