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Simulation of the Software-Defined Network for a High-Performance Computing Cluster

Igor Sergeevich Konstantinov, Jurij Gennadievich Chashin and Sergej Aleksandrovich Lazarev
Belgorod State National Research University, 85 Pobedy St., 308015 Belgorod, Russia

Abstract: The study considers the issues of using the software-defined networks, the current state of the research trends in this area and the most significant projects. The simulation of a high-performance computer network for increase in the performance of the university computing cluster due to the optimization of topology and network traffic between the computational nodes is described.

Key words: A software-defined network, computing cluster, network simulation, increase in the network performance, topology optimization, traffic optimization

INTRODUCTION

The recent technology of construction of the high-performance Computer Networks (CN) for various centers for the data (storage) and Processing (DPC/DC) is lately being the subject of research and discussions.

This technology suggests placement of the intelligent part of the Software-Defined Network (SDN) at the central server and switch control by means of the Openflow protocol. Such approach shall ensure the independence of the high-level control functions from the hardware as the result of which the transfer and routing processes shall be speeded up (Chashin, 2013).

The motivating factors for transition from the standard CN to the SDN are:

- Reduction in the equipment cost
- Enhanced network control options
- Software resource and data flows management
- Reduction of the probability of the unauthorized network infiltration, etc.

However, there is a number of constraining factors:

- A fixed (dedicated) control network required
- Insufficient scalability
- «raw» current version of the Openflow protocol
- Equipment upgrade issues
- Limited number of the switch models supporting Openflow, etc.

Despite the existing disadvantages the researchers' community is sure that all the difficulties will be overcome, the new solutions will appear in particular, the new versions of the Openflow protocol.

Procedure: Currently there are a few large projects over the world dealing with the development of SDN. The most famous among them are: Open Network Foundation, Openflow in Europe-Linking Infrastructure and Applications, Felix, ON.LAB, GENI, etc. In Russia these include the projects by the Center for the Applied Research of the Computer Networks (CPI KS).

The Open Network Foundation (ONF) project units >100 companies-members, promotes the SDN-standards. The main achievement is the release of an open Openflow protocol, currently working on the version 1.4 is being performed that will include among other things the optical port support.

The project Openflow in Europe-Linking Infrastructure and Applications (OFELIA) provides equipment and resources for research with the use of the Openflow. A great number of the studies, primarily in the area of creation of the cross-domain controlled networks have been conducted.

The FELIX project is the combination of the OFELIA and RISE project (equivalent of OFELIA in Japan). It is planned to use the Network Service Interface (NSI) protocol together with Openflow for creation of the integrated cross-domain network. Currently (until March 2014), searching for the possible applications is being performed. The possible options are: Operation according to the principle follow the moon, the long-distance transmission ultra high definition (high-resolution video), etc.

The objective of the ALIEN project is creation of the Hardware Abstraction Level (HAL) the level of abstraction allowing working with various equipment switches, optical switches, etc.) (ALIEN, 2014).

Within the OpenflowSec.org project the Security Enhanced (SE) Floodligh service is designed that allows establishing the security policies in the Openflow.

Correspoding Author: Igor Sergeevich Konstantinov, Belgorod State National Research University, 85 Pobedy St., 308015 Belgorod, Russia

The FlowVizor project employs the network hypervisor being a layer between the switches and Openflow controllers that allows dividing the network into the independent levels-layers. Each layer is a certain network subset controlled by a separate Openflow controller. The actions within one layer do not affect any other. This is why one may test the new ideas and developments on the basis of the existing operating network without interfering its routine operation (Sherwood *et al*., 2014).

Along with the above-mentioned ones there is a variety of the interesting projects such as TestON the system for automated SDN testing; Ocf a framework for the network testing control, etc.

