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O.B. Tkachova[1], Mohammed Jamal Salim[2], Raed Yahya Abdulghafoor[2]

[1] *Kharkiv National University of Radio Electronics, Kharkiv*
[2] *Odessa National Academy of Telecommunications named after O.S. Popov, Odessa*

INTEGRATION SDN CONTROLLERS INTO OPENSTACK. EVALUITION OF PERFORMANCE AND RELIABILITY

The significant grows of cloud computing technology requires the development of new methods for virtualized resources managing. The analysis of OpenStack network module is proposed in the paper. The main components of Neutron and OpenStack interaction with third-party elements are also observed. The main attention pays to OpenStack -SDN integration. The interaction between plug-ins of Neutron and SDN controller are considered. To obtain more information about OpenStack –SDN solution the parameters for different types of SDN controller were analyzed. Performance and reliability of SDN controllers are evaluate in the paper: the experimental model of SDN-OpenStack integration was created. Such characteristics of SDN-OpenStack solution as delay, max amount of UDP and TCP data flows obtained in the experiment.

***Keywords**: openstack technology, module Neutron, SDN controller, cloud computing, performers and reliability evaluation.*

Introduction

The OpenStack technology has greatest popularity among the existing management tools in cloud computing [1]. However, convergence OpenStack with traditional information systems often does not lead to successful results. The possibility of technologies have significant limitations in case when virtual compute node located in different zones of network infrastructure. OpenStack convergence problems often associated with limitation of load balancing algorithms, traffic filtering rules and delays in processing and data transmission [2].

Today paradigm of software-defined network (SDN) is used to ensure the effective functioning and correct interaction between physical and virtualized elements. The main feature of SDN is a centralized management and monitoring. Management and monitoring performed by single network element – a controller [3]. The controller is a key element of SDN that directly interacts with the OpenStack network module.

Many companies, such as Cisco, HP, Juniper, IBM provide their solutions based on the concept of SDN. In addition, propose their own methods of integration into existing technology. The advantages of SDN integration into cloud technology are advanced management functions, optimal load balancing and traffic distribution [4]. Such approach provides a seamless convergence and compliance with required quality of service.

However, the network solutions that are based on the SDN concept has several disadvantages. Firstly, controller becomes a potential point of failure of network. Since the network performance depends on the controller performance and controller's characteristics. Secondly, there is a lack of proper resources and knowledge to evaluate the integration of SDN controllers into OpenStack. Consequently, this has led to confusion in the market about the promised benefits of SDN in OpenStack.

Analysis of the interaction between OpenStack and SDN elements, evaluation of performance and fault tolerance of different types of controllers are an important task. The solution to this task will help to develop a series of recommendations. According to this recommendation can be create an optimal network solution that appropriate for significant goals.

The model of interaction OpenStack-SDN that reviewed in the paper give the full information about interaction process and place of SDN controllers in the interaction virtualized and physical components. Also in paper proposed experiment that based on model of interaction. Experimental data help to evaluate the characteristics of controllers and to identify further direction of research.

1. The model of OpenStack-SDN interaction

Neutron or OpenStack network module provides an interface between virtual machines with other network elements. Functional core module based on the model abstraction, which includes virtual network subnet, IP-addresses and ports [5]. Neutron main components are:

- Neutron-server — this is the main process of OpenStack Networking server. It forwards requests from the API to configured OpenStack Networking plug-in. Administrator of cloud computing network chose the appropriate plug-in type.

In addition, part of the Neutron includes three agents that interact with the main process through a message queue, or via a standard API and allow for the network settings.

- Neutron-dhcp-agent provides DHCP-services (Dynamic Host Configuration Protocol) to all endpoints.
- Neutron-l2-agent supports L2 functionality for virtual machines to an external network.
- Neutron-l3-agent supports L3/NAT functionality, to allow virtual machines to access external network.

Neutron functionality has some significant disadvantages and limitations. Thus, the absence of interaction of the flexible transport layer and some types of routers. This leads to restrictions of the functions and scalability limitations in VLAN, firewall and NAT configuration. Such situation does not allow to effectively organizing the interaction of distributed computing nodes via Neutron [6].

Software Defined Networking is introduced to overcome the deficiencies of Neutron. SDN is a network technology that allows centralized programmable control plane to manage the entire data plane, so that the network operators and providers can control and manage their own virtualized resources and networks [7]. SDN is a new networking model that allows open API communication between the hardware (Physical elements) and the Virtualized elements [8].

OpenStack-SDN connection establishment

Information about the changes in requirements for network resources or network topology arrives from Neutron to SDN controller through Northbound API. The controller processes the new information, creates or updates the management rules and sends them to both physical and virtual network elements through Southbound API. The Figure 1 below gives a general idea about the integration of SDN Controller into OpenStack.

The first step is to obtain request for the introduction of a new service or the provision of the existing one. Orchestrator Heat generates queries to the primary components of the Nova and Neutron. Extended to support the new Neutron primitive FlowRule (3), which denotes the logical link between virtual machines. The FlowRule describes how to steer the traffic between the ports, which is required to support traffic splitting among different network functions (2). Nova will retain the requests until the last one is received. A new API has been introduced in Nova and called by Heat to specify constraints such as minimum amount of bandwidth required in the connection between two VMs (3). Neutron creates a network connection between the virtual machines that are involved in the provision and data processing: configure the network and subnet, determine the active IP - addresses and ports of virtual machines (4).

This model is based on a set of rules generated by the Neutron module and delivered Nova kernel (5). Next Nova scheduler creates virtual machines and provides information about them (IP - address and the active ports) module Neutron (6, 7).

All network management rules that created in Neutron are transmitted SDN controller only after the port of virtual machines receive status «active» (8). SDN controller generates its own set of commands, which based on the FlowMods rules. This set of commands allows to interact the components of the virtual and physical infrastructure, control and monitor of network elements states (9).