The Russian Center for Applied Research of the Computer Networks performs research in a few directions:

- Network simulation; the Mini Network simulation tool developed
- Designing of the SDN-switch on the basis of the Programmable Logic Device (PLD)
- Designing of a network Operating System (OS)

There has been developed the tool for the network OS testing-HCProbe. Currently, the research on the creation of the network OS featuring the required options (routing with QoS, load balancing, traffic filtering, etc.) is being performed:

- The use of Openflow for the DPC including the wireless networks
- Ensuring safety within the SDN
- SDN verification for organization of the correct and safe network operation

A great number of interesting international publications about the surveys in this area are available. The publication about PacketShader (Han *et al*., 2010). is one of the first and most comprehensive works concerning the use of the Graphics Processing Unit (GPU) for the package processing. Using the well-known CUDA technology it is possible to increase the performance by >4 times.

The publication about the advantages of the Openflow of GMPLS (Das *et al*., 2014) and about the methods of interaction between these protocols. There is an example of the already operating cross-domain optical network based on Openflow and GMPLS (Channegowda *et al*., 2013).

Openflow is mentioned in a few publications of the GLIF project (Roberts, 2012) within the frameworks of which it is planned to use it together with the NSI protocol, yet no details are available at the moment.

MAIN PART

Assignment of the research objective: In the research University "BelGU" there is a high-performance computing cluster used in the scientific research and in the educational process that combines:

- The supercomputer "Nezhegol"
- The supercomputer "Kudesnik"
- The high-end servers with the GRID-systems: NorduGRID, Unicore, GlobusToolkit

The issue is that because of the restrictions of the available network equipment and the established topology that is far from being optimal, it is not always possible to achieve the maximum performance of the computing cluster.

In order to speed up the cluster operation the use of the SDN is considered as an option. It is suggested that the modification of topology and control optimization will allow speeding up the operation due to the reduction of the routes length and for example, the management of the streaming priorities.

Research task solution: In order to study the possible versions of the SDN the Mininet network neighborhood simulation system was chosen that allows networking the switches, Openflow-controllers, hosts and emulating the network activity. This system is widely used in the foreign educational institutions in order to learn the principles of operation of the computer networks and routing, the Openflow applications, analysis of the complex topologies.

MiniNet quite qualitatively emulates the real physical network, allows setting different parameters of the virtual network channels such as throughput capacity, packet delay and loss, jitter, etc. It is also possible to integrate the created virtual network in the real-mode network. The emulator supports up to 4096 nodes and is able to generate the up to 2 Gb ces-1 traffic. Thus, by forwarding the data streams along the few virtual network routes, it is possible to explore the SDN-mechanisms and perform different estimates of the performance taking into account various factors such as e.g., the effect of the different line interference.

The location of the high-performance equipment of our cluster allows investigating a variety of the alternative topologies. The simplest one among them is the topology with the use of a single Openflow controller. The students of the department for the Information Technologies and Applied Mathematics (ITiPM) have simulated and tested a great number of the SDN designs controlled by the Pox server.

Beside the research involving the optional versions of topologies and the SDN-mechanisms, the students conduct investigations of the Openflow controllers. As the test switch the popular switch by D-Link-DES 1100-16 was used that appeared to be available due to its presence by the partner company providing internet services. The switch has given a good account of itself due to its high availability, high rate of the package processing and reasonable price. Its main features are:

- The switching matrix rate-3.2 Gb sec^{+}
- The maximum package redirecting rate-2.38 Mbps
- The size of the MAC-addresses table 8 Kb

As of today, the controller has been adjusted to the network interaction which is expressed by the controller's capability to hear the CS and log the streams passing through it. Unfortunately, this switch is unsuitable for the use in a cluster because of its operation at the Fast Ethernet speed whereas the channel with at least the Gigabit Ethernet speed is required. It is planned to use the D-Link DGS-1210-28 further on.

DISCUSSION

In the course of the experiments with the SDN-Model of the high-performance university computing cluster the possible ways of increasing its performance due to optimization of the network topology and control of the traffic between the computational nodes were investigated.

CONCLUSION

The results obtained in the course of simulation allow drawing the conclusion on the perspectiveness of the SDN-based solution application for the solution of the specified task. One should also mention the relevance and prospectivity of this direction, the interest of the international community and express the hope for the appearance of the new innovative solutions in the SDN area.

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