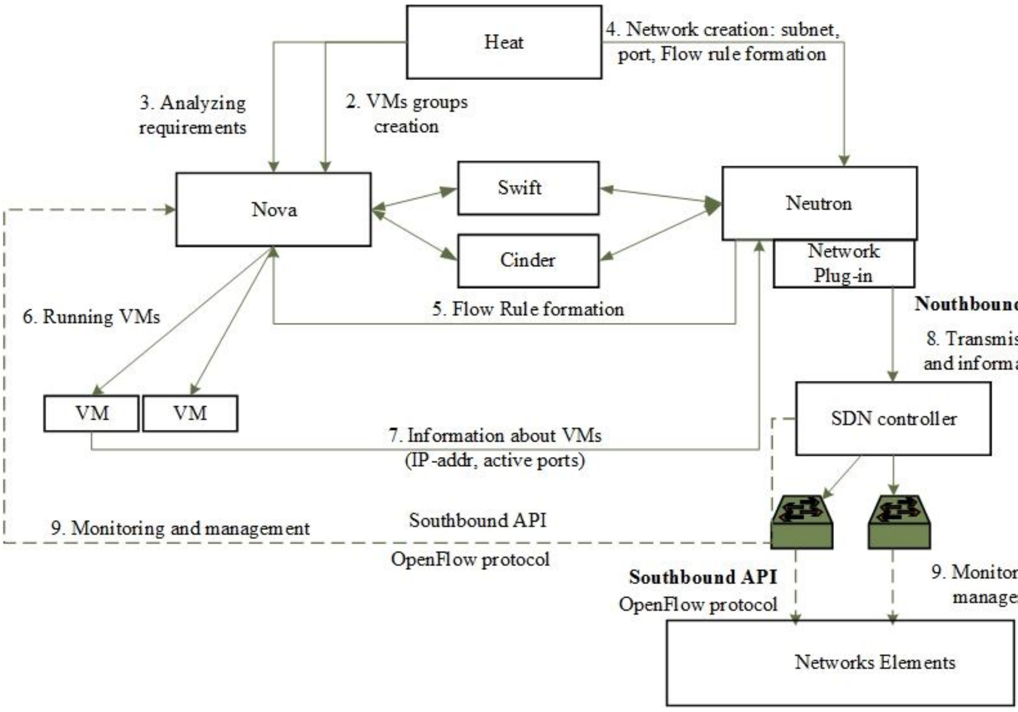

Fig. 1. Interaction process between SDN controller and Neutron

Neutron interacts with other network components, in particular the controller SDN, by the special plug-ins. Plug-ins provide correct communication algorithms and transmission of management information. Today variety of plug-ins is developed. Plug-ins have different features and performance. The choice of plug-in type depends on network operation system (NOS) of controller's.

Table 1 shows the main types of network operating systems and plug-ins that used in the Neutron module for interactions with SDN controller [9].

Table 1

Controllers and plug-ins type

	Open Daylight	Flood Light	RUY	POX
Platform	Linux	Linux, Windows	Linux, Windows	Linux, Windows
Neutron Plug-in	Modular Layer 2	Rest Proxy plug-in	RUY plug-in	No
Integration level	Hight	Middle	Hight	-
OpenFlow support	1.0, 1.3	1.0	1.0, 1.2, 1.3	1.0

Currently available next plug-ins: Open vSwitch, Cisco UCS/Nexus, Linux Bridge, Nicira Network Virtualization Platform, Ryu OpenFlow Controller, NEC OpenFlow. Also several types of network operating systems such as Open Daylight, RYU, Floodlight, NOX, that allow to organize the interaction between Neutron and SDN controller [6-8].

Controller's characteristics have the greatest impact on performance, availability and reliability in the whole network. However, the existing NOS are significant differences, which significantly affects to the controller's performance. For example, data flows establishment time and forming control information time are significantly different for different SDN controllers.

Since the goal of convergence of OpenStack and SDN can be significantly different, necessary to know the basic functional characteristics of controller to achieve the optimal results.

2. Evaluation of OpenStack -SDN solutions

In the case of SDN controllers integration into OpenStack should be evaluated the following parameters: scalability coefficient, delay time, packet loss ratio. Controller's parameters are greatly depend of NOS type and selected Neutron plugin.

The proposed study to determine the main characteristics of the controller for different loads. Consider the fragment of a network that consider of multiple virtual machines (Management Node and User node) and remote physical node. KVM hypervisor provides virtualization. As a physical connection was considered a point-to-point topology (Gigabit Ethernet). The logical connection between the VMs and network environment is provided through the GRE tunnel.

In experiment the next SDN controllers characteristics are consider: Open Daylight, RUY, Floodlight, POX. During the experiment, the characteristics of virtual machines remain constant; the type of controller's network operating system is change in each part of experiment.

The experimental model of Neutron and SDN controller interaction is shown on Fig. 2.

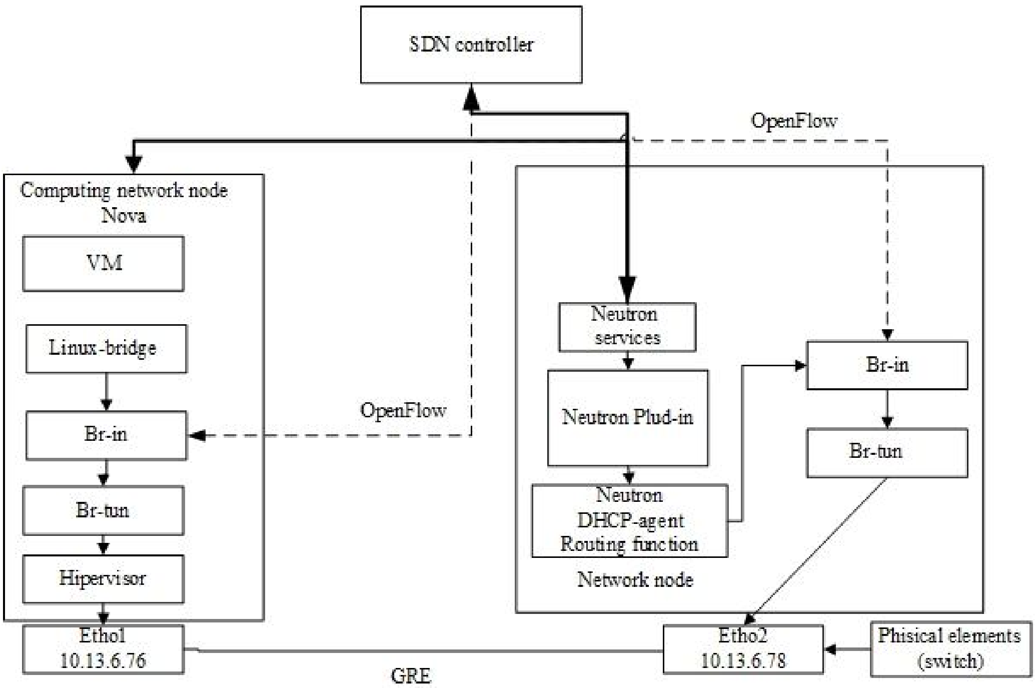

Fig. 2. Fragment of experimental network

To evaluate the basic network parameters of controllers were used the following commands that allow you to install [10]:

- Average flow setup latency (ms)

```
$ for i in `seq 1 20`; do
ping -c 1 -q 10.10.10.2
```

- Average steady-state latencies (ms)

```
$ ping -c 50000 -f 10.10.10.2
```

- Max TCP unicast through under varying MSS (viz., 90 bytes, 1490 bytes, 9000 bytes)$ for i in 90 1490 9000; do

```
iperf -c 10.10.10.2 -t 60 -m -M $i
```

- UDP under varying number of parallel sessions (1 session and 3 session)

```
$ for i in 1 3; do
iperf -c 10.10.10.2 -u -t 60 -b 10G –P
```

- Max allowed TCP flows between known hosts, without zero drops (measured in flows/sec).

Essentially these experiment claimed features of the network-virtualization solution, including the following [10].

- ability to handle overlapping IP ranges, overlapping MAC addresses;
- the ability to provision QoS configurations on a per-virtual-network basis;
- the ability to live-migrate virtual machines across L2 and L3 boundaries;
- fault tolerant of controller, and limited impact for faults on data plane (vSwitch, ports, VMs).

The results obtained in the execution of these commands for different types of controllers shown in Table 2.

The obtained results help to determine the current scope of Open Daylight, RYU, Flood light controllers that integrated into OpenStack.

Analyze the obtained results we can see that the characteristics of SDN controllers for integration with OpenStack vary considerably. Thus, the Open Daylight

2\setup latency and average steady-state latencies are higher than in RUY and Floodlight. However, Open Daylight fault tolerates is significantly higher: the transmission loss of multiple flows were minimal. POX does not support integration with OpenStack, as we obtained in results.

Floodlight demonstrated the highest transmission speed of TCP and UDP data flows и and the minimum delay time. This suggests that Floodlight has the highest performance of the reviewed controllers.

The obtained results show that SDN controllers currently have the capability to handle around 1000 flows per second. A computing node, on the other hand, handles around 100000 flows per second [19]. It clearly indicates a huge gap between the current capabilities of SDN controllers and the demands of cloud computing.

Table 2

Results of experiment

	Open Daylight	RUY	Flood light	POX
Average flow setup latency (ms)	10,48	6,9	5,4	-
Average steady-state latencies (ms)	3,3	2,7	1,56	-
Max TCP unicast through under varying MSS (viz., 90 bytes, 1490 bytes, 9000 bytes)	MSS - 1490: 18 MBps MSS - 9000: 19 MBps	MSS - 1490: 29,1 MBps MSS - 9000: 29,3 MBps	MSS - 1490: 31,2 MBps MSS – 9000: 48,7 MBps	-
UDP under varying number of parallel sessions	P = 1 session 11,05 MBps, 0% loss P = 3 sessions 1,8 MBps, 2% loss	P = 1 session 21,9 MBps, 15 % loss P = 3 sessions 2,1 MBps, 10 % loss	P = 1 session 28,4 MBps, 27% loss P = 3 sessions 3,31 MBps, 15% loss	-
Max allowed TCP flows between known hosts without zero drop	100 flows per second - 0 % loss 1000 flows per second - 3 % loss 10000 flows per second - 98 % loss	100 flows per second - 0% loss 1000 flows per second - 7% loss 10000 flows per second - 100 % loss	100 flows per second - 0% loss 1000 flows per second - 10% loss 10000 flows per second - 100% loss	-

Conclusion

OpenStack technology allows to organize effective establishing, providing and supporting processes in cloud computing network. However, the technology has a number of disadvantages that limit OpenStack wide-spread use in the convergence with other networks. Lack of flexibility interaction between transport layer protocols leads to restrictions of scalability functions, load balancing, filtering and NAT overcoming.

This research will allow evaluating production readiness of SDN integration into OpenStack as there is less resources (limited documentation and limited bug support) in the market. Through this work, we tried to analyze which distribution of OpenStack works best with selected SDN controllers.

Data plane analysis was perform to evaluate the performance and reliability (fault tolerance) of SDN controllers in case their integration into OpenStask. For evaluation of this criteria the experimental scheme suggested in paper. The experimental results show that the performance of controllers significantly limited compared to the possibilities of cloud resources (controllers currently have the capability to handle around 1000 flows per second without loss).

Thus, modern SDN – OpenStack solutions can provide sufficient performance and reliability only for limited flows number - 1000 flows per second. Methods of increasing the performance of controllers is a further step in SDN - OpenStack solutions.

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Рецензент: д-р техн. наук, проф. Є.В. Дуравкін, Харківський національний університет радіоелектроніки, Харків.

ІНТЕГРАЦІЯ SDN КОНТРОЛЕРІВ У OPENSTACK. АНАЛІЗ ПРОДУКТИВНОСТІ ТА НАДІЙНОСТІ

О.Б. Ткачова, Мохаммед Джамал Салім, Раєд Яхя Абдулгхафур

У статті проведено аналіз технології OpenStack, яка широко застосовується в якості інструменту управління ресурсами віртуального середовища. Основна увага приділяється інтеграції SDN контролерів у OpenStack технологію: взаємодії між плагінами модулю Neutron та SDN контролером. В рамках оцінки ефективності OpenStack-SDN рішень проведено експеримент, який дозволяє оцінити основні параметри різних типів контролерів. У результаті проведення експерименту отримані наступні SDN контролерів: середній час затримки, швидкість передачі, максимальну кількість UDP і TCP потоків.

***Ключові слова**: технологія OpenStack, модуль Neutron, диспетчер SDN, хмарні обчислення, виконавці і оцінка надійності.*

ИНТЕГРАЦИЯ SDN КОНТРОЛЛЕРОВ В OPENSTACK. АНАЛИЗ ПРОИЗВОДИТЕЛЬНОСТИ И НАДЕЖНОСТИ

Е.Б. Ткачева, Мохаммед Джамал Салим, Раед Яхя Абдулгхафур

В статье проведен анализ технологии OpenStack, которая получила широкое распространение в качестве инструмента управления ресурсами виртуальной среды. Основное внимание уделяется интеграции SDN контроллеров в OpenStack технологию: взаимодействию между плагинами модуля Neutron и SDN контроллером. В рамках оценки эффективности OpenStack-SDN решений проведен эксперимент, который позволяет оценить основные параметры различных типов контроллеров. В результате проведения эксперимента получены следующие SDN контроллеров: среднее время задержки, скорость передачи, максимальное количество UDP и TCP потоков.

***Ключевые слова**: технология OpenStack, модуль Neutron, диспетчер SDN, облачные вычисление, исполнители и оценка надежности.